# PATENT SPECIFICATION

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689,454

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COMPLETE SPECIFICATION

## Improvements in Snap Action Electric Switches

We, NATIONAL RESEARCH DEVELOPMENT CORPORATION, a British Corporation, established by Statute, of 1, Tilney Street, London, W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

In snap-action electric switches it is desirable when the switch is operated that there is no decrease in contact force until the snap motion in actually initiated. It is the object of the present invention to provide an improved form of switch in which the application to the switch blade of the operating force causes an initial rise in the contact force between the contacts to be broken.

More particularly the invention is concerned with a snap-action switch of the kind comprising a blade system which carries, or itself forms, a movable contact or contacts, and which is arranged in compression between its ends so as to be bowed freely therebetween, the disposition of the contact assembly being such that through a change in the bow formation upon the application to the blade system laterally at or near one end thereof of the operating force an initial rise in the contact pressure is caused between the contacts to be broken, and wherein the contact assembly is disposed not more than one quarter of the blade length away from the end of the blade remote from the point or anchorage to or near which the operating force is applied.

According to the present invention a switch of the kind hereinbefore referred to is modified in that the blade system consists of two blades mounted together between two anchorages and mechanically coupled at or near one end, the operating force being applied to the opposite end of one blade and the other blade carrying, or itself forming, the movable contact or contacts disposed not more than one quarter of the length of said blade away from the anchorage end thereof remote from its said coupled end.

As a preliminary to the understanding of the invention, reference is made initially to Figures 1 to 7, 9 and 9a of the drawing left with the provisional specification.

Reference will be made later herein to Figure 8 which illustrates a construction embodying the invention.

Referring now to the drawing left with the provisional specification it will be observed that in all the figures a blade system is supported between two anchorages. These may be adjustable and may take the form described in British Patent Specification No. 617,076, in which case they are intended to remain locked in position once they have been adjusted to their correct angular disposition. The switch is operated by the application to the blade of forces such as F (Figures 1 and 2) causing the blade to adopt the configuration shown in Figure 3.

Figures 1 to 5 show the two ends of the blade spring set in line. This alignment, however, is not essential to the proper functioning of the switch. For instance, if both ends of the blade are twisted in opposite directions (as in Figure 9) and then locked, a snap action is obtained but the switch develops a non-locking property, the blade tending to return to the configuration of Figure 9 when the operating force is removed.

Again, if the two ends of the blade of Figure 1 are turned in the same direction, the non-locking effect disappears, and the snap action is still retained, but the force required to operate the switch is reduced

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(Figure 9a). As explained in the Specification No. 617,076 such twists in the same sense applied to the two anchorages (which are then locked in position) will reduce the positive stiffness of the blade until when the twists are large enough a point is reached at which the blade has zero stiffness. At this point the snap effect disappears.

Adjustment of the angles of twist of the anchorages therefore provide a means of varying the bias of the switch action (locked or non-locking) and the force required to operate the switch, which is directly related to the forces between the blade and the contacts on which it is designed to bear.

If an external force F is applied at a point $X_1$ to a blade set as in Figure 1, movement of $X_1$ to $X_2$ causes movement of a point $C_1$, at the remote end, to $C_2$. Thus, if X moves downwards C moves upwards. This is true so long as C lies in approximately the last quarter of the blade. Moreover it is found that a certain point in the blade in this quarter will have the property that when X reaches $X_3$, which is shown in Figure 2 and is on the line of centres, C reaches $C_3$ which is coincident with $C_1$ or lies between $C_1$ and $C_2$.

Now when X has reached $X_3$ the stiffness measured at X passes through zero to negative and the blade flies over to the shape shown in Figure 3 with X at $X_4$ provided there is no restraint to the motion of X.

It follows therefore that if the contact is provided to bear on the blade in position $C_1$ with a certain contact force $f_1$, the initiation of the operation of the switch by the application of a force F will cause the contact force $f$ to increase, and further that $f$ will not fall below the value of $f_1$ under the snap motion initiated by X reaching $X_3$.

