

Feb. 25, 1958

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2,824,919

PRESSURE RESPONSIVE SWITCH

Filed Oct. 5, 1954

3 Sheets-Sheet 1

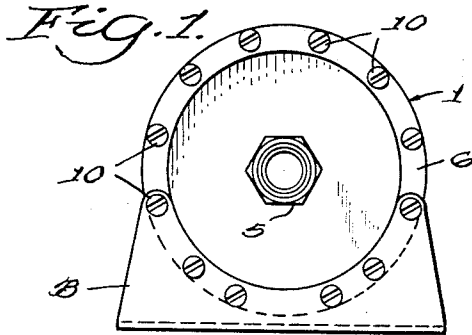
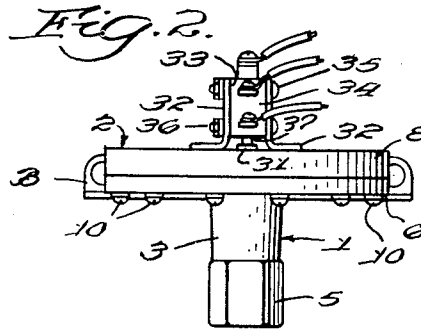
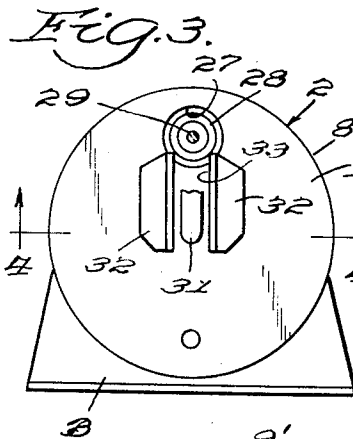


Fig. 4.

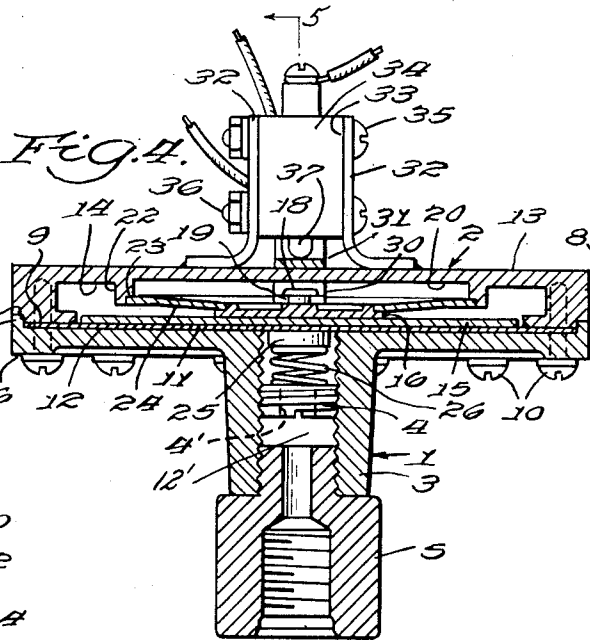
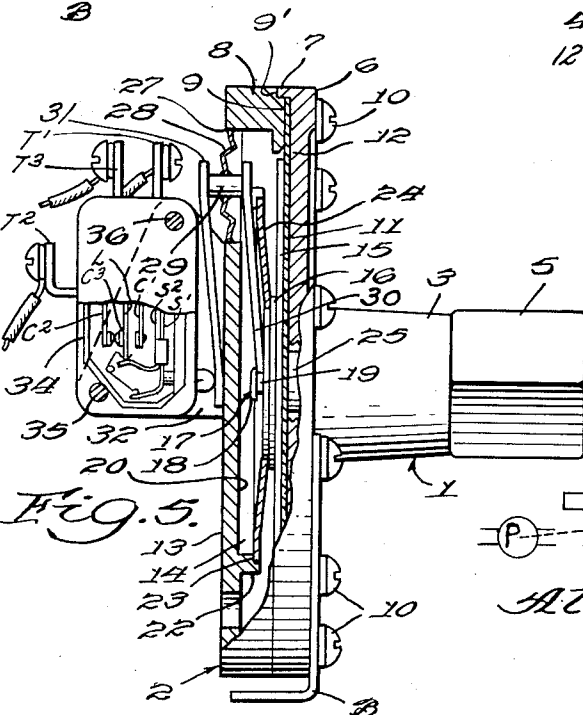
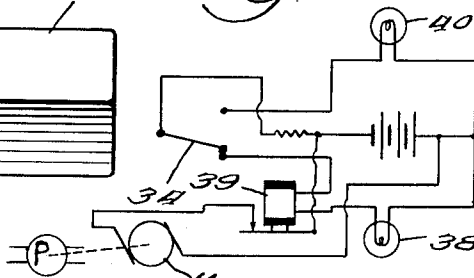


Fig. 8.



