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3,349,201

ELECTRICAL SWITCH WITH PHASED CONTACT OPERATION

Filed Feb. 1, 1966

2 Sheets-Sheet 1

Fig. 1

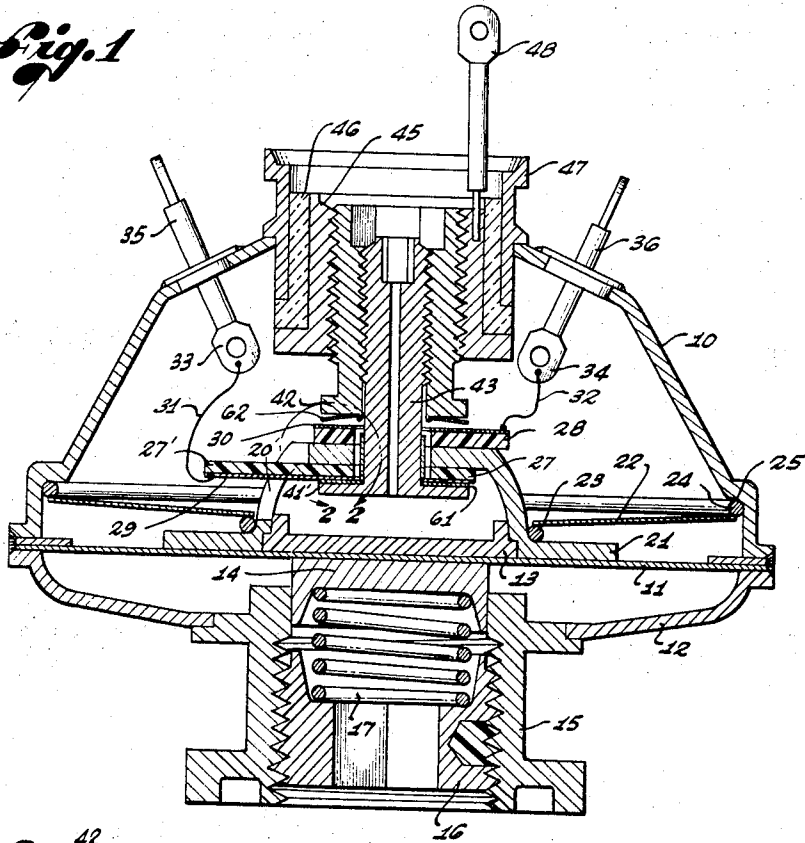


Fig. 2

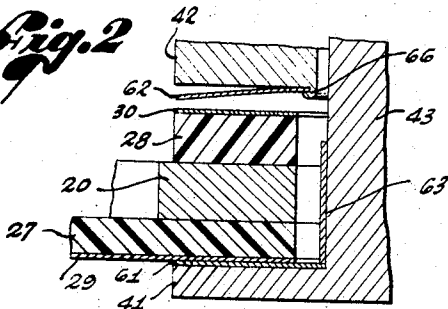


Fig. 3

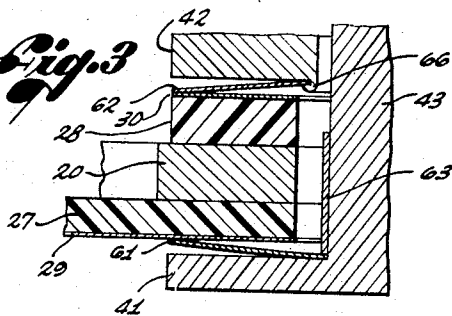
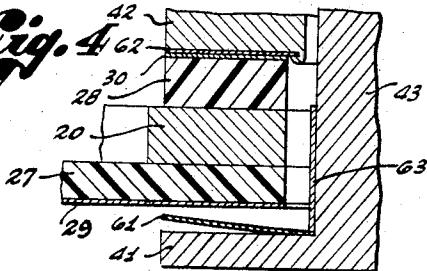