These are highly desirable properties in a snap-action switch.

It follows of course that if the force F continues to be applied at $X_1$ after the blade has snapped over, $X_1$ will move to $X_5$ (Figure 4) and $C_4$ to $C_5$. Should the switch be of the change-over type with a second contact set to bear on the blade at $C_4$ the result would be a lowering of the contact force at $C_4$ which is undesirable.

This may be avoided in three ways. In the first, the lever (dolly) which operates the switch can be provided with stops which prevent this motion from $X_4$ to $X_5$. In the second, as it is necessary to obtain rapid snap action to allow $X_3$ to move freely towards $X_4$, the lever has an extension which, while embracing the blade at X, will do so with some clearance, this clearance, combined with the stops referred to, preventing movement from $X_4$ to $X_5$. In the third, a subsidiary spring member, e.g. a blade or a coil spring, may be provided which tends to force the dolly towards the central position. This spring has two valuable effects; it removes the slack in the dolly pivots and it applies to the blade, when in either of its rest positions, a force which tends to increase the contact force $f$ at either position $C_1$ or $C_4$.

Figure 6 is a side view of the blade spring shown in plan in Figure 1. It will be seen that the extension S, which engages with the operating lever, is made in one piece with the main blade, which is rivetted to anchorages A and B at each end. The blade S engages tightly with the operating lever, and the latter embraces the main blade with some clearance as explained.

The effects described above can be obtained with an alternative method of construction in which the anchorage A, adjacent to the operating lever, is allowed to rotate when the blade is caused to deflect. This however, demands freedom of motion of the anchorage A, which is under some side thrust; this is therefore not a preferred construction. A modification of this arrangement consists in applying the force F as a twist to the anchorage itself, thus overcoming initial friction.

To obtain extremely rapid changeover the arrangement of Figure 5 may be used. Here the two ends of the blade again are anchored but the centre of the blade is restrained between two pins $P_1$ and $P_2$ which allow the blade to slide readily. The pins $P_1$, $P_2$ may be displaced upwards or downwards on the diagram to give " locking " action to the switch and may be displayed to the left or right to modify the speed of the snap action. The same general effects are obtained, $C_1$ moving to $C_2$ as X moves from $X_1$ to $X_2$ under the influence of the operating force F. But in this case there are two snap actions, one on each side of the pins $P_1$, $P_2$: the right-hand side cannot snap over until the left-hand side has operated. Thus the right-hand side which carries the contacts at $C_1$ will receive a sharp initiating impulse when the left-hand side snaps over, thus being carried very rapidly up to its own unstable point, then forced to snap over. In this construction any tendency for the contact resistance to fluctuate as the point C changes position against the fixed contact, causes resistance changes which can exist only for a very short time indeed.

In connection with switches of the so-called micro-gap type, it is necessary that the traverse of the point C between its "on" and "off" position is very small (say 0.020 inch). At the same time it is desirable to retain a fairly large "bow" on the main blade in order to give a large angular motion of the dolly. If the blade were of uniform width these two requirements might lead to the placing of C very close to B with several consequent manufacturing difficulties. These can be avoided by increasing the width of the blade near to B as shown in Figure 7. The distance between B and C can now be increased while maintaining the traverse of C at 0.020 inch for the following reason. That part of the blade which has been widened will be stiffened in proportion. The forces developed on this stiffer part of the blade when the switch is operated will be of the same order as before, and therefore the deflection at a given distance from the support B in Figure 7 will be reduced. But by setting C further from B the desired small displacement is restored. As a result, small errors in the location of C will have little effect on the traverse and adequate space is available for the fixed contacts.