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3 Sheets-Sheet 2

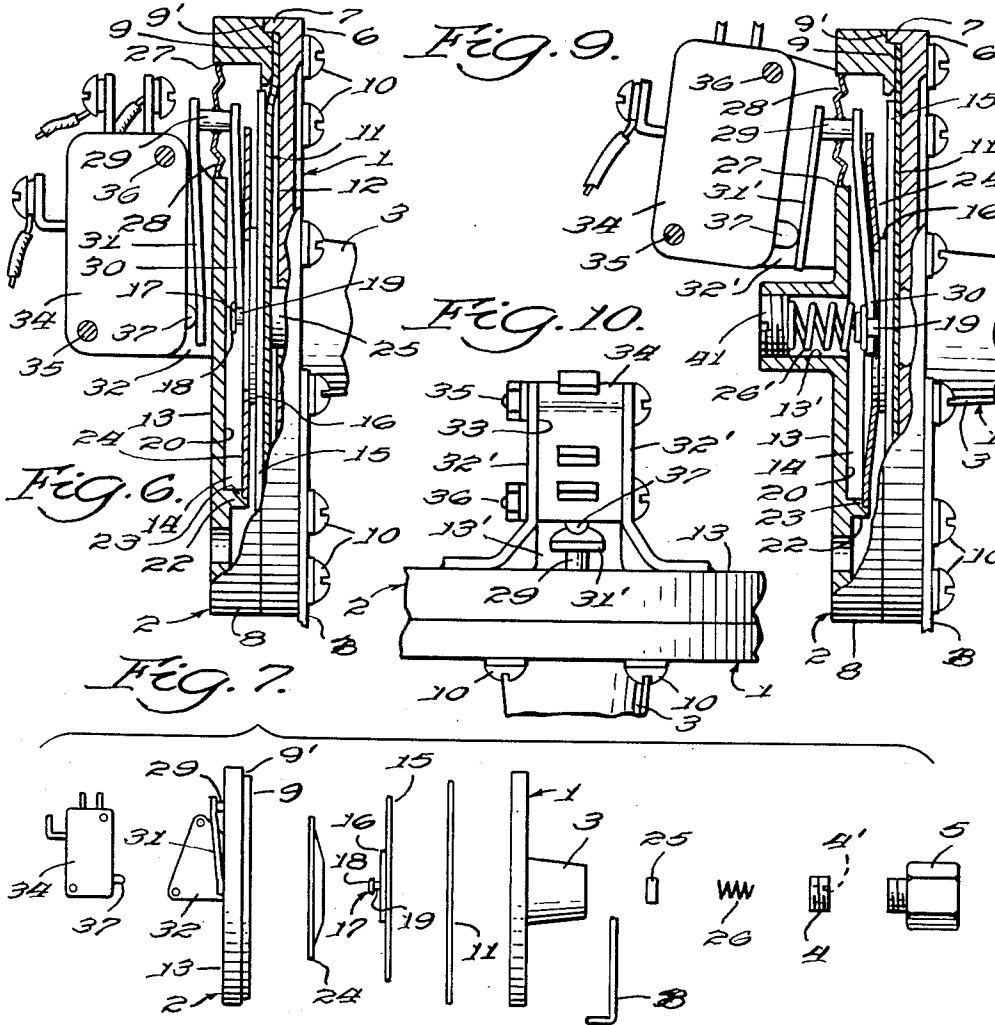
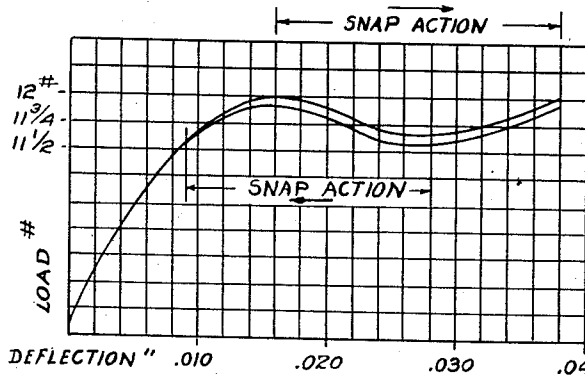


Fig. 11.

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FIG. 12.

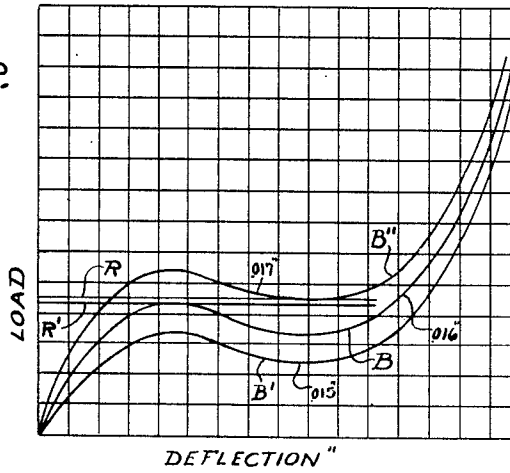


FIG. 13.