Fig. 4



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2 Sheets-Sheet 2

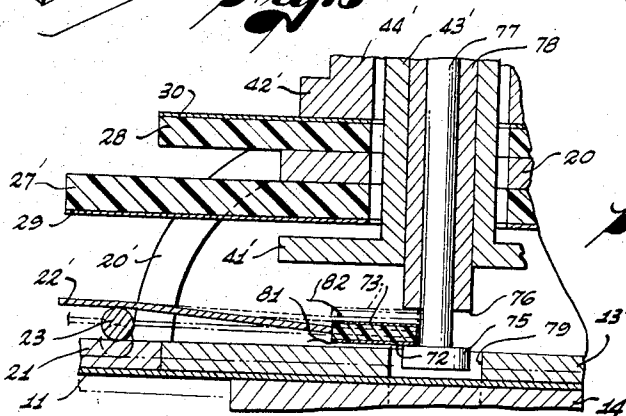
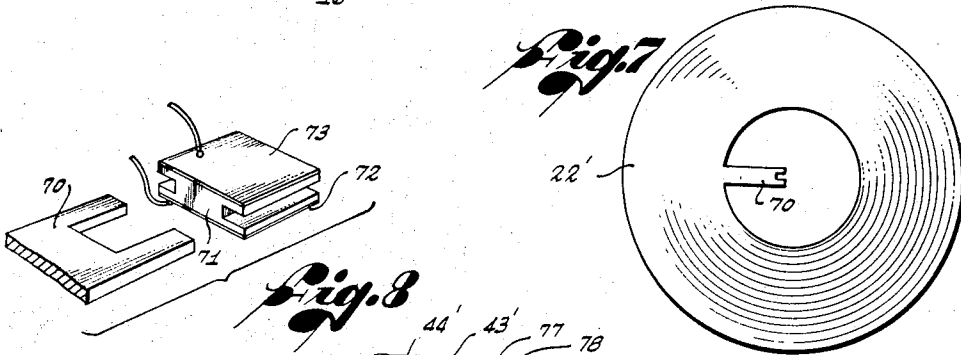
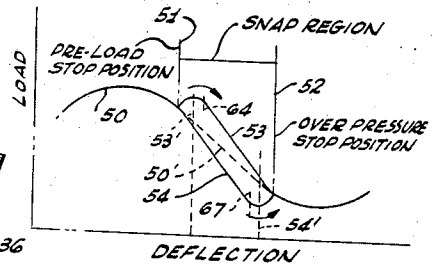
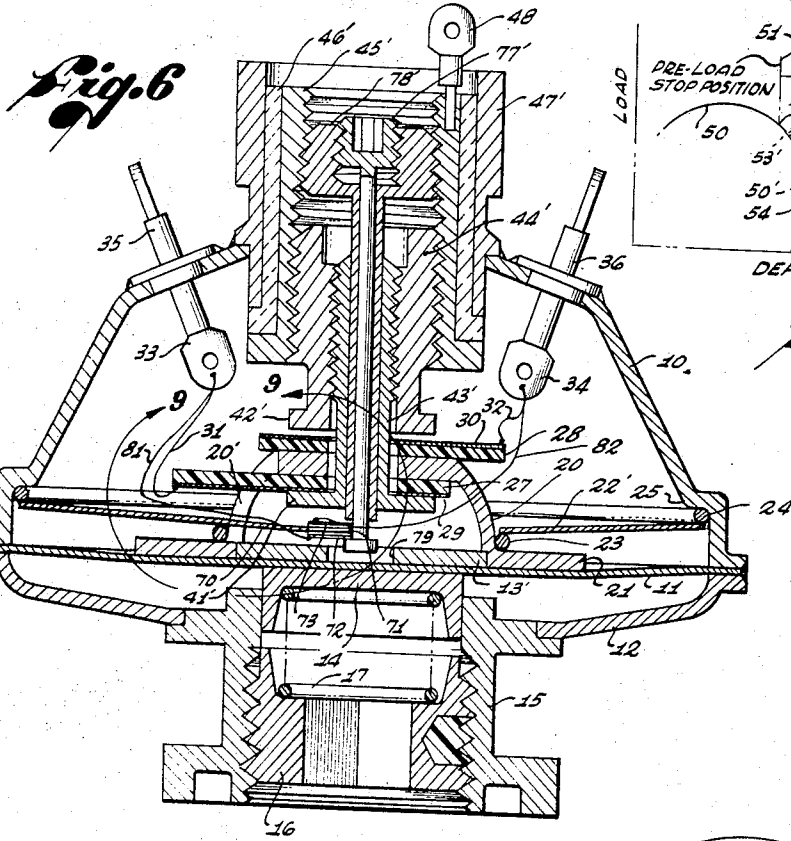


Fig. 9
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3,349,201
ELECTRICAL SWITCH WITH PHASED CONTACT OPERATION

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 6 Claims. (Cl. 200-67)

This invention relates to switch mechanisms of the type employing a snap-action spring for snapping movable electrical contacts between closely spaced stops, and more particularly to means to prevent undesired make-and-break operations during the initial movement of the spring from either position.