Figure 8 shows a construction of the kind hereinbefore referred to and modified in accordance with the invention. In this side elevation A and B are fixed anchorages between which the blades $D_1$, $D_2$ are secured as shown in plan in Figure 1. Operating forces are applied to $D_1$ at X. When $D_1$ snaps over it pulls blade $D_2$ with it by virtue of the bridge piece P, the blades and bridge piece being punched out in one piece. It will be seen that the force exerted by $D_1$ on $D_2$ will depend on the distance *a*. In manufacture the clearance between B and P is adjustable and set by a suitable jig to confer on the assembly the right performance characteristic.

It is to be noted that the initial movement of $D_1$ will at first cause a very small pull on $D_2$ since P is merely flexed sideways, but as $D_1$ moves further P comes into tension and drags $D_2$ with it. But $D_2$ will not move very far before the blade $D_1$ snaps over; hence $D_2$ does not receive its major operation force until $D_1$ has already started to move at high velocity. This results in extremely rapid operation of $D_2$ which is entirely unaffected by any residual pressure applied to $D_1$ by the hand operating the switch dolly. The anchorage B may rotate and P be removed, or B may be fixed, the upper half of A be fixed and the lower half attached to $D_1$ be allowed to rotate.

What we claim is:—

1. A switch of the kind herein referred to, modified in that the blade system consists of two blades mounted together between two anchorages and mechanically coupled at or near one end, the operating force being applied to the opposite end of one blade and the other blade carrying, or itself forming, the movable contact or contacts disposed not more than one quarter of the length of said blade away from the anchorage end thereof remote from its said coupled end.

2. A switch as claimed in claim 1, substantially as described with reference to Figure 8 of the drawings herein referred to.

S. W. SLAUGHTER,
Agent for the Applicants.

PROVISIONAL SPECIFICATION

## Improvements in Snap Action Electric Switches

We, NATIONAL RESEARCH DEVELOPMENT CORPORATION, a British Corporation, established by Statute, of 1, Tilney Street, London, W.1, do hereby declare the nature of this invention to be as follows:—

It has already been proposed to provide a snap-action switch in which the blade consists of a "sine-spring" set to have a negative stiffness when the middle of the blade lies in a position of symmetry between its two anchorages. The proposal was made either that one of the sine-spring anchorages should be rotated to cause the switch blade to snap from one contact to the other, or alternatively, that the blade, held in fixed anchorages, should be caused to move by the pressure of the operating lever (or "dolly") upon a part of the spring blade lying between the anchorages.

The present invention can be applied to either of these two basic constructions: although it concerns primarily the disposition of the electrical contacts against which the blade is forced by the movements of the "dolly," and also the provision of additional restraints on the blade.

We have found that it is advantageous to dispose these contacts near the end of the blade remote from the point at which the operating force is applied, e.g. at a position not more than about one quarter of the blade length away from the remote anchorage.

A number of examples of switches made in accordance with the present invention are illustrated diagrammatically in the accompanying drawing.

In the examples illustrated, the two anchorages are intended to be and remain locked in position once they have been adjusted to the correct angular disposition. External forces such as F (Figure 1) due to the movement of the switch "dolly" will cause the blade to move as shown in Figures 2 and 3.

Figures 1 to 5 show the two ends of the blade spring as being set in line within each other although such exact alignment is not essential to the proper functioning of the switch. For instance if both ends of the blade are twisted in opposite directions (as in Figure 9) and then locked a snap-action is obtained but the switch developes a non-locking property, the blade tending to return to the conformation of Figure 9 when the operating force is removed.

Again if the two ends of the blade of Figure 1 are turned in the same direction, the non-locking effect disappears, and the snap action is still retained, but the force required to operate the switch is reduced (Figure 9a). As explained in Patent Application No. 32770/45 (Serial No. 617,076) such twists of the same sense applied to the two anchorages (which are then locked in position) will reduce the stiffness of the blade until when the twists are large enough a point is reached at which the blade has zero stiffness. At this point the "snap" effect disappears.