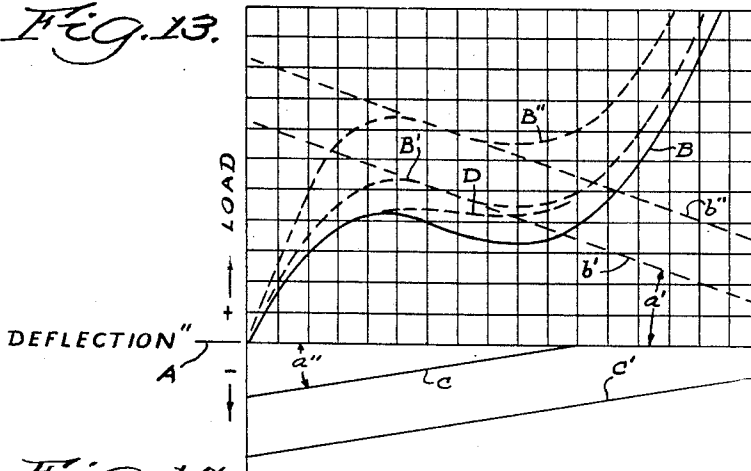
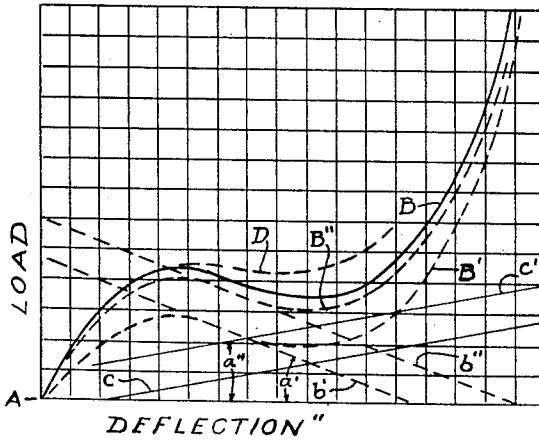


FIG. 14.



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PRESSURE RESPONSIVE SWITCH

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Application October 5, 1954, Serial No. 460,457

10 Claims. (Cl. 200—83)

This invention relates to pressure responsive control and indicating apparatus and more particularly to an improved form thereof effective to operate within very narrow ranges of pressure changes and variations.

An object of the invention is to provide a pressure responsive switch mechanism effective by its inherent resilient properties to be caused to partake of a working stroke or movement when the pressure to which it is subjected reaches a predetermined maximum value and to again be caused to partake (by the said inherent resiliency) of a working stroke or movement in the opposite direction when the pressure has dropped to a predetermined minimum value.

Another object of the invention is to provide a pressure responsive switch mechanism of the above character employing a snap action coned disk spring (hereinafter referred to as a "Belleville" spring) together with means for overcoming the inherent differences in seemingly identical Belleville springs and switches in load-deflection characteristics to the end that all mechanisms employing the pressure responsive combined snap actions of a Belleville spring and a snap action switch designed for use within specified ranges of pressures can be adjusted, as an incident to manufacture, to operate within the required range of operation.

A further object of the invention is to provide a pressure responsive switch operating mechanism effective to operate devices such as an electric switch at predetermined maximum and minimum pressures within very close tolerances of the said pressures.

Still another object of the invention is to provide a pressure responsive switch actuator means which is constructed and arranged to operate at predetermined maximum and minimum pressures within a tolerance of not more than 2% plus or minus of the pressures for which it is designed.

A still further object of the invention is to provide a pressure responsive switch mechanism in which the foregoing objectives are realized in practice, which is of simple and light weight construction, and which is both economical to manufacture and reliable in use.

With the foregoing objects in view, together with such additional objects and advantages as may subsequently appear, the invention resides in the parts, and in the construction, combination and arrangement of parts, described, by way of example, in the following specification of certain modes of execution of the invention; reference being had to the accompanying drawings which form a part of said specification and in which drawings:

Figs. 1 through 7 relate to one embodiment of the invention and in which:

Fig. 1 is a view of the pressure receiving end,

Fig. 2 is an elevation as viewed from the top of Fig. 1,

Fig. 3 is an elevational view as viewed from the opposite end of Fig. 1,

Fig. 4 is an enlarged scale medial sectional view taken on the line 4—4 of Fig. 3,

Fig. 5 is an enlarged scale view with portions thereof shown in section on the line 5—5 of Fig. 4 and showing the parts in the position occupied when the device is subjected to the minimum or less than the minimum

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pressure at which it is intended to operate, and further showing interior details of the switch,

Fig. 6 is a fragmentary view taken on the line 5—5 of Fig. 4, but showing the position of the parts when the device has been caused to operate by application of the maximum pressure for which it is designed, and

Fig. 7 is an exploded view of the component parts of the form of the invention shown in the preceding views,

Fig. 8 is a circuit diagram showing one application of the device.

Fig. 9 is a view taken on the same line as Figs. 5 and 6 but showing a second form of the invention, and

Fig. 10 is a fragmentary view of the switch supporting means taken as viewing a portion of Fig. 9 from the top thereof,

Figs. 11, 12, 13 and 14 are a series of graphs to illustrate the problem and the solution thereof with respect to the interaction of the spring components involved in the invention and in which:

Fig. 11 is a graph, somewhat distorted, to show the operating requirements in a representative pressure responsive operating means embodying the present invention,

Fig. 12 is a graph illustrating by a medial line the load-deflection curve of a Belleville spring employed in one embodiment of the invention and in lines at each side thereof the corresponding curves of springs made from the same material and showing the variation that is incident to variations within the normal commercial tolerance of the thickness of the metal from which the spring is made,

Fig. 13 is a graph representing the interaction of the Belleville spring and a helical spring when combined in the manner shown in the form of the invention disclosed in Figs. 1 through 7 illustrating the manner in which adjustment of the helical spring compensates for the inherent variations in the Belleville springs, and

Fig. 14 is a graph generally similar to Fig. 13, but showing the mode of interaction and effects of adjustment when the springs are arranged as shown in Figs. 9, 10 and 16.