A typical switch of this type uses a preloaded disk spring known as a Belleville spring. The periphery of the spring is retained, and its center portion is able to undergo axial movement. A movable contact assembly is engaged by the center portion of the spring, and includes a pair of spaced electrical contacts for engaging respective fixed contacts at the stop positions.

The spring normally biases the movable assembly to one stop position in which one set of contacts is closed. By applying opposing pressure on the assembly which overcomes the bias, the center portion of the spring snaps the assembly to its other stop position. In this manner, the normally open contacts are closed substantially instantaneously upon opening of the normally closed contacts. Similarly, upon relieving the applied pressure, the spring instantly snaps the movable assembly back to restore the respective sets of contacts to their normally open and closed conditions.

The Belleville spring in such switches is restricted in its travel to the snap region, or negative spring rate portion, of its deflection load characteristic. However, there is a disadvantage in that, when the spring reverses its movement from a stopped position, there is a momentary departure from its normal negative rate load deflection characteristic. Such departure is characterized by a creep deflection of positive slope with pressure change preceding the sudden snap due to the negative rate of the spring.

During this creep deflection interval of the spring's movement, vibrations of the switch mechanism permit the contacts which are in the process of gradually opening to be subjected to rapid make-and-break operations. Such a situation, of course, is intolerable in applications which call for chatter-free and reliable switching operations.

It is an object of my invention to provide an improved pressure-actuated electric switch which substantially eliminates the possibility of unwanted make-and-break contact operations.

It is another object of my invention to provide, for an electric switch in which a Belleville spring effects travel of a movable contact, means to nullify the effect of creep deflection of the spring.

It is also an object of my invention to provide, for an electric switch having spaced contacts to be separated by snap action of a spring from respective stationary contacts, simple and inexpensive means for phasing the opening of one set of contacts and closure of the other set of contacts so as to avoid the possibility of both sets being open simultaneously.

The above and other objects and advantages of my invention will become apparent from the following description taken in conjunction with the accompanying drawings of illustrative embodiments thereof, in which:

FIGURE 1 is a longitudinal sectional view of an improved pressure-controlled electric switch in accordance with my invention;

FIGURE 2 is an enlarged fragmentary sectional view of a portion of the switch indicated at 2-2 of FIGURE

1, wherein one set of contacts is closed and the other is open;

FIGURE 3 is an enlarged fragmentary sectional view, like FIGURE 2, wherein the movable contacts are in transit, with my improved means for maintaining electrical connection between the separating contacts and phasing the break between them until the Belleville spring passes beyond its creep deflection;

FIGURE 4 is an enlarged fragmentary sectional view, like FIGURE 2, wherein the movable contacts have reached the over pressure stop position;

FIGURE 5 is an illustrative graph of a portion of the deflection load characteristic of the Belleville spring of the switch of FIGURE 1, to aid in explaining the invention;

FIGURE 6 is a longitudinal sectional view of a pressure-controlled electric switch having different means of my invention for phasing the break operations of the switch contacts;

FIGURE 7 is a top plan view of the Belleville spring used in the switch of FIGURE 6;

FIGURE 8 is an exploded view of the inner end of the tongue of the Belleville spring and the insulation block carried thereon which supports the phasing contacts; and

FIGURE 9 is an enlarged fragmentary sectional view of the portion of the switch indicated at 9-9 of FIGURE 6.

Referring to FIGURE 1, there is shown a pressure switch having a hollow housing or body 10 with an enlarged end covered by a thin, flexible diaphragm 11, and a hollow bonnet or cap 12. The peripheral edges of the housing 10, diaphragm 11 and cap 12 are secured together, as by welding.

Bearing against opposite sides of the diaphragm 11 are a pressure plate 13 and a bearing shoe 14. The plate 13 and the shoe 14 are oppositely biased. In this connection, the shoe 14 is slidable in a sleeve 15 that is secured within the center of the cap 12, and a screw member 16 is adjustably positioned in the outer end of the sleeve 15. A compression spring, shown as a helical spring 17, is located between the shoe 14 and the screw 16, so as to exert a predetermined load on the shoe 14.

