

Aug. 25, 1964

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3,146,327

SEALED MAGNETICALLY OPERABLE SWITCH

Filed Nov. 6, 1962



FIG. 1

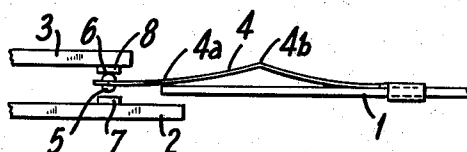


FIG. 2



FIG. 3

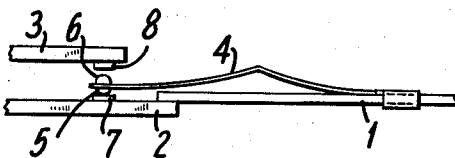


FIG. 4

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SEALED MAGNETICALLY OPERABLE SWITCH
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Filed Nov. 6, 1962, Ser. No. 235,664

3 Claims. (Cl. 200-166)

This invention relates to sealed metallic contact reed switches, and particularly to improvements in the construction of such switches which allow extremely superior switching performance.

The well known transfer type sealed metallic contact reed switch employs a movable reed with appreciably high stiffness whose geometrical shape and dimensions are determined by the conditions necessary for the magnetic path and the restoring force either directly as a contact or as a medium for carrying contacts at the tip thereof. An inherent defect with such a construction is that the bouncing vibrations of the moving reed are sustained for an appreciably long time interval because the kinetic energy that is stored in the movable reed can not be damped rapidly upon release of the reed.

One method of preventing such vibrations caused by the bouncing action is by pressing down the movable reed with a spring, however, such a method invariably increases the mechanical load on the reed, thus reducing the sensitivity of the switch. If a spring with a stiffness smaller than that of the movable reed were connected by some means to the free end of the reed and a contact were provided at the tip of the spring, the superior switching performance according to this invention could not be obtained. With such a construction, a considerable amount of bow or bend would have to be given to this spring in order to secured a sufficient contact pressure in the normal unactuated position of the movable reed. This would necessarily enlarge the magnetic pole gap between the mating parts of the movable reed and the stationary reed with which the movable reed in the operated state establishes contact. This, in turn, would require a larger magnetomotive force to operate the movable reed and would result in a decrease in sensitivity.

There is a further disadvantage in the construction of the conventional transfer type sealed metallic contacts. Since the restoring force of the moving reed alone is relied on, an appreciable time interval is spent for a travel of an infinitesimally small gap distance in the initial separation stage of the contacts. Therefore, unless the build-up time of the voltage appearing across the contacts is sufficiently small, the contact gap will break down to produce arc discharge, which at times develops into a phenomenon known as temporal contact bridging.

Accordingly, it is an object of this invention to provide a switch of the type described which eliminates the above disadvantage period.

A feature of the invention is that the magnetic pole section for generating the magnetic pull and the contact section for switching of an electrical circuit are separated from each other. This construction permits the use of the optimum material, shape, and dimensions of contacts in the contact section irrespective of the magnetic pole section, with consequent improvement in contact stability, switching ability, and contact longevity.

All of the objects, features and advantages of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawing, in which

FIG. 1 shows a side view of the longitudinal cross section of a sealed metallic contact reed switch in accordance with an embodiment of the invention,

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FIG. 2 shows a magnified side view of the sealed metallic contact parts and the magnetic poles for the longitudinal cross section of the switch illustrated in FIG. 1,

FIG. 3 shows a magnified plan view of the sealed metallic contact parts and the magnetic poles of the switch illustrated in FIG. 1, and

FIG. 4 shows a magnified view of the contacts and magnetic poles in the operated state of the movable reed which constitutes an integral member of the sealed metallic contact reed switch structure shown in FIG. 1.

Briefly, in accordance with the invention, a switch is provided having a movable reed of ferromagnetic material, first and second stationary reeds preferably also of ferromagnetic material, a spring mounted on the movable reed, and contacts on the spring and each of the stationary reeds. The spring is connected at one of its ends to the movable reed and is biased so that an intermediate part of the spring in the proximity of the free end of the movable reed exerts a suitable pressure upon this reed. The switch is operated by the application of a magnetic field. When the reed is actuated, the spring contact engages the first stationary reed contact, and the spring is bent in a direction opposite to the pressure so that the free end of the movable reed becomes separated from the spring at its point of engagement therewith. The spring is installed on the movable reed in such a manner that upon release of this reed a spring stiffness results which is lower than the stiffness of the movable reed. An optimum low spring stiffness is provided to minimize chatter due to the collision between the movable reed and the first stationary reed as well as due to spring rebound. Since the spring is merely biased into engagement with the free end of the movable reed, the effective length of the spring is substantially increased and the stiffness relatively decreased upon actuation of the movable reed. This construction substantially reduces chatter produced by vibrations of the spring in the closure of the contacts and in any succeeding collisions between the movable reed and the first stationary reed.

Upon removal of the applied magnetic field, the movable reed is released and the intermediate portion of the spring reengages the free end of this reed. As a consequence the effective length of the spring is substantially shortened and the stiffness increased. This enables the movable reed to produce a sufficient contact force by a relatively small amount of displacement of the movable reed in the direction of the second stationary reed.

Upon removal of the magnetic field that has been applied, the movable reed initiates release operation by its restoring force. It will be understood that the spring mounted on the movable reed and the free end of this reed are designed to maintain a suitable gap when this reed establishes contact with the first stationary reed and the spring contact is in engagement with the first stationary contact. Accordingly, the spring contact will not initiate separation from the first stationary reed until the movable reed reaches a comparatively large speed which is invariably larger than the initial separation speed.