Before beginning the detailed description of the illustrated embodiments of the device, it should be noted that the Belleville spring component is shown disproportionately thick for clearness of illustration in Figs. 4, 5, 6, 9 and 16.

Referring first to the form of the invention shown in Figs. 1 through 7, the device comprises a frame structure including a pressure connected member 1 and a switch carrying member 2. The member 1 includes an internally screw threaded neck portion 3 constituting a pressure receiving orifice the threads of which are adapted to receive an adjustable spring supporting abutment 4 having an axially disposed bore 4' extending therethrough and to be later referred to in greater detail. The outer end of said bore is adapted to engage the threaded neck of a nipple 5 for connection to a source of pressure. The neck portion 3 at its other end terminates in a circular flange portion 6 having a shallow circumferential rib portion 7 on its outer face. The switch supporting member 2 includes an annular wall 8 terminating in a mating flange face 9 and including a circumferential groove 9' engaging the rib 7. A series of screws 10 extending through the flange 6 and threadedly engaging the wall 8 serve to hold the members 1 and 2 in assembly with a diaphragm 11 clamped therebetween and secured in position by the screws 10 passing therethrough and by engagement with the side of the rib 7; said diaphragm normally lying on the flat inner surface 12 of the member 1 as shown in Fig. 4 and forming a pressure responsive wall to the chamber 12' formed by the interior of the member 1. The end wall 13 of the member 2 is spaced outwardly away from the face 9 thereof with resultant formation of a cavity 14 in which cer-

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tain of the diaphragm operated mechanism is located. Mounted on the outer face of the diaphragm 11 is a rigid circular plate 15 slightly smaller in diameter than the inner diameter of the flange 9 and concentrically mounted on the outer surface of the plate 15 is a smaller plate 16 carrying a centrally disposed, outwardly projecting stud 17 having a head 18 of larger diameter with resultant formation of an annular channel 19 between the adjacent surfaces of the plate 17 and the stud head 18. The inner face 20 of the wall 13 of the member 2 carries an annular inwardly projecting rib 22 coaxially disposed with respect to the axial line of the diaphragm and the plates 15 and 16; the end face of said rib having a shallow counterbore 23 for reception of the outer diameter of a Belleville spring 24 mounted therein with the coned inner diameter disposed away from the wall face 20 and resting on the outer surface of the plate 16 near the outer edge thereof; the relation between the various parts being such that when thus arranged and assembled, the Belleville spring is only slightly compressed between its seat in the counterbore 23 and the surface of the plate 16. Freely mounted in the threaded bore 3 of the member 1 and bearing against the diaphragm is a heavy disk 25 serving as one abutment for a compression spring 26 disposed in said bore with the opposite end thereof seated on the adjustable abutment 4 thus providing an adjustable initial loading on the diaphragm and the Belleville spring.

Extending through the wall 13 of the member 2 at one side of the cavity 14 and bordering on the inner face of the wall 8 is a circular opening 27 in which a thin circularly corrugated resilient metal diaphragm 28 is secured by soldering; said diaphragm having a pin 29 extending axially therethrough and projecting beyond the inner and outer faces of the diaphragm. Secured to the inner end of the pin 29 and fixed to and extending therefrom toward the axial line of the members 1 and 2 is an arm 30 having its free end extending into the annular groove 19. The outer end of the pin 29 carries a second arm 31 extending substantially parallel to the outer face of the wall 13 toward the axial line of the members 1 and 2. The outer face of the member 2 carries a pair of angle brackets 32, 32 defining a space 33 in which a sensitive snap action switch 34 is secured by screws 35 and 36, said switch having an outwardly urged, spring biased operating member comprising a plunger 37 disposed at right angles to the length of the arm 31 and yieldingly contacting the free end of said arm.

As pressure is applied to the diaphragm 11, it is moved away from the face 12 when the pressure and the force exerted by the spring 26 are sufficient to overcome the opposition offered by the Belleville spring. As the Belleville spring is collapsed by the pressure, the movement of the plates 15 and 16 with the movement of the diaphragm 11 moves the arm 30 with consequent rocking of the pin 29 through warping of the diaphragm 28 and resultant movement of the arm 31 to move the plunger 37 into the switch casing.

The switch may be any one of several types available for such use; the illustrated switch being similar to that described and claimed in my co-pending application Serial No. 433,390, filed in June 1, 1954, now Patent No. 2,748,215, granted May 29, 1956, and being a single pole double throw switch inherently biased for snap action movement in one direction and movable by snap action in the opposite direction by movement of the plunger into the casing to a predetermined extent. The switch illustrated differs from that shown in the said patent only in that the terminals are arranged for connection to leads by binding post screws instead of by soldered connections. Specifically, it includes fixed contacts C1 and C2 connected respectively to terminals T1 and T2 and a moving contact C3 carried by a resilient leaf L which is connected to the terminal T3. The leaf L is moved by snap action devices to effect contact between the contact C3 and one or the other of the fixed contacts by action of the leaf springs S1 and S2 which tend normally to move the

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plunger 37 outwardly and which are oppositely moved by inward movement of the plunger deriving from the imposition of increased pressure on the diaphragm and consequent snap action of the Belleville spring. The load of the springs S1 and S2 on the plunger and consequently imposed on the diaphragm, but due to uncontrollable differences in the individual springs, the loads thus imposed by seemingly identical switches varies to a greater extent than the range within which the present invention is required to operate. The mode of operation of the device and of compensating for these variations will be discussed in connection with the graphs constituting Figs. 11 through 14.