Within the housing 10, the pressure plate 13 is locked in the open end of a cup element 20 which has a flange 21. As shown in FIGURE 1, the lower faces of the pressure plate 13 and the flange 21 are coplanar.

The pressure plate 13 is urged toward the shoe 14 by a control spring 22, which may be of the coned disk type known as a Belleville spring. As shown, a register ring 23 is located around the lower end of the cup 20 and adjacent the flange 21, and a second register ring 24 is positioned on a ledge 25 formed in the housing 10. As shown, the outer edge portion of the spring 22 bears against the register ring 24, and the inner edge portion of the spring bears against the register ring 23.

The upper end of the cup 20 carries a movable contact assembly which comprises a pair of rings 27, 28 of insulation material which are suitably secured, as with a bonding material, to the inner and outer faces of the upper end of the cup. The remote faces of the rings 27, 28 support metal contacts 29, 30 which may be layers of metal deposited on the rings.

As shown, the ring 27 within the cup 20 is provided with a radial finger or tab 27' that extends through an opening 20' in the side wall of the cup. The metal contact 29 on the ring 27 extends along the tab 27'. Externally of the cup, leads 31, 32 are soldered or welded to the contacts 29, 30, and extend to the inner ends of terminals 33, 34, which in turn extend through insulating supports 35, 36 to the exterior of the housing 10.

The pressure plate 13, the cup 20, the insulation rings 27, 28 and the contacts 29, 30 constitute a movable con-

tact assembly. Such assembly is limited to travel between stationary contacts 41, 42. As shown, the fixed contact 41 is constituted of the flange of an elongated metal rod 43 which extends through the contact assembly, and the fixed contact 42 is constituted of the flange of a metal screw member 44 which is threaded on the rod 43. As shown, the screw member 44 is threaded into a tapped metal sleeve 45. The sleeve 45 is secured to the housing 10, as by a glass insulation sleeve 46 bonded to the sleeve 45 and a surrounding metal sleeve 47 that is welded in the upper end of the housing 10.

Since the rod 43, the screw member 44 and the sleeve 45 are metal, the stationary contacts 41, 42 are conductively connected together. This assembly forms a common for the switch, the connection to which is provided by a terminal 48 that extends into the body of the sleeve 45.

As will be apparent, the positioning of the fixed contacts 41, 42 is initially effected by appropriate threading adjustments of the rod 43 and the screw member 44. Such adjustments are carried out in conjunction with adjustment of the screw 16 to effect the desired load supporting characteristics of the spring 22. The spring 17 is used as a trim device in securing the desired pressure settings, and is chosen such that its positive rate, together with the negative rate of the control spring 22, is additive to secure the desired composite force deflection characteristic for the entire switch assembly. For a more detailed description of such a trim device, reference may be made to my U.S. Patent No. 2,824,919, "Pressure Responsive Switch," issued Feb. 25, 1958.

Thus, the lower stationary contact 41 constitutes the preload stop position for the spring and the movable contact assembly. The other stationary contact 42 is so positioned that it is engaged by the other movable contact 30 when external fluid pressure and that force applied on the shoe 14 causes the spring 22 to snap upwardly. The upper stationary contact 42 also functions as a stop to prevent damage to the diaphragm, i.e., an over pressure stop position for the spring and movable contact assembly.

As previously explained, movement of the spring 22 from either of its stop positions is characterized by a creep deflection immediately preceding its snap action. Referring to FIGURE 5, which shows a portion of the deflection load characteristics 50 of the spring, the preload and over pressure stop positions are indicated along lines 51, 52 between which a Belleville spring would be expected to exhibit a purely negative spring rate in the snap region 51, 52, characterized by dotted negative slope portion 50' of the characteristic. However, when the spring is started from the preload stop position—by applying sufficient fluid pressure to the diaphragm 11 along with the force exerted by the biased shoe 14—its deflection load characteristic in the snap region is characterized by a curve 53 which has a positive slope during the initial part of the spring travel, such curve 53 reaching a peak 53', and then becoming negative. The point at which the spring snaps is that at which the curve 53 passes the peak 53' and enters the negative region thereof. The positive spring rate exhibited prior to the peak 53' is illustrative of the creep deflection preceding snap action, and may be appropriately called roll-off, or creep.