For this reason and also due to the small equivalent mass of the spring, the rate of increase in speed at the initial period of contact separation is large, the contact passing through the small gap region within a comparatively small time interval. Therefore even if the build-up rate of the voltage appearing across the contacts is comparatively large, the resulting arc due to the electrical breakdown of the gap is nevertheless minimized. Moreover, even when the moving reed initiates operation after the application of a magnetic field, the spring is bent in the direction of the second stationary reed to produce a contact pressure, with the result that the spring contact will not initiate separation from the secondary reed until the

movable reed has travelled a distance corresponding to this bend and acquired a comparatively large speed.

This feature of construction, combined with the feature that the equivalent mass of the spring is considerably small, results in a large rate of increase in the speed of the initial separation of the contacts and hence, comparatively rapid passage in the infinitesimally small gap. Therefore the possibility of production of arc due to electrical breakdown of the gap can be maintained at a minimum even if the voltage appearing across the contacts is comparatively large.

Where contacts are provided directly on a movable reed with high stiffness as with conventional transfer type sealed metallic contact construction, no sliding action takes place in contact closure. This tends to cause a pip to build up on one of the contact surfaces on account of the arc discharge, ultimately causing sticking or short-circuiting of the contacts. Because no sliding action takes place with the conventional construction, a powder having poor conductivity, collects in the arc discharge area between the contacts and tend to cling to or collect on the contact surfaces, resulting in poor electrical conductivity. In contrast, where a contact is provided at the tip of a spring having a stiffness in accordance with this invention, a sliding action in contact separation and closure takes place, and as a result, build-up or accumulation of powder or other material of poor conductivity on the contact surfaces is not formed.

With a contact directly installed on the movable reed as in the conventional construction, the physical shape and dimensions of this reed are essentially determined by the conditions necessary for the magnetic path and the restoring force. This makes it extremely difficult to reduce the stiffness of the movable reed. It is possible to reduce this stiffness by cutting the movable reed at the base to separate the reed into two parts and to reconnect these two parts with a hinge spring of low stiffness, but this construction tends to increase bouncing oscillation upon restoration of the movable reed. The high stiffness of the movable reed tends to rapidly decrease the contact pressure by the electrical erosion that takes place on this reed contact. Accordingly, the upper limit of stiffness of the spring on which the movable reed contact is provided should be determined by a predetermined amount of erosion and an allowable decrease in contact pressure, it being difficult to adopt the stiffness below this upper limit where the contact is provided directly on the movable reed.

For minimizing bouncing oscillations (i.e., the bouncing frequency, duration and amplitude) in restoration of the movable reed, it is desirable that the amount of predeflection necessary to produce pressure against the second stationary reed contact with the movable reed held at normal position be made as large as possible compared with the moving distance of the tip of the movable reed. In conventional constructions, wherein the stiffness of the movable reed is high, increasing the predeflection amount decreases the switch sensitivity because the pressure of the movable reed with respect to the second stationary reed becomes excessive. Where the contact is provided at the tip of a spring with the stiffness lower than that of the movable reed according to this invention, however, the relation between the predeflection amounts of the spring pressure against the second stationary reed contacts is governed mainly by the composite stiffness of the movable reed and the spring, with the result that the aforementioned conditions can be easily met while the amount of rebound of the contact upon restoration can be minimized.

The construction described herein provides prolonged contact time, dissipation of most of the kinetic energy stored in the movable reed by the friction between the contacts and between the spring and the moving reed, lowering of the vibration frequency of the movable reed, and reduction of chatter during operation. Another advantage of this construction results from the fact that

the natural frequency of the spring can be suitably predetermined, as can also the ratio of the overall length of the spring to the length between the point at which the spring makes contact with the movable reed and the location of the moving contact. With this information, the rebound amplitude of the spring contact as it rebounds after collision with the second stationary reed contact upon restoration of the movable reed can be minimized, and the possibility of arcing due to reapproach of the spring contact to the first stationary reed contact is also minimized.

Referring now to the various figures, the numeral 1 denotes a movable reed of a ferromagnetic material having a stiffness less than that of a first stationary reed 2 and a second stationary reed 3. The stationary reeds may also be of a ferromagnetic material. The movable reed 1 and the first stationary reed 2 establish a small operating gap between their overlapping ends.

A spring 4 is secured to the movable reed 1 by for example, a clamp 1a, or other suitable means. The stiffness of the spring 4 should be significantly less than that of the movable reed 1, and should be bent slightly upward at some suitable intermediary point such as at point 4b for example, so that the entire length of the bottom side of the spring may not contact with the upper surface of the movable reed 1. In addition, some part of the spring 4 in proximity to the tip thereof, as at 4a for example, should make contact with the movable reed 1 with a desired amount of pressure. A lower contact 5 and an upper contact 6 should be provided on the opposite sides of the tip of the spring 4.

When the movable reed 1 is in normal position, such as that shown in FIGS. 1 and 2, the contact 6 should make contact with the contact 8 on the second stationary reed 3 and the spring 4 should be biased as at 4a, against the free end of the movable reed 1. Since the spring 4 is so biased into pressure contact with the movable reed 1, its stiffness in this state becomes larger than that of the spring in its free state, which allows a sufficient contact pressure to be developed with a comparatively small amount of bend, as will appear.

Upon the application of a magnetic field by