A representative wiring diagram is shown in Fig. 8 in which the switch is shown in its normal position as when the operating means is in the position shown in Figs. 4 and 9 in which the switch is connected to close a circuit including a signal light 38 and to energize a relay 39 for closing of a circuit which through motor M may operate a pump P or operate a valve to build up the pressure to a point at which the switch is operated to open that circuit and to close a circuit including a signal light 40 to indicate that pressure has been built up to the maximum again. If desired, the relay may be omitted and only the signal lights or other signal may be operated by the switch to indicate the pressure condition to an observer. So far as the present invention is concerned, the only requirement of the switch is that it shall be of such type that it can be operated by the movement of the arm 31 or its equivalent connected to the pin 29.

The action of the switch operating device is believed to be obvious. As the pressure rises, the diaphragm 11 gradually tends to flatten the Belleville spring to a point at which it moves by snap action through a considerable distance without increase in load and (depending on the extent to which it is coned) with an actual decrease in load carrying requirement. This action communicated to the switch 34 and causes it to partake of its snap action in opposition to its inherent bias and to open the circuit normally closed and close the circuit normally open. As the pressure drops, the diaphragm is moved back toward the face 12 of the member 1 by the Belleville spring 24 until the Belleville spring reaches its critical point in moving to its normal position whereupon, it moves by snap action to its normal position with consequent following movement of the switch 34. The details of the interaction of the Belleville spring and the associated coil springs will be referred to following description of the modified form of the device shown in Figs. 9 and 10.

Figs. 9 and 10 show a modification of the device shown in the preceding figures in that the associated and modifying coil spring is positioned at the opposite side of the diaphragm and combines with the Belleville spring to oppose the pressure imposed loading instead of combining with the pressure source to impose the loading on the Belleville spring. In this modification, the coil spring 26 and its abutment members 4 and 25 are omitted and the wall 13 of the member 2 is provided with an axially disposed, internally threaded sleeve 13' in which a coil spring 26' is disposed with one end bearing against the end of the arm 30 which is in engagement with the groove 19 and the opposite end bearing against a screw plug 41 disposed in the threaded sleeve 13' and by which the spring 26' may be caused to apply any desired initial loading on the diaphragm 11.

In both forms of the invention, after assembly of the device, it is subjected to pressure and the springs 26 or 26' are then adjusted until the device acts within the desired pressure range. The first described form of the invention has the disadvantage that the device must be disconnected for each adjustment until the final adjustment is attained, but thereafter the adjustment is sealed within the device and can not be tampered with. The second form of the device can be adjusted without re-

moval from the pressure source, but the adjusting means is not free from tampering. Since in the last described form of the invention the sleeve 13' protrudes into the space occupied by the switch 34 in the first form of the invention, the brackets 32', 32" are modified to position the switch at an angle and the switch operating arm 31' is disposed at a corresponding angle to effect operation of the switch. Any desired form for support of the device may be provided; an example being a bracket B fixed thereto by certain of the screws 10.

Having described the mechanism of the device, there remains to be described the manner in which the combined spring forces interact to achieve the novel result as shown in Figs. 11, 12, 13 and 14.

Referring first to Fig. 11, the graph shows a curve illustrating the required load-deflection curve in one embodiment of the invention. The pressure switch in question was required to operate in one direction in response to a total load of 12 pounds plus or minus 1.5% or 2.88 ounces. Upon reaching the required top load, the springs were required to move at least .018" to operate the switch in one direction and then at 11½ pounds load to again move at least .018" in the opposite direction to effect operation of the switch in the opposite direction; both of said movements to be of snap action character. The invention has been embodied in switch operating devices having other snap action load-deflection characteristics and the present illustration is selected as typical. Referring to the curve in Fig. 11, it will be noted that the deflection of the springs is gradual as the pressure load rises to 12 pounds and that at that point without further load increase, due to system pressure deriving from elasticity in the fluid under pressure or in the system or both, the springs move from a total deflection of .016" to .038" as represented by the upper line of the curve in this figure and the arrow pointing to the right on said line. As the pressure load decreases to about 11½ pounds the springs gradually deflects toward their former position, as indicated by the lower line of the curve and the arrows pointing to the left on said line, and at that point (about .028") it snaps back to a deflection of about .009" and remains there until the pressure load again builds up to 12 pounds. At this point, it should be mentioned that insofar as the term "snap action" is employed with reference to the movement of the Belleville spring and the switch, the term is intended to include all movements thereof in which the snap action springs partake of any considerable movement without significant change in the pressure applied load thereon at the time of the beginning of such movement whether such action be due to the elasticity of the fluid under pressure, the elasticity of the components of the system within which the fluid is contained, the bias imposed by the associated helical spring, the inherent resiliency of the snap action springs or any combination of such factors.