After the spring has snapped to the over pressure stop position, i.e., where the normally open contacts 30, 42 are closed, reducing fluid pressure on the diaphragm 11, the pressure on the shoe 14 is sufficiently below that which precipitated the snap action, again results in a curve 54 which, like the curve 53, exhibits a positive spring rate that reaches a maximum 54' before the spring snaps back to the preload stop position to again close the normally closed 29, 41 contacts.

During these initial movements of the spring from either stop position, i.e., when it is exhibiting a positive spring rate, vibrations are effective to cause contact chatter, i.e., wherein the contacts are rapidly made and

broken. To avoid this condition, auxiliary flexible contacts are provided in the form of light leaf springs 61, 62, which are attached to and therefore conductively connected to the fixed contacts 41, 42.

As shown in FIGURES 1-4, the leaf springs 61, 62 are formed as coned disks. As best seen in FIGURE 4, the leaf spring 61 is placed around the rod 53, with its inner edge held against the fixed contact by a sleeve 63 that is secured on the rod 43. At the preload stop position 51 of the control spring 22 (FIG. 5), the outer edge of the leaf spring 61 is sandwiched between the fixed contact 41 and the movable contact 29 (see FIG. 2). However, upon movement of the movable contact assembly away from the fixed contact 41, the outer edge of the leaf spring 61 (see FIG. 3) follows and maintains contact with the movable contact 29 until the control spring 22 is in the negative region of the curve 53 (FIG. 5).

Thus, the leaf spring 61 effectively maintains electrical contact between the separating contacts 29, 41 throughout the creep deflection interval of the control spring 22. The possibility of unwanted make-and-break operations of the contacts 29, 41 are avoided, because conductive connection between them is maintained until the control spring enters the negative region of the curve 53 and snaps. The snap, of course, effects clean separation of the movable contact 29 from the leaf spring 61, and avoids any possibility of unwanted make-and-break operations between them.

In this latter connection, I prefer to have the leaf spring 61 follow the movable contact 29 past the peak 53' of the curve 53 and into the negative region thereof, e.g., as to a point along a line 64 which is spaced from the peak 53' a sufficient distance to insure that the Belleville spring is already undergoing its snap action.

The leaf spring 62 is arranged to operate in the same manner with the movable contact 30. As shown in FIGURES 2-4, the inner edge of the leaf spring 62 is anchored to the fixed contact 42 by means of a small axial extension of the screw member 44 that is turned over against the inner edge of the leaf spring 62, as indicated at 66. As shown in FIGURE 4, the leaf spring 62 is sandwiched between the movable contact 30 and the fixed contact 42 in the over pressure stop position. On decreasing the fluid pressure to allow the control spring 22 to return the contact assembly to the normally closed position of the contacts 29, 41, the leaf spring 62 follows the movable contact 30 (FIG. 3) past the peak 54' (FIG. 5) of the creep deflection, and preferably into the negative region of the curve 54, as illustrated by line 67, thereby avoiding undesired make-and-break operations of the separating contacts 30, 42. The operation of the leaf spring 62 in this respect is identical to that of the leaf spring 61 previously described.

As will now be apparent, the leaf springs 61, 62 are auxiliary contacts which function to "phase" the opening of their associated main contacts while the deflection load characteristic of the control spring changes from a positive to a negative spring rate upon leaving a stop position. To accomplish the desired results, the phasing contacts are made with a sufficiently high ratio of stiffness to weight so as to enable them to possess a high natural frequency so that, during separation of associated contacts, there is no possibility that vibrations will cause separation of the phasing contact from the movable contact during the critical period.

A highly desirable advantage of a switch with phasing contacts in accordance with my invention is that such contacts may be constructed to act as small negative rate springs. In such case, they tend to neutralize the initial positive rate of the Belleville spring that carries the contact assembly, and reduces the amount of roll-off travel of the Belleville spring.

Another advantage of the arrangement of the contacts in accordance with my invention is that they permit one set of contacts to be closed before the other set of contacts

is opened. Such make-before-break operation is illustrated in FIGURE 3, wherein the phasing travel of the leaf springs 61, 62 is sufficiently long so as to establish electrical connection via the leaf spring 62 between the contacts 30, 42 while the separating contacts 29, 41 are still in electrical contact via the leaf spring 61. Such make-before-break operations are highly desirable when it is required that there must be no time delay between connections to or operations of circuits connected to the respective sets of contacts.