Adjustment of the angles of twist of the anchorages therefore provides a means of varying the bias of the switch action (locking or non-locking) and the force required to operate the switch, which is directly related to the forces between the blade and the contacts on which it is designed to bear.

If an external force F is applied at a point $X_1$ to a blade set as Figure 1, movement of $X_1$ to $X_2$ causes movement of a point $C_1$, at the remote end, to $C_2$. Thus if X moves downwards C moves upwards. This is true so long as C lies in approximately the last quarter of the blade. Moreover it is found that a certain point in the blade in this quarter will have the property that when X reaches $X_3$, which is shown in Figure 2 and is on the line of centres, C reaches $C_3$ which is coincident with $C_1$ or lies between $C_1$ and $C_2$.

Now when X has reached $X_3$ the stiffness measured at X passes through zero to negative and the blade flies over the shape shown in Figure 3 with X at $X_4$ provided there is no restraint to the motion of X.

It follows therefore that if a contact is provided to bear on the blade in position $C_1$ with a certain contact force $f_1$, the initiation of the operation of the switch by the application of a force F will cause the contact force $f$ to increase, and further that $f$ will not fall below the value of $f_1$ until the "snap" motion is initiated by X reaching $X_3$.

These are highly desirable properties in a snap-action switch.

It follows of course that if the force F continues to be applied at $X_4$ after the blade has snapped over, $X_4$ will move to $X_5$ (Figure 4) and $C_4$ to $C_5$. Should the switch be of the change-over type with a second contact set to bear on the blade at $C_4$ the result would be a lowering of the contact force at $C_4$ which is undesirable.

This may be avoided in three ways. In the first, the lever (dolly) which operates the switch can be provided with stops which prevent this motion from $X_4$ to $X_5$. In the second, as it is necessary, to obtain rapid snap action, to allow $X_3$ to move freely towards $X_4$, the lever has an extension which, while embracing the blade at X, will do so with some clearance, this clearance, combined with the stops referred to, preventing movement from $X_4$ to $X_5$. In the third, a subsidiary spring member, e.g. a blade or a coil spring, may be provided which tends to force the dolly towards the central position. This spring has two valuable effects: it removes the slack in the dolly pivots and it applies to the blade, when in either of its rest positions, a force which tends to increase the contact force $f$ at either positions $C_1$ or $C_4$.

Figure 6 is a side view of the blade spring shown in plan in Figure 1. It will be seen that the extension S, which engages with the operating lever, is made in one piece with the main blade, which is rivetted to anchorage A and B at each end. The blade S engages tightly with the operating lever, and the latter embraces the main blade with some clearance as explained.

The effects described above can be obtained with an alternative method of construction in which the anchorage A, adjacent to the operating lever, is allowed to rotate when the blade is caused to deflect. This however demands freedom of motion of the anchorage A, which is under some side thrust; this is therefore not a preferred construction. A modification of this arrangement consists in applying the force F as a twist to the anchorage itself, thus overcoming initial friction.

To obtain extremely rapid changeover the arrangement of Figure 5 may be used.

Here the two ends of the blade again face each other but the centre of the blade is restrained between two pins $P_1$ and $P_2$ which allow the blade to slide readily. The pins $P_1$, $P_2$ may be displaced upwards or downwards on the diagram to give "locking" action to the switch and may be displaced to the left or right to modify the speed of the snap action. The same general effects are obtained, $C_1$ moving to $C_2$ as X moves from $X_1$ to $X_2$ under the influence of the operating force F. But in this case there are two snap actions, one on each side of the pins $P_1$, $P_2$: the right-hand side cannot snap over until the left-hand side has operated. Thus the right-hand side which carries the contacts at $C_1$, will receive a sharp initiating impulse when the left-hand side snaps over, thus being carried very rapidly up to its own unstable point, then forced to snap over. In this construction any tendency for the contact resistance to fluctuate as the point C changes position against the fixed contact, causes resistance changes which can exist only for a very short time indeed.