Coned disk springs (commonly known as "Belleville" springs) acquire a constant load deflection characteristic under which they partake of extended movement without increase in the applied load at about a height to thickness ratio (h/t) of 1.5:1. This tendency increases with the increase in that ratio until at about 2.75:1 the spring acquires a substantially complete snap action characteristic in which it practically reverses its initial form; the snap action portion of its load deflection curve sloping downwardly steeply.

The snap action switches used with the pressure responsive portion of the apparatus are spring biased to maintain either a normally open or a normally closed position or, in the case of a double throw switch, normally to maintain the contacts closed at one side of the throw of the switch, and upon application of sufficient force to the operating member to move by snap action to the other position and then upon release of the operating force to a predetermined extent to return to their normal position

by snap action. In commercial production of seemingly identical switches the input or actuating forces and the output or re-actuating forces (which are the forces exerted by the switch as it returns to normal position and which combine with the re-actuating forces of the Belleville springs as they too return to normal position) vary too widely to come within the tolerances within which the present invention is required to operate. This variance derives from differences in the individual actuating springs of the switches in which such factors as spring thickness, temper, work hardening, and the like as well as friction all contribute. As will be hereafter evident, the adjustable helical spring makes possible the compensation for these variations in the Belleville springs and the individual switches regardless of how they may happen to be combined in assembly.

The illustrated embodiments of the invention are concerned with a snap action characteristic which is as nearly a horizontal line as is possible without the possibility that the curve will at any time exceed a predetermined maximum load. For clearness of illustration, the curves in Figs. 12, 13 and 14 are those of a Belleville spring having a ratio h/t of 1.75:1 combined with the snap action forces of a switch; said forces being assumed to be those of a switch whose characteristics are substantially at the median point of the range of actuation and re-actuation forces of the switches employed; the said h/t ratio serving to permit the use of an associated helical spring of sufficient size and strength to be illustrated. As will be hereinafter evident, a Belleville spring of lesser h/t ratio might be used, but the helical spring would be so fine as to make illustration difficult.

Many factors enter into the actual deflection characteristics of Belleville springs initially calculated for a specific use, but chief among these is the thickness of the material from which they are formed. This factor varies the load-deflection characteristic in the order of the cube of the thickness of the material. In Fig. 12 there is shown a line B representing the load-deflection characteristics of a Belleville spring having a h/t ratio of 1.75:1 and formed of metal .016" thick. Such sheet metal is furnished with a commercial tolerance of plus or minus .001" which means that the material may vary from .015" to .017" in thickness; the former thus having a load-deflection resistance which is about 67% of the latter as shown by the dotted curves B' and B'', respectively. Other factors such as variations in work hardening in different areas on the surfaces of the sheet of metal and in the h/t ratio deriving from the extents to which individual springs spring back in the coning operation may combine with thickness variations to further increase this difference or these factors may oppose each other to varying extents. The net result is that Belleville springs cannot be made from sheet metal of existing commercial tolerances and be held within the close limits required by the present invention. Since material thickness variation is the factor producing the greatest variations in the springs, it has been selected for illustration of the compensating means by which through the principles of the present invention widely divergent Belleville springs combined with widely divergent snap action switch characteristics may be brought to act uniformly within closely defined limits as illustrated, by way of example, in Fig. 12 in which the desired range of action is between the lines R and R'.

Fig. 13 shows the interaction of a Belleville spring combined with an associated switch actuating spring and a supplementary adjustable helical spring when employed in the manner shown in Figs. 1 through 7. In this arrangement, the helical spring supplements the load imposed by the fluid pressure on the diaphragm but since the abutment for the spring is stationary, except as it may be adjusted, the proportion of the total load imposed on the diaphragm by the helical spring gradually decreases as the diaphragm is moved toward the outward limit of its travel by pressure of the system.

Since in this use of the combined springs the ultimate load is the combined force of pressure and of the helical spring, the Belleville spring must be calculated so that the weakest of the springs will have a load characteristic curve B which is greater than the correspondingly calculated Belleville spring for the desired load magnitude as indicated by the curve D. Thus, making allowance for the variations in material thickness above discussed, and again assuming the spring thickness to be .016", the springs formed from those portions of the material having a thickness of .015" will have a load-deflection curve B' while those formed from the portions of the material having a thickness of .017" will have a corresponding curve B". Since in this construction, the coil spring approaches zero value as the Belleville spring is compressed the graph is provided with an abscissa A representing zero value and the direct proportion curve representing the force exerted by the coil spring is located below this line.

The normal deflection curve of a spring represented by B' drops off rapidly as the snap action occurs and the actual load decreases; the rate of such decrease in its load-deflection characteristic being indicated by the line b' running at an angle a' to the abscissa A. Now, if this tendency to deflect is opposed by another spring having a direct proportion or straight line curve C representing a load-deflection rate that produces a lesser angle a'' with reference to the abscissa A and which assumes a constantly smaller proportion of the load imposed on the Belleville spring, the effect of the combined forces on the diaphragm may be plotted by first plotting the load-deflection curve and then on each ordinate of the graph, plotting the actual deflection of the Belleville spring by lowering each point of intersection of its original curve by the amount represented by the distance from the abscissa A to the curve C on that ordinate. Theoretically, it should be possible to match the angle a' with a spring having a deflection curve of equal, but opposite angle, but in practice there is always the chance that the individual Belleville springs might vary sufficiently so that the resultant curve of the combined springs showed an increasing load-deflection value, and in the present case, even if that were slight, it would be objectionable. By making the angle a'' slightly less than the angle a' , the resultant curve will be like that shown by the curve D which represents the desired type of load-deflection curve.