Another form of my invention is illustrated in FIGURES 6-9. In this embodiment, the phasing leaf contacts 61, 62 of FIGURES 1-4 are not used. Phasing is accomplished directly by a Belleville spring 22', which differs from the Belleville spring 22 of FIGURE 1 in that (see FIGURE 7) it is provided with an integral radial tongue 70 extending inwardly of its central opening. As shown in FIGURE 6, the tongue 70 extends through the opening 20' in the side wall of the cup 20. Fitted on the inner end of the tongue 70 is an insulating block 71 (see FIGURE 8) which has contacts 72, 73 in the form of metal layers deposited on its opposite faces. Any suitable means may be employed to attach the block 71 to the tongue 70, e.g., by providing the tongue 70 and block 71 with mating rails and grooves.

The assembly of the tongue 70, the block 71 and the contacts 72, 73 constitute an auxiliary movable contact assembly. The contacts 72, 73 are movable between auxiliary stationary contacts 75, 76 located within the cup 20 adjacent the main stationary contact 41'. (The same numbers are used to designate parts in FIGURES 6-9 which are identical to those in FIGURES 1-4. Where parts in FIGURES 6-9 are similar and correspond to parts shown in FIGURES 1-4, primes of the corresponding numbers are used.)

The spacing of the stationary contacts 75, 76 preferably is adjustable, and to this end the lower contact 75 is constituted of the flange of an elongated rod 77 that extends through the center of the rod 43', and the contact 76 is constituted of the lower end of a sleeve 78 surrounding the rod 77 and extending through the rod 43'. At its upper end, the sleeve 78 is provided with an enlarged threaded head 78' that is screwed into the thread insert 45'. Similarly, the upper end of the rod 77 is provided with a threaded head 77', which is screwed into the head 78' of the sleeve 78. As will be apparent, the auxiliary stationary contacts 75, 76 are located in the desired positions and spaced apart the desired distance by approximate adjustments of the heads 77', 78'. In this connection, space limitations may require that the pressure plate 13' be provided with a central opening 79 to form a space into which the stationary contact 41' may be moved.

Inasmuch as the movable contacts 29, 30 and 72, 73 are physically separated, electrical connections are provided between the corresponding movable contacts 29, 72 and 30, 73. To this end, a lead 81 is connected between the auxiliary movable contact 72 and terminal 33, and a lead 82 is connected between the auxiliary movable contact 73 and terminal 34. It will be appreciated that the travel of the various parts is quite small, e.g., of the order of a few thousandths of an inch, so the various leads 31, 32, 81, 82 can undergo such small movement without damage or interference with any other parts.

FIGURE 9 illustrates the operation of the auxiliary movable contact assembly 71-73 upon movement of the main movable contact assembly 27-30 from the lower stationary contact 41' to the upper stationary contact 42'. The desired phasing is accomplished by virtue of the different spring movement of the tongue 70 and the main body of the control spring 22'. Referring to FIGURE 9, these differences in deflection are manifested by movement of the body of the control spring 22' into its snap region before the auxiliary movable contact assembly 71-73 starts its upward movement to effect separation of the movable contact 72 from the stationary contact 75.

As in the case of the leaf spring contact 61, 62 of the embodiment of FIGURES 1-4, the contact 72 dwells on the contact 75 at least until the control spring 22' is in the negative portion of its snap region. The snap of the control spring 22' in this instance not only avoids the possibility of unwanted make-and-break operations between the contacts 29, 41', but also causes the auxiliary contact assembly 71-73 to snap from the lower contact 75 to the upper contact 76. The phasing travel of the auxiliary contact assembly is determined by the lever effect of the tongue 70.

The auxiliary movable and fixed contacts cooperate in the same way during the return movement of the Belleville spring 22'. Thus, the movable contact 73 is caused to remain in engagement with the auxiliary stationary contact 76 until the main body of the Belleville spring 22' has moved into the negative spring rate portion of its snap region.

From the foregoing, it will be apparent that various modifications can be made in the illustrative embodiments shown and described herein without departing from the spirit and scope of my invention. Accordingly, I do not intend that my invention be limited, except as by the appended claims.