In the application of this invention to switches of the so called "micro-gap" type, it is necessary that the traverse of the point C between its "on" and "off" position is very small (say 0.020 inch). At the same time it is desirable to retain a fairly large "bow" on the main blade in order to give a large angular motion of the dolly. If the blade were of uniform width these two requirements might lead to the placing of C very close to B with several consequent manufacturing difficulties. These can be avoided by increasing the width of the blade near to B as shown in Figure 7. The distance between B and C can now be increased while maintaining the traverse of C at 0.202 inch, with the result that small errors in the location of C have little effect on the traverse and that adequate space is available for the fixed contacts.

Figure 8 shows a construction which is generally related to Figure 5. In this side elevation A and B are fixed anchorages between which the blades $D_1$, $D_2$ are secured as shown in plan in Figure 1. Operating forces are applied to $D_1$ at X. When $D_1$ snaps over it pulls blade $D_2$ with it by virtue of the bridge piece P, the blades and bridge piece being punched out in one piece. It will be seen that the force exerted by $D_1$ on $D_2$ will depend on the distance $a$. In manufacture the clearance between $D_1$ and P is adjustable and set by a suitable jig to confer on the assembly the right performance characteristic.

It is to be noted that the initial movement of $D_1$ will at first cause a very small pull on $D_2$ since P is merely flexed sideways, but as $D_1$ moves further P comes into tension and drags $D_2$ with it. But $D_2$ will not move very far before the blade $D_1$ snaps over; hence $D_2$ does not receive its major operating force until $D_1$ has already started to move at high velocity. This results in extremely rapid operation of $D_2$ which is entirely unaffected by any residual pressure applied to $D_1$ by the hand operating the switch dolly.

It is to be understood that all the constructions described, except that of Figure 8, can be modified to allow the anchorage adjacent to the operating lever to rotate when the blade snaps over. In Figure 8 anchorage B may rotate and P be removed, or B may be fixed, the upper half of A be fixed and the lower half attached to $D_1$ be allowed to rotate.

Dated this 25th day of January, 1949.

S. W. SLAUGHTER,
Agent for the Applicants.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

689,454 PROVISIONAL SPECIFICATION

*I SHEET*

*This drawing is a reproduction of the Original on a reduced scale.*

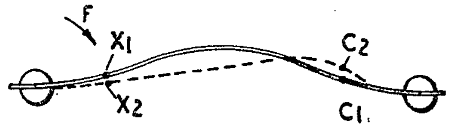


FIG.1

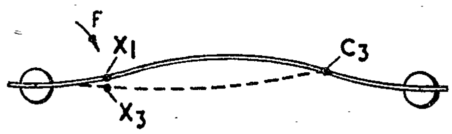


FIG.2


FIG.3

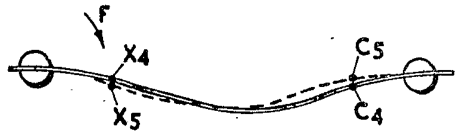


FIG. 4

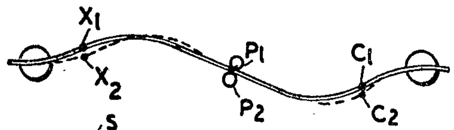


FIG.5


FIG.6

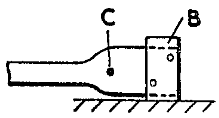


FIG.7

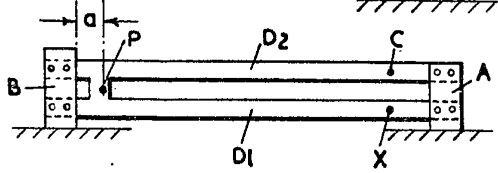


FIG. 8

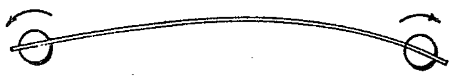

FIG.9

FIG.9a