Next, assuming that the Belleville spring has load-deflection characteristics represented by the line B'', it is first of all evident that in general the load deflection curve is the same as B' in the area in which the action of the spring is desired as is also the line b'' corresponding to the line b', but is merely higher. It is then evident that by the expedient of axially adjusting the abutment against which the coil spring reacts to cause it to apply a greater initial load on the diaphragm, a point will be reached at which the load applied by the coil spring plus the pressure applied load will cause the Belleville spring to partake of its snap action movement at the same point as in the first described combination. In the graph, this adjustment is represented by moving the curve C to the right to the position represented by C', at which point the various intersections of the curve B'' with the ordinates of the graph when reduced by the distances between the abscissa A and the intersections of the curve C' on the same ordinates will result in the same curve D. Accordingly, regardless of the normal variations which will occur in the manufacture of Belleville springs, by the application of the principles of the invention, they can all be brought within a predetermined and very narrow range of action and that the range of deflection without material variation in the load resistance can be substantially increased.

Fig. 14 is a graph representing the application of the invention to the form of the invention shown in Figs. 9, 10 and 16, in which the pressure derived force is re-

sisted by the combined snap actions of a Belleville spring and snap action switch modified by another spring having a direct proportion curve.

In this graph, the line B again represents the same calculated Belleville spring as in Fig. 13, but since in this case the load-deflection action of the spring is supplemented by another spring, the actual springs produced will be such that the strongest of the Belleville springs will have a load deflection curve B'' that is slightly lower than the calculated load-deflection curve B, while the weakest of the Belleville springs will have a correspondingly lower but similar curve B'; the rates of deflection upon the occurrence of snap action being represented by the lines b' and b'', respectively; said lines being substantially parallel and being disposed at an angle a' to the abscissa A. Now, if in addition to the load-deflection resistance of the spring represented by B'', there is added a spring load having a direct proportion curve C of slightly lesser rate as represented by the angle a'' , the resultant deflection curve of the combined springs will be the result of adding to the curve B'' at each ordinate the distance between the abscissa A and the intersection of the curve C with the same ordinate. Thus, assuming the adjustment of the initial load on the spring to be such as to produce the curve D on this graph, the continuation of this combination or adding of values will produce the said line D. If the Belleville spring should have a minimum value as indicated by the curve B' in this graph the adjustment of the helical spring would be changed to increase the initial load on the diaphragm to the desired extent as represented by the line C' after which the two springs would operate in the same manner as indicated by the curve D.

With reference to both Figs. 13 and 14, it is appreciated that the projection of the curve D by combining the curves representing the related snap action springs and helical springs in the areas outside of the range of the desired snap action will produce anomalies. However, since the invention is concerned only with the obtaining of a desired snap action by "constant load" characteristics within predetermined limits, and since the principles of the invention will produce that result, any anomalies outside of the desired range of action may be disregarded.

While the foregoing discussion of the graphs has been directed to the effects of Belleville springs of different thickness and the compensation therefor, assuming that the switch springs therewith combined are identical and at the median point in their range of variation, it will be appreciated that it may also be assumed that the curves B, B' and B'' may equally well represent Belleville springs of identical characteristics combined with switch springs having higher, median and lower load-deflection characteristics with equal capability of being brought into the desired range of pressure response by appropriate adjustment of the associated helical spring. From this it follows that regardless of how the Belleville springs and switches may be combined in assembly and of the causes of individual variation in their characteristics, appropriate adjustment of the helical springs will bring the combined snap action into operative condition within the desired limits.

It is especially to be noted that important advantages derive from the disclosed constructions of the invention. The invention is especially designed for use on aircraft and other locations which are subject to vibration. It is essential that snap action switches be employed in order that contact breaking time be reduced to a minimum. Even this is not sufficient as will be apparent when the fact is that even in snap switches the gradual loading of the snap producing spring means gradually reduces contact pressure to zero value before the snap actually takes place. Under those conditions, chattering action of the contacts will occur and if the movement of the spring means is slow, the chattering may be prolonged. The present invention takes cognizance of

that problem and provides switch actuating means which responds to pressure changes with snap action and that snap action is transmitted to the spring biased actuating member of the snap action switch. By such a combination the switch contacts are maintained at operative contact pressure until a pressure change of predetermined magnitude has effected snap action of the pressure responsive means and that quick acting snap action is utilized to actuate the snap action switch. This reduces the contact breaking time to a very few milliseconds.

It is appreciated that in the light of the foregoing disclosure, changes and modifications will suggest themselves to others skilled in the art. Consequently, the invention is not to be deemed to be limited to the exact forms thereof above described by way of example, and it will be understood that the invention embraces all such changes and modifications in the parts and in the construction, combination and arrangement of parts as shall come within the purview of the appended claims.