I claim:

1. Switch apparatus comprising:
 - a housing (10);
 - stationary and movable contacts (41, 29 of FIGS. 1-4; 41', 29' of FIGS. 6-9 in said housing;
 - a support member (20) for said movable contact movable toward and away from said stationary contact;
 - a preloaded disk spring (22, 22') having laterally spaced, relatively fixed and axially movable portions, the movable portion of said disk spring engaging said support member (20) and operable when moved to cause said movable contact to make and break contact with said stationary contact;
 - a stop member (41 of FIGS. 1-4; 41' of FIGS. 6-9), said movable portion of said disk spring normally biasing said support member so that said movable contact engages said stationary contact, said disk spring throughout a predetermined distance of movement to the movable portion thereof from said stop member having a deflection load characteristic that deviates from normal and includes a positive slope preceding a negative slope;
 - follower spring means including an auxiliary contact element (61 of FIGS. 1-4; 72 of FIGS. 6-9);
 - a conductive connection (63 of FIGS. 1-4; 31, 81 of FIGS. 6-9) between said auxiliary contact element and one of said stationary and movable contacts; and means biasing said auxiliary contact element into engagement with the other of said stationary and movable contacts throughout said predetermined distance (cone shape of leaf spring 61 of FIGS. 1-4; tongue 70 of disk spring 22' in FIGS. 6-9).
2. Switch apparatus as defined in claim 1, including:
 - a second stationary contact and a second movable contact (30, 42 of FIG. 1-4; 30, 42' of FIGS. 6-9) both movable contacts being supported for movement in unison and insulated from each other;
 - said follower spring means including a second auxiliary contact element (62 of FIGS. 1-4; 73 of FIGS. 6-9);
 - a further conductive connection (66 of FIGS. 1-4; 32, 82 of FIGS. 6-9) between said second auxiliary contact and one of said second stationary and movable contacts;
 - a second stop member (42 of FIGS. 1-4; 42' of FIGS. 6-9), said movable portion of said disk spring upon moving from the first stop member operating said support member to bring said second movable contact into engagement with said second stationary contact,

said disk spring throughout a second predetermined distance of movement of said movable portion thereof away from said second stop member having a deflection load characteristic that deviates from normal and includes a positive slope preceding a negative slope;

and means operable during movement of said second movable contact away from said second stationary contact to bias said second auxiliary contact into engagement with said second stationary and movable contacts through said second predetermined distance (cone shape of spring 62 of FIGS. 1-4; tongue 70 of spring 22' of FIGS. 6-9).

3. Switch apparatus as defined in claim 2, wherein each auxiliary contact element is a metal leaf (61, 62 of FIGS. 1-4) sandwiched between the associated stationary and movable contacts upon engagement thereof, wherein the associated conductive connection is formed of a portion of said leaf attached to the one contact, said portion of said leaf being frusto-conical and having a negative spring rate substantially less than that of said snap spring.

4. Switch apparatus as defined in claim 2 wherein said metal leaves are attached to the respective stationary contacts.

5. Switch apparatus as defined in claim 1, wherein said auxiliary stationary contact (75 of FIGS. 6-9) is spaced from and conductively connected to said stationary contact, said disk spring including an auxiliary spring element (tongue 70), said auxiliary contact element being mounted on said auxiliary spring element (71, 72), said auxiliary spring element normally biasing said auxiliary contact element against said auxiliary stationary contact while said movable contact is biased against said stationary contact, a conductive connection (31, 81) between said movable contact and said auxiliary contact element, and said snap spring and said auxiliary spring element coacting to permit said auxiliary contact element to remain in engagement with said auxiliary stationary contact throughout said predetermined distance.

6. Switch apparatus as defined in claim 1, including

a second pair of stationary and movable contacts (30, 42' of FIGS. 6-9), the two movable contacts being movable in unison between said stationary contacts;

said disk spring normally biasing said movable contacts so that one movable contact (29) is normally urged against its stationary contact (41');

a pair of spaced auxiliary stationary contacts (75, 76) spaced from and conductively connected to each other and to both of the stationary contacts of said first and second pairs;

a pair of spaced auxiliary movable contacts (72, 73) movable between said auxiliary stationary contacts; said disk spring carrying an auxiliary spring element (tongue 70) for moving said auxiliary movable contacts between said auxiliary stationary contacts, said auxiliary movable contacts being conductively connected to the corresponding movable contact of said first and second pairs, and said disk spring and auxiliary spring element coacting to cause the auxiliary movable contacts to remain in engagement with the associated auxiliary stationary contacts throughout said predetermined distances.

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