

[54] PRESSURE SWITCH

10,800	12/1955	Germany	200/83 Y
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[21] Appl. No.: 188,038

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[52] **U.S. Cl.** **200/83 SA, 200/83 J**

[51] **Int. Cl.** **H01h 35/34**

[58] **Field of Search**..... 200/83 SA, 83 S,
200/83 F, 83 P, 82 R, 81 R, 83 J, 83 Y

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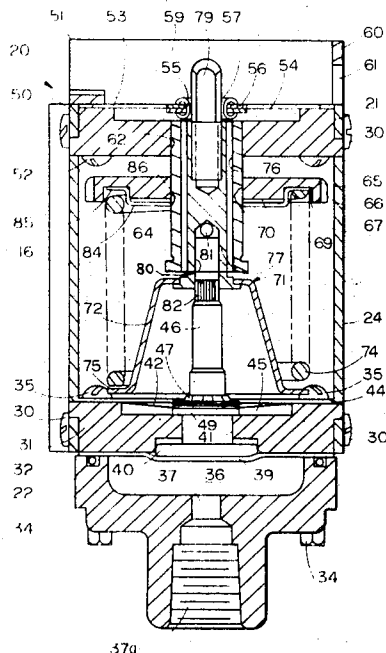
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[57] **ABSTRACT**

A modular differential spring and contact assembly is adapted for mounting on a pressure sensing module in selected positions providing optimum sensitivity for different spring rates of the pressure sensing components. Independent adjustment means are provided for range spring force, differential spring force, differential pick-up, and sensitivity so that the pressure switch assembly is operative in a wide variety of pressure ranges with different pressure sensing means, range springs and contact means.