I claim:

1. In a pressure responsive electric switch having snap action movement in one direction in response to a predetermined higher pressure and a snap action movement in the opposite direction in response to a predetermined lower pressure, a frame structure enclosing a chamber having an orifice affording means of connection of said chamber with a source of pressure, a diaphragm attached to said frame structure and forming a wall of said chamber operative to yield in response to pressure in said chamber, means engaging said diaphragm exteriorly of said chamber operative to yieldingly oppose pressure imposed loads on said diaphragm including a snap action spring reacting against a fixed abutment on said frame structure, a snap action switch carried by said frame structure and having a spring biased operating member, means extending between said diaphragm engaging means and said switch operating member effective to transmit movements of said diaphragm in response to imposed higher pressure to said switch operating member in opposition to the spring bias of said switch operating member, and means for compensating for variations in the combined load imposed on said diaphragm by said snap action spring and said spring biased switch operating member comprising a spring having a portion thereof engaging an adjustable abutment carried by said frame structure and another portion yieldingly exerting force against said diaphragm; the adjustment of said abutment being effective to determine the extent of force exerted against said diaphragm by said last named spring relative to the forces imposed thereon by said snap action spring and said spring biased switch operating member with resultant accurate determination by adjustment of said adjustable abutment of the point at which said diaphragm will respond by snap action to increase of pressure in said chamber.

2. A pressure responsive switch as claimed in claim 1 in which said snap action spring comprises a Belleville spring.

3. A pressure responsive switch as claimed in claim 1 in which said diaphragm engaging means includes a plate resting on said diaphragm and a Belleville spring interposed between said plate and said frame structure.

4. A pressure responsive switch as claimed in claim 1 in which said adjustable spring comprises a helical spring disposed within said chamber and mounted therein to oppose the bias imposed on said diaphragm by said snap action spring and said switch operating member.

5. A pressure responsive switch as claimed in claim 1 in which said adjustable spring is disposed exteriorly of said chamber and is interposed between said frame structure and said diaphragm engaging means effective to additively combine with said snap action spring and said switch operating member to oppose pressure imposed loads on said diaphragm.

6. A pressure responsive switch as claimed in claim 2 in which said adjustable spring comprises a helical

spring disposed in said chamber and mounted therein to oppose the bias imposed on said diaphragm by said snap action spring and said switch operating member.

7. A pressure responsive switch as claimed in claim 2 in which said adjustable spring comprises a helical spring disposed exteriorly of said chamber and is interposed between said frame structure to additively combine with said snap action Belleville spring and said switch operating member to oppose pressure imposed loads on said diaphragm.

8. A pressure responsive switch as claimed in claim 3 in which said adjustable spring comprises a helical spring disposed within said chamber and exerts force on said diaphragm in opposition to the bias imposed on said diaphragm by said plate through said Belleville spring and said switch operating member.

9. A pressure responsive switch as claimed in claim 3 in which said adjustable spring comprises a helical compression spring interposed between an adjustable abutment carried by said frame structure and said plate and additively combines with the bias of said Belleville spring and said switch operating member to yieldingly oppose pressure imposed loads on said diaphragm.

10. In a pressure responsive electric switch having snap action movement in one direction in response to a predetermined higher pressure and a snap action movement in the opposite direction in response to a predetermined lower pressure, a frame structure enclosing a chamber having an orifice affording means of connection of said chamber with a source of pressure, an element mounted for movement on said frame structure and forming a wall of said chamber operative to yield in response to pressure in said chamber, means engaging said element exteriorly of said chamber operative to yieldingly oppose pressure imposed loads on said element including a snap action spring reacting against a fixed abutment on said frame structure, a snap action switch carried by said frame structure and having a spring biased operating member, means extending between said element engaging means and said switch operating member effective to transmit movements of said element in response to imposed higher pressure to said switch operating member in opposition to the spring bias of said switch operating member, and means for compensating for variations in the combined load imposed on said element by said snap action spring and said spring biased switch operating member comprising a spring having a portion thereof engaging an adjustable abutment carried by said frame structure and another portion yieldingly exerting force against said element; the adjustment of said abutment being effective to determine the extent of force exerted against said element by said last named spring relative to the forces imposed thereon by said snap action spring and said spring biased switch operating member with resultant accurate determination by adjustment of said adjustable abutment of the point at which said element will respond by snap action to increase of pressure in said chamber.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,824,919

February 25, 1958

Allen V. C. Davis

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, lines 40 and 41, for "Figs. 9, 10 and 16" read -- Figs. 9 and 10 --; lines 45 and 46, for Figs. 4, 5, 6, 9 and 16" read -- Figs. 4, 5, 6 and 9 --; column 7, lines 74 and 75, for "Figs. 9, 10 and 16" read -- Figs. 9 and 10 --; column 4, lines 5 and 6, for "and consequently" read -- is constantly --; line 37, after "action" insert -- is --; column 5, line 38, for "deflects" read -- deflect --; line 41, for "it snaps" read -- they snap --; line 42, for "remanis" read -- remain --; column 8, line 54, for "repsonse" read -- response --.

Signed and sealed this 3rd day of June 1958.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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