6 Claims, 13 Drawing Figures



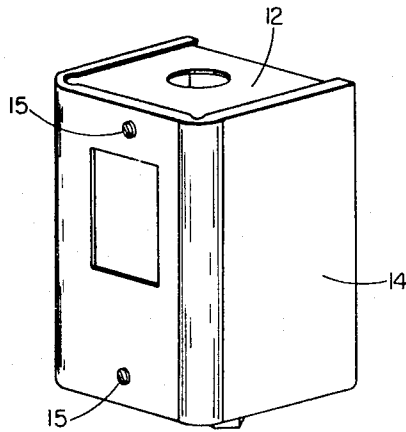


FIG. 1

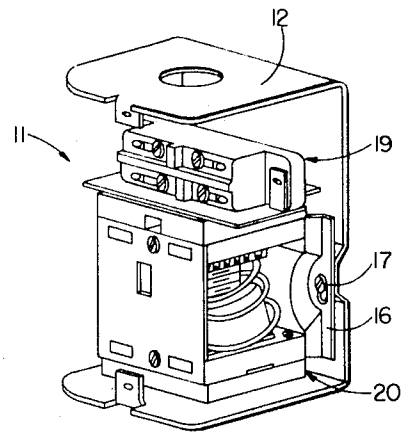


FIG. 2

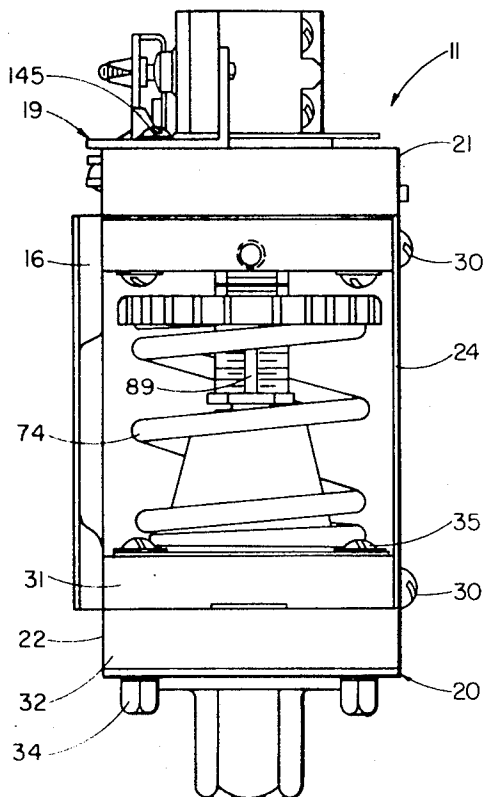


FIG. 3

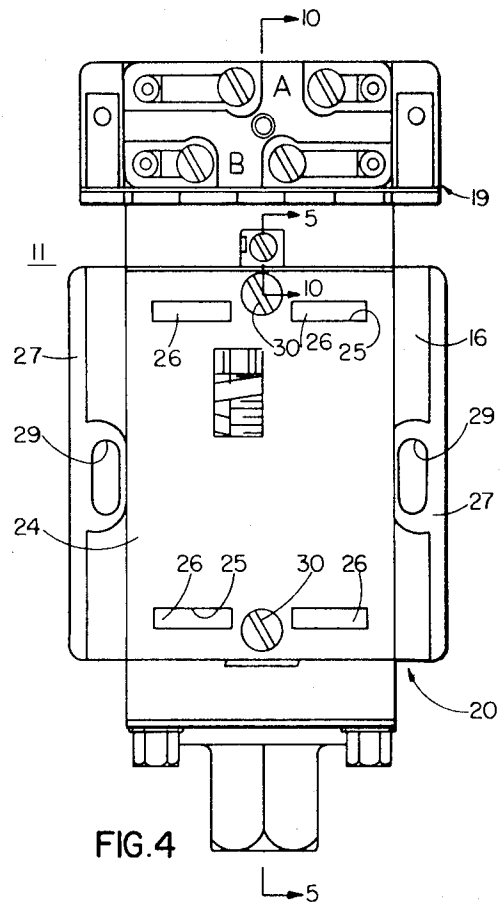


FIG. 4

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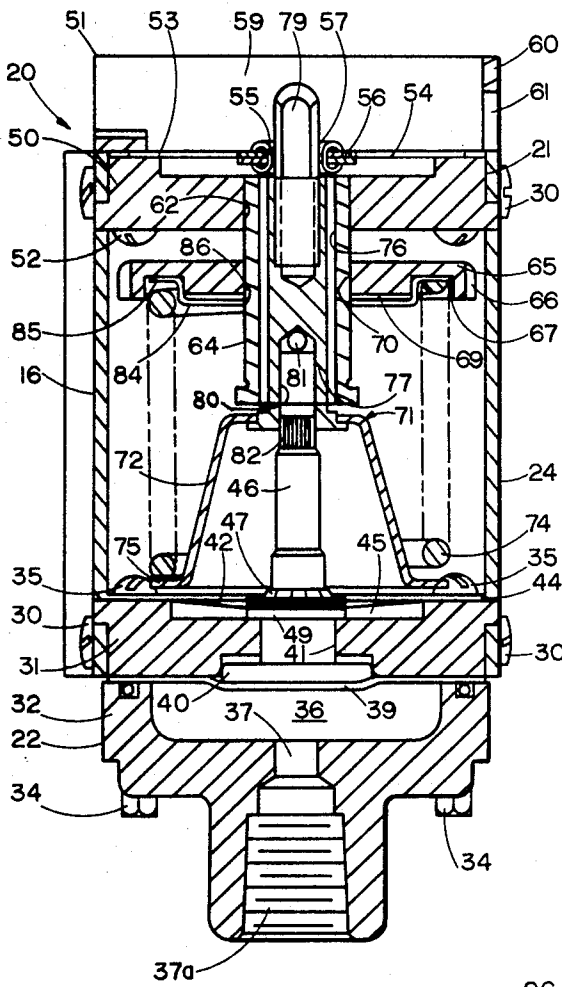


FIG. 5

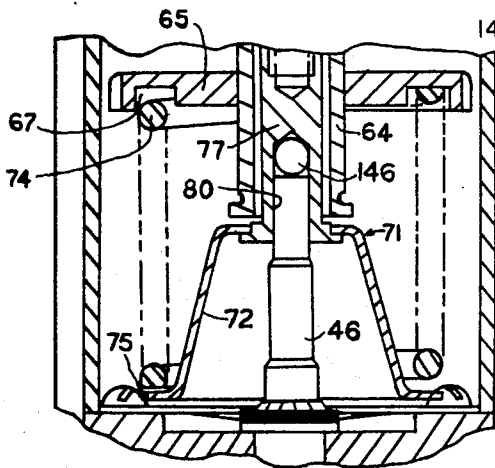


FIG. 13

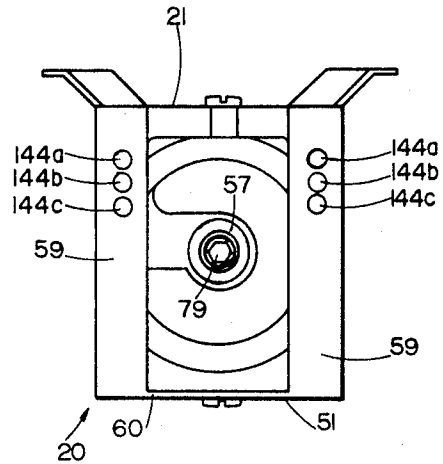


FIG. 6

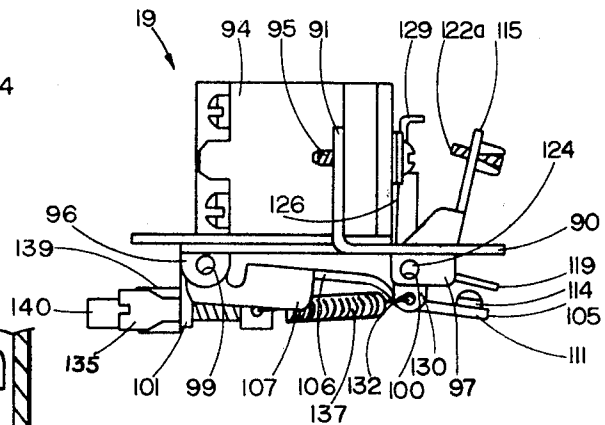


FIG. 7

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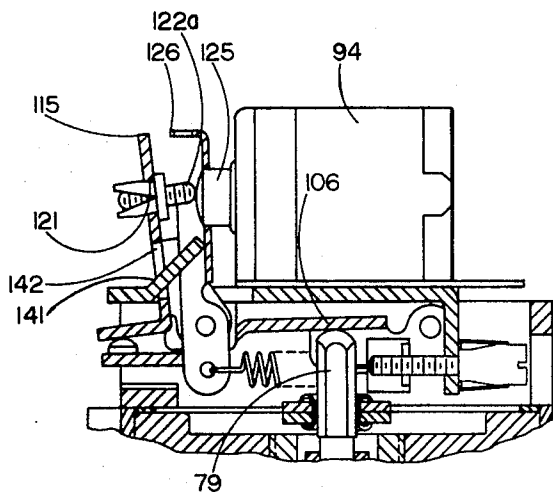


FIG. 10

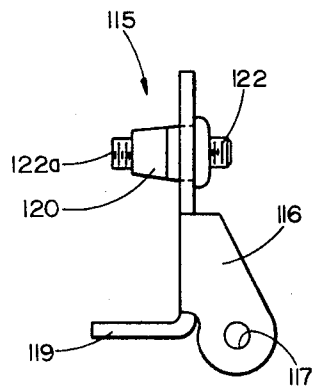


FIG. 11

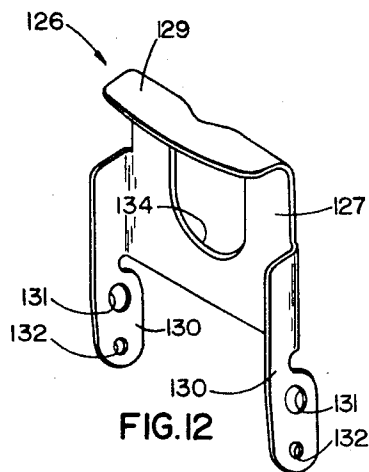


FIG. 12

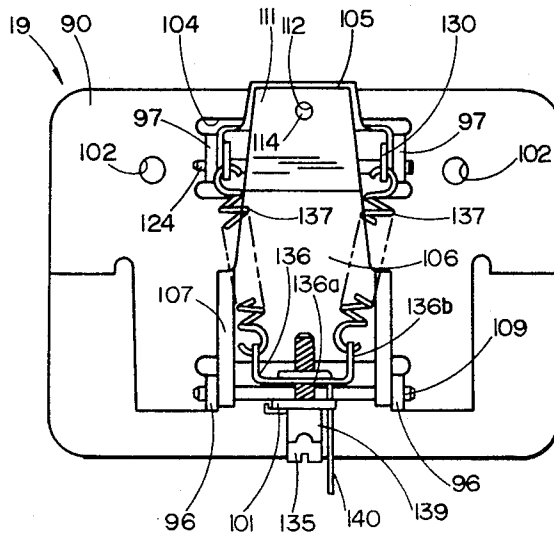


FIG. 8

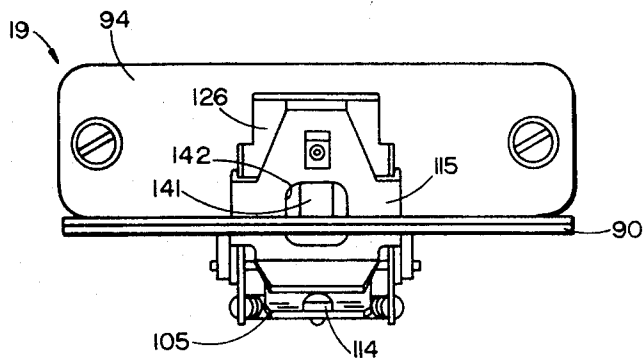


FIG. 9

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PRESSURE SWITCH

The invention relates to pressure responsive electrical switches, and more particularly to a pressure switch assembly which is generally modular in construction.

It is an object of the present invention to provide a pressure switch which may be easily assembled and has interchangeable components which facilitate adaptation to a large variety of applications.

It is a further object of the present invention to provide a pressure switch with a differential spring and contact module which has means for presetting both the differential force and the differential pick-up point before attachment to, and without regard to the identity of, the pressure sensing components of the pressure switch.

It is a still further object of the present invention to provide a pressure switch for which the differential spring and contact module may be attached to the pressure sensing components selectively in a plurality of positions to provide optimum sensitivity with range springs having greatly differing spring rates.

These and other objects and advantages of this invention will become apparent from the following description wherein reference is made to the drawings, in which:

FIG. 1 is a perspective view of a pressure switch assembly made in accordance with the present invention with a housing and cover attached thereto;

FIG. 2 is a perspective view similar to FIG. 1 with the cover removed;

FIG. 3 is a side view of the pressure switch assembly of FIG. 1;

FIG. 4 is a front view of the pressure switch assembly of FIGS. 1-3;

FIG. 5 is a cross-sectional view of a pressure sensing module of the pressure switch assembly taken generally along the lines 5-5 of FIG. 4;

FIG. 6 is a top view of the pressure sensing module of FIG. 5;

FIG. 7 is a side view of a differential contact module for use in the pressure switch of the present invention;

FIG. 8 is a bottom view of the differential contact module of FIG. 7;

FIG. 9 is a rear end view of the differential contact module of FIG. 7;

FIG. 10 is a fragmentary cross-sectional view of the pressure switch assembly taken generally along the lines 10-10 of FIG. 4;

FIG. 11 is a side view of an operating lever for use in the differential contact module of FIGS. 7-9;

FIG. 12 is a perspective view of a differential lever for use in the differential contact module of FIGS. 7-9; and

FIG. 13 is a fragmentary cross-sectional view similar to FIG. 5 and illustrating an alternative embodiment of a range spring adjusting means.

A preferred embodiment of the pressure switch of the present invention is illustrated in FIGS. 1-4. A pressure switch assembly 11 may be encased in a housing 12 having a U-shaped cover 14 releasably attached thereto, as by a pair of screws 15. A rear attachment plate 16 of the pressure switch assembly 11 may be affixed to the housing 12 by a pair of screws 17 or other suitable means. In suitable applications, the pressure switch assembly 11 may be used without the housing 12 and cover 14.

The pressure switch assembly 11 generally comprises a differential contact module 19 and a pressure sensing module 20. The pressure sensing module 20 may employ a diaphragm, bellows, or piston operator, each of which is well known in the art. For purposes of illustration, a diaphragm operated pressure sensing module 20 is shown herein and is best described with reference to FIGS. 3-6.

The pressure sensing module 20 has an upper base assembly 21 and a lower base assembly 22 which are joined by a front attachment plate 24 and the rear attachment plate 16. The attachment plates 16 and 24 are preferably provided with apertures 25 (FIG. 4) for interaction with corresponding alignment bosses 26 formed on front and rear faces of the upper base assembly 21 and lower base assembly 22 to ensure proper relative alignment of the respective base assemblies. The rear attachment plate 16 may be provided with a pair of flanges 27 containing openings 29 to facilitate mounting of the pressure switch assembly 11 by use of the screws 17. The front attachment plate 24 and rear attachment plate 16 are connected to the upper base assembly 21 and lower base assembly 22 by suitable fasteners, such as screws 30.

The lower base assembly 22 includes a lower base 31 and a cover 32, which are preferably metal castings and are connected to each other by a plurality of threaded fasteners such as cooperating nuts 34 and bolts 35. The lower base 31 and cover 32 form a pressure chamber 36 communicating externally of the pressure switch assembly 11 through a generally cylindrical opening 37 having an outer enlarged portion 37a which may be internally threaded to facilitate connection of the pressure switch assembly 11 to the source of external pressure to be measured. The lower base assembly 22 houses a pressure sensing means which may be a diaphragm 39 formed of a suitable material such as rubber or plastic and held between the lower base 31 and cover 32 in a position defining the upper end of the pressure chamber 36. The diaphragm 39 operably abuts a pressure plate 40, having an upper portion of reduced diameter, preferably molded of plastic, which is mounted for vertical reciprocating motion within a complementary shaped opening 41 extending through the lower base 31.

A lower guide diaphragm 42, preferably comprising a thin sheet of polyester film (indicated by a single line), is mounted beneath a metallic holding plate 44. The holding plate 44 is in turn secured to the lower base 31 by the bolts 35. A recess 45 is provided in the upper face of the lower base 31 so that the lower guide diaphragm 42 is free to vertically reciprocate between positions both above and below its rest position. However, the lower guide diaphragm 42 must be of sufficient thickness to prevent any lateral motion and should be provided with at least one perforation (not shown) so that its motion is independent of pressure differentials which might otherwise exist between the two sides of the diaphragm 42. A generally cylindrically lifter pin 46 is inserted through a central opening in the lower guide diaphragm 42 and secured by a suitable fastener such as a pushnut 47 with a lower end portion 49 of the lifter pin 46 located beneath the lower guide diaphragm 42. The lower end portion 49 of the lifter pin 46 rests on the upper surface of the lower base 31 just over the reduced portion of the pressure plate 40 so that vertical reciprocating motion of the pressure di-

aphragm 39 is transferred through the pressure plate 40 to the lifter pin 46 which freely moves with the lower guide diaphragm 42 in a vertical direction although laterally constrained thereby.

The upper base assembly 21 includes an upper base 50 and a top spacer 51 which are preferably metallic castings connected together by suitable fasteners such as screws 52. A metallic holding plate 53 is held between the upper base 50 and top spacer 51 for securing an upper guide diaphragm 54 against an upper surface of the upper base 50. The upper guide diaphragm 54, is formed of polyester film (indicated by a single line), as is the lower guide diaphragm 42, and is also perforated to permit vertical reciprocating motion independent of pressure differentials. The upper guide diaphragm 54 is provided with a central opening 55 which is preferably reinforced with a pair of washers 56, one washer 56 being cemented on each of the upper and lower surfaces of the upper guide diaphragm 54 around the central opening 55 and serving as a base for securement of a peripheral eyelet 57 within the opening.

The top spacer 51 has a pair of upstanding sidewalls 59 connected by a front wall 60, having an opening 61 therethrough.

The upper base 50 has a central opening 62 therethrough which is threaded to accommodate a threaded range spring adjusting column 64 held in place by a set screw (not shown). A range spring adjusting knob 65 preferably has knurled peripheral surface 66 and an annular depression 67 formed in a lower surface 69 thereof. A central opening 70 of the range spring adjusting knob 65 is threaded for attachment of the range spring adjusting knob 65 to the range spring adjusting column 64.

A spring guide and center post assembly 71 has a frusto-conical lower portion 72 which serves as a guide for placement of a range spring 74, preferably a compression spring, and has a peripheral lower flange which serves as a lower spring seat 75 for the range spring 74. An upper portion of the spring guide center post assembly 71 extends through an axial opening 76 in the range spring adjusting column 64 and serves as a center post 77. A pushrod 79 is connected to an upper end portion of the center post 77 and extends through the eyelet 57 in the central opening 55 of the upper guide diaphragm 54. A blind opening 80 is provided in a lower portion of the center post 77 for interaction with the lifter pin 46. A spacer 81 may be used to position the spring guide and center post assembly 71 with respect to the lifter pin 46 and may, if desired, be a ball bearing. A knurled portion 82 of the lifter pin 46 interacts with the opening 80 to prevent rotation of the spring guide and center post assembly 71 with respect to the lifter pin 46. The lifter pin 46 and the spring guide and center post assembly 71 combine to serve as a stem responsive to motion of the pressure plate 41.

An upper spring seat 84 has a peripheral flange 85 which is shaped and positioned to fit within the annular depression 67 on the lower surface 69 of the range spring adjusting knob 65. A central opening 86 of the upper spring seat 84 has a plurality of inwardly extending keys (not shown) which ride in longitudinal splines 89 (see FIG. 3) formed on the range spring adjusting column 64 to hold the upper spring seat against rotational motion during rotation of the range spring adjusting knob 65.

During operation of the pressure switch assembly 11, an increase in pressure in the pressure chamber 36 causes an upward movement of the pressure diaphragm 39 which, in turn, biases the pressure plate 40 for upward vertical motion. The pressure plate 40 applies a corresponding upward biasing force to the lower end portion 49 of the lifter pin 46 which applies the force to the spring guide and center post assembly 71. To effect upward motion of the spring guide and center post assembly 71, the upward biasing force must overcome the downward force applied to the lower spring seat portion 75 of the spring guide and center post assembly 71 by the range spring 74. Therefore, the compressive force of the range spring 74, applied through the lifter pin 46 and pressure plate 40, determines the minimum pressure which must be applied to a particular pressure sensing means, such as the pressure diaphragm 39, to effect upward motion of the spring guide center post assembly 71. This minimum value of pressure which will operate the pressure switch assembly 11 may be regulated by adjusting the compressive force of the range spring 74. This is readily accomplished by rotating the range spring adjusting knob 65 so that it moves vertically along the threaded range spring adjusting column 64. The upper spring seat 84, keyed in the splines 89 of the range spring adjusting column 64, moves vertically, without rotation, as the range spring adjusting knob 65 is turned and thereby effects an increase or decrease in spring compression while preventing rotation of the range spring 74 and any frictional interaction thereof with adjacent parts.

If the pressure in the pressure chamber 36 is sufficient to upwardly bias the spring guide and center post assembly 71 with a force greater than the downward biasing force of the range spring 74, the center post 77, and accordingly the pushrod 79, is moved upwardly through the upper base assembly 21. The upward travel of the spring guide and center post assembly 71 is limited by the position of the range spring adjusting column 64.

Since any lateral motion of the center post 77 during operation of the pressure switch assembly 11 would inhibit accurate pressure switch operation, as will be later demonstrated, the lower guide diaphragm 42 and upper guide diaphragm 54 maintain vertical alignment of the center post 77 without frictional losses. The lower guide diaphragm 42 is rigidly connected to the lifter pin 46 and, as previously indicated, may freely move through a limited vertical range while being rigidly constrained against lateral motion. Similarly, the upper guide diaphragm 54 is laterally rigid so that the pushrod 79, riding within the central opening 55, has its permissible lateral motion constrained by the eyelet 57. During vertical motion of the center post 77, the push rod 79 is free to move through the eyelet 57 without interaction therewith. However, should any lateral motion cause the pushrod 79 to abut the eyelet 57 during its vertical motion, the eyelet 57 will move vertically with the pushrod 79 due to the free vertical motion of the upper guide diaphragm 54. In this manner, substantially frictionless vertical alignment is provided for the lifter pin 46 and the spring guide and center post assembly 71.

The differential contact module 19 is illustrated in FIGS. 7-9 and includes a base plate 90, preferably a metal stamping, having a pair of upstanding arms 91 formed thereon. Each arm 91 is preferably provided

with a threaded aperture to facilitate connection of a snap switch 94 through the use of a pair of screws 95. A pair of depending front legs 96 and a pair of depending rear legs 97 are formed on the base plate 90. Each of the front legs 96 is provided with one of a pair of axially aligned, substantially circular openings 99 and each of the rear legs 97 is provided with one of a pair of axially aligned, substantially circular openings 100. The openings 99 and 100 are preferably equidistant from the lower planar surface of the base plate 90. The base plate 90 has a vertically depending forward leg portion 101. Formed in the base plate 90 are a pair of mounting holes 102 (FIG. 8), and a generally rectangular central opening 104 located between the rear legs 97.

A main lever 105 has a substantially planar central portion 106 with a pair of generally parallel depending legs 107 located on opposite sides thereof. The main lever 105 is connected to the base plate 90 by means of a hinge pin 109 which is inserted through a pair of aligned openings in the depending legs 107, and through the aligned openings 99 in the front legs 96 of the base plate 90. In this manner, the hinge pin 109 serves as a pivot for rotational motion of the main lever 105 with respect to the base plate 90. The main lever 105 is bent to provide a rear end portion 111 which is substantially parallel to, but displaced vertically lower than, the central portion 106. An opening 112 (FIG. 8) is provided in the rear end portion 111 of the main lever 105 to accommodate a button 114 which may be formed of a suitable material such as a synthetic plastic.

An operating lever 115 (FIG. 11) has a pair of generally parallel spaced leg portions 116 extending outwardly in one direction from a central planar body portion. Each of the leg portions 116 has one of a pair of axially aligned openings 117 therein and the operating lever 115 is bent to provide a substantially planar lower end portion 119 extending generally outwardly opposite the leg portions 116 and substantially at right angles to the main portion of the operating lever 115. A plastic grommet 120 is fitted in an opening 121 (FIG. 10) in the operating lever 115 and provided with a threaded member, such as a set screw 122, in a threaded opening therethrough.

The operating lever 115 is connected to the base plate 90 by fitting it through the central opening 104 of the base plate 90 with the lower end portion 119 extending beneath and substantially parallel to the main planar portion of the base plate 90 and with the openings 117 in the leg portions 116 aligned with the openings 100 in the rear legs 97. A hinge pin 124 (FIG. 8) is fitted through the aligned openings 100 and 117 so that the operating lever 115 is connected to the base plate 90 but is free to rotate relative thereto around the hinge pin 124 with the lower end portion 119 of the operating lever 115 positioned directly above and in abutting relation with the button 114 on the main lever 105 (see FIG. 7). In this manner, a forward end portion 122a of the set screw 122 is placed in abutting, operative relationship with a pushbutton 125 of the snap switch 94 (see FIG. 10).

A differential lever 126 (FIG. 12) is preferably stamped and formed of metal and has a substantially planar main portion 127 and an upper portion 129 extending generally at right angles therefrom. A pair of spaced, substantially parallel, depending leg portions 130 are formed on opposite sides of the main portion

127. Each leg portion 130 is provided with one of a pair of axially aligned openings 131 and one of a pair of axially aligned differential spring openings 132. The differential lever 126 is connected to the rear legs 97 of the base plate 90 by fitting the hinge pin 124 through the openings 131 in the leg portions 130 of the differential lever 126. In this manner, the operating lever 115 and the differential lever 126 are provided with a common pivot around the hinge pin 124 (see FIG. 7). An opening 134 is provided in the main portion 127 of the differential lever 126 to enable the forward end portion 122a of the set screw 122 to abut the pushbutton 125 of the snap switch 94.

The forward leg 101 of the base plate 90 is provided with an aperture to accommodate a differential adjusting screw 135. A differential spring bracket 136 has a central portion 136a threaded onto the differential adjusting screw 135 for linear motion along a threaded shank portion thereof upon rotation of the screw 135. A pair of laterally extending leg portions 136b of the bracket 136 are each provided with a differential spring opening for attachment of one end portion of one of a pair of differential springs 137 having their other end portion connected to the differential lever 126 by reception in one of the differential spring openings 132 in one of the leg portions 130 of the differential lever 126. In this manner, rotation of the differential adjusting screw 135 in one direction moves the differential spring bracket 136 in a forward direction, thereby stretching the differential springs 137 and increasing the force thereof. Rotation of the differential adjusting screw 135 in the other direction decreases the force of the differential springs 137. If desired, a spring clip 139 may be attached to the forward leg 101 to abut the differential adjusting screw 135 and prevent changes in spring tension during operation of the pressure switch assembly 11. A differential indicator 140 may be threaded onto the differential adjusting screw 135 for calibration of the differential springs 137. If the differential indicator 140 is used the opening in the central portion 136a of the differential spring bracket 136 should not be threaded.

The differential springs 137 bias the differential lever 126 so that, as the operating lever 115 moves toward the snap switch 94, the upper portion 129 of the differential lever 126 abuts the operating lever 115 and urges it in a direction away from the snap switch 94. This motion of the differential lever 126 is limited by a differential stop portion 141 of the base plate 90 (FIGS. 9, 10) which abuts the main portion 127 of the differential lever 126 through a differential stop opening 142 in the operating lever 115.

During operation, motor of the operating lever 115 controls the condition of the contacts of the snap switch 94. When the operating lever 115 is moved toward the snap switch 94, the forward end portion 122a of the set screw 122 engages and inwardly biases the pushbutton 125 to trip the snap switch 94. When the operating lever 115 is moved away from the snap switch 94, the set screw 122 releases the pushbutton 125, allowing the snap switch 94 to reset.

Since, as is well known in the art, a snap switch trips when its pushbutton is in a position more greatly depressed than the position of the pushbutton which enables the snap switch to reset, it is possible to provide a force differential for the pressure switch by applying a force to the operating lever 115 which must be over-

come to trip the snap switch but is removed before the snap switch resets. This differential force is provided by the differential springs 137 and applied through the differential lever 126 to the operating lever 115.

The differential lever 126 is biased by the differential springs 137 for clockwise rotation, as illustrated in FIG. 7, around the rear hinge pin 124. This motion is limited by interaction of the differential lever 126 with the differential stop portion 141 of the base plate 90. When the operating lever 115 is moved toward the snap switch 94, an upper end portion of the operating lever 115 picks up the upper portion 129 of the differential lever 126 so that the differential lever 126 is rotated together with the operating lever 115. This action causes the differential springs 137 to apply a force opposing the motion of the operating lever 115. Since both the operating lever 115 and differential lever 126 are pivoted about the rear hinge pin 124, they will move together without frictional interaction.

Because it is necessary that the differential force be applied to the operating lever 115 only when the snap switch 94 is being tripped, adjusting means must be provided for fixing the rest point or pick-up and drop-out point of the differential lever 126 at a position between the trip and reset points of the snap switch 94. For this reason the set screw 122 is provided. Since the physical position of the differential lever 126 at which it is picked up by the operating lever 115 is fixed, the points in the motion of the operating lever 115 at which the snap switch trips and resets may be adjusted relative to the pick-up point. If the set screw 122 is adjusted so that its forward end portion 122a is moved closer to the pushbutton 125, the motion of the operating lever 115 necessary to trip the snap switch 94 will be decreased. Conversely, if the set screw 122 is adjusted to move its forward end portion 122a further from the pushbutton 125, increased motion of the operating lever 115 will be required to trip the snap switch 94. Since the pick-up point of the differential lever 126 is not altered by this adjustment, the pick-up of the differential force relative to the trip and reset points of the snap switch 94 may be readily altered thereby. Adjustment of the set screw 122 toward the pushbutton 125 moves the differential pick-up to a later point during tripping while adjustment of the set screw 122 away from the pushbutton 125 moves the differential pick-up to an earlier point during tripping. In this manner, the set screw 122 may be adjusted so that the operating lever 115 picks-up and drops-out the differential lever at a point between the trip and reset positions of the snap switch 94 so that the differential force is applied to the operating lever 115 when the snap switch 94 is being tripped but not when it is being reset.

It should be readily apparent from the foregoing discussion that, although adjustment of the differential adjusting screw 135 changes the tension of, and accordingly the force of the differential springs 137, it does not affect the pick-up or drop-out position of the differential lever 126. Therefore, independent means are provided for adjusting the pick-up position for the differential lever 126 and the force applied thereby.

Since pressure switches generally apply a relatively large force through a distance which is small in comparison with the throw required to operate the snap switch 94, a series of levers must be provided for multiplying the normal travel of the pressure sensing means to provide sufficient motion to operate the snap switch

94. This multiplication is provided by the main lever 105 and operating lever 115.

It is well known that the relative sizes of the force applied to a lever and the force applied by that lever in response thereto depend upon the relative lengths of their respective lever arms (the distance from the point on the lever at which the force is applied to the fulcrum). If we call the force applied to the lever the effort force and the force applied by the lever in response thereto the resistance force, then the resistance force will be equal to the effort force multiplied by the ratio of the effort lever arm to the resistance lever arm. The distance traveled by the resistance force will be equal to the distance traveled by the effort force multiplied by the ratio of the resistance lever arm to the effort lever arm. It can be seen, therefore, that to increase the distance traveled by a force, the force must be applied to a lever whose resistance lever arm is greater than its effort lever arm. Such a lever will also act to proportionately decrease the force applied.

A combination of two levers is used in the pressure switch of the present invention to accomplish the multiplication of distance necessary to operate the snap switch 94. The operating lever 115 rotates about the rear hinge pin 124, which therefore serves as its fulcrum. The point of application of the resistance force is at the position of the set screw 122 and the point of application of the effort force is at the point at which the button 114 on the rear end portion 111 of the main lever 105 interacts with the lower end portion 119 of the operating lever 115. Each of these distances is fixed and the resistance lever arm is preferably greater than the effort lever arm.

The main lever 105 has its fulcrum at the front hinge pin 109. The resistance lever arm is the distance from the button 114 to the fulcrum and the effort lever arm is the distance from the fulcrum to the point on the central portion 106 at which the effort force is applied by the pushrod 79 (see FIG. 10). Although this effort lever arm is adjustable, as will be subsequently shown herein, the resistance lever arm is significantly greater than the effort lever arm, thereby providing the required distance multiplication.

It should be noted that the fulcrum of the main lever 105, the fulcrum of the operating lever 115, and the point of interaction of the levers 105 and 115 form a substantially straight line to minimize frictional interaction between the button 114 and the lower end portion 119 of the operating lever 115.

It has been determined that as the lever ratio of the differential contact module 19 is altered by moving the point of application of the effort force from one end of the main lever 105 to the other, the sensitivity of the differential contact module 19 (i.e., the pressure excursion which will cause a change in condition of the snap switch 94 for a given setting of range spring force and differential spring force) increases, reaches a maximum or peak value (minimum pressure excursion), and then decreases. The point of application of the effort force which produces peak sensitivity for the differential contact module 19 depends, for a given differential contact module, solely upon the spring rate of the range spring 74 or, in a bellows-operated pressure switch, upon the combined spring rate of the range spring and bellows.

Therefore, the sidewalls 59 of the top spacer 51 in the upper base assembly 21 are provided with a plural-

ity of spaced apart pairs of threaded openings 144a,b,c. Each of the pairs of openings 144a,b,c causes interaction of the pushrod 79 with the central portion 106 of the main lever 105 at a position to provide the lever ratio needed for optimum sensitivity, or near-optimum sensitivity, for operation with range springs, or range spring and bellows combinations, having different spring rates.

After the operating spring rate for the pressure switch assembly 11 has been determined, the differential contact module 19 is attached to the upper base assembly 21 by aligning the mounting holes 102 in the base plate 90 with the pair of openings 144a,b, or c which will provide optimum sensitivity for the device, and connecting the modules by use of a pair of threaded fasteners 145 (see FIG. 3).

A pressure sensing module 20 having an alternative range spring adjusting means is illustrated in FIG. 13, wherein similar numbers have been used to identify similar parts.

In this embodiment, the upper spring seat 84 is omitted so that the range spring 74 is seated within the depression 67 in the range spring adjusting knob 65. Elimination of the upper spring seat 84 removes the need to provide the splines 89 in the range spring adjusting column 64. As in the principal embodiment, the range spring 74 abuts the lower spring seat 75 on the lower portion 72 of the spring guide and center post assembly 71. The opening 80 in the center post 77 receives the lifter pin 46 so that the upper end portion of the lifter pin 46 abuts a ball bearing 146. The knurled portion 82 (FIG. 5) of the lifter pin 46 is omitted to permit the spring guide and center post assembly 71 to rotate with respect to the lifter pin.

When the range spring adjusting knob 65 is rotated, it travels vertically along the threaded portion of the range spring adjusting column 64 to effect a change in the compression of the range spring 74. Unlike the principal embodiment, as shown in FIG. 5, wherein the range spring adjusting knob 65 frictionally engages the upper spring seat 84, the range spring 74 in FIG. 13 is arranged for rotational motion with the range spring adjusting knob 65. This biasing force is transmitted through the range spring 74 to the lower spring seat 75 of the spring guide and center post assembly 71 which rotates around the lifter pin 46 on the "needle point" bearing formed by the interaction of the lifter pin 46 and the ball bearing 146. A similar bearing contact is formed by the interaction of the push rod 79 (see FIG. 10) at the upper end portion of the center post 77 with the central portion 106 of the main lever 105.

Thus, in the embodiment of FIG. 13, when the main spring adjusting knob 65 is rotated, either to tighten or loosen the range spring 74, both the range spring 74 and the spring guide and center post assembly 71 rotate with the range spring adjusting knob 65 to provide ease of adjustment for the range spring 74 with a minimum of friction. In this manner, even a range spring providing large forces for pressure switch operation in a high pressure range can be fully compressed solely by finger adjustment and without the use of tools.

In this manner a modular pressure switch can be provided which permits ease of interchangeability of range springs and operators and has a differential contact module selectively mountable thereon in a plurality of positions to provide optimum sensitivity regardless of

the type of operator used or the spring rate of the range spring.

It should be understood that certain modifications may be made without departing from the spirit of the present invention. For example, instead of providing a plurality of pairs of openings 144a,b,c in the sidewalls 59 of the top spacer 51 to provide optimum sensitivity for the pressure switch assembly 11, a pair of grooves could be provided in the sidewalls 59 of the top spacer 51 to accommodate attachment of the differential contact module 19 in the precise position yielding optimum sensitivity for the particular operator and main spring utilized. Also, if desired, the differential contact module may be used with a fixed minimum differential by omitting the differential lever 126, differential springs 137, differential spring bracket 136, differential adjusting screw 135, spring clip 139 and differential indicator 140. In this manner the fixed differential force of the differential contact module is that resulting from the force and push button travel characteristics of the snap switch 94.

I claim:

1. A pressure responsive device comprising:

a pressure sensing module including a pressure chamber, a stem movable in one direction when pressure in the pressure chamber is greater than a selected value and movable in an other direction when the pressure in the pressure chamber is less than the selected value and including a first stem portion and a second stem portion, the second stem portion being mounted for rotational movement relative to the first stem portion, a compression spring having end portions and being arranged to apply a biasing force urging the stem to move in the other direction, means applying a pressure responsive force urging the stem to move in the one direction, an adjusting knob abutting one of the end portions of the compression spring, and a spring seat on the second stem portion abutting the other end portion of the compression spring, the adjusting knob being threadably mounted on the pressure sensing module to change the magnitude of the biasing force by rotation of the adjusting knob, the compression spring and the second stem portion,

a differential module including means responsive to movement of the stem and connectable to the pressure sensing module in a plurality of positions, selectively, for providing different values of sensitivity for the pressure responsive device, and attachment means connecting the differential module to the pressure sensing module in one of the positions to provide a selected sensitivity for the pressure responsive device.

2. A pressure responsive device comprising:

a pressure sensing module including a pressure chamber and a stem, the stem having end portions and being movable in one direction when pressure in the pressure chamber is greater than a selected value and movable in an other direction when the pressure in the pressure chamber is less than the selected value,

a differential module having means responsive to movement of the stem and connectable to the pressure sensing module in a plurality of positions, selectively, for providing different values of sensitivity for the pressure responsive device, attachment means connecting the differential module to the

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pressure sensing module in one of the plurality of positions to provide a selected sensitivity for the pressure responsive device,

a first flexible sheet member disposed exteriorly of the pressure chamber and secured at its edges, means connecting one of the end portions of the stem to the first flexible sheet member, and

a second flexible sheet member disposed exteriorly of the pressure chamber, secured at its edges and provided with a central reinforcing member having an aperture therethrough for containing the other of the end portions of the stem.

3. A pressure responsive device as in claim 2 wherein said means responsive to movement of the stem comprises an electric switch means.

4. A pressure responsive device as in claim 3 wherein the switch means has a first operative condition and a second operative condition, and said differential module includes lever means responsive to movement of said stem in said one direction to place the switch means in said first operative condition and responsive to movement of said stem in said other direction to place the switch means in said second operative condition, differential means applying a differential force to the lever means at a differential means rest point while said stem is moving in said one direction and removing the differential force from the lever means at said differential means rest point while said stem is moving in

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said other direction, a first adjustment means for adjusting said differential point, and a second adjustment means for adjusting the differential force.

5. A pressure responsive device as in claim 3 wherein said differential module comprises a base member, a main lever having end portions and pivotally mounted to said base member at one of said end portions, an operating lever having an end portion and pivotally mounted to said base member with its end portion operatively engaging the other of said end portions of said main lever, cooperating engaging means on said operating lever and switch means to determine operative conditions of said switch means, a differential lever pivotally mounted to said base member and having a rest position between said operating lever and said switch means, and differential spring means applying a differential force biasing said differential lever toward said operating lever.

6. A pressure responsive device as in claim 5 wherein said cooperating engaging means comprises a reciprocating member mounted on said switch means for controlling the operative conditions of said switch means, and a member mounted on said operating lever and having an end portion positionable a selected distance from said operating lever for operatively engaging said reciprocating member, and wherein said member is adjustable to change said selected distance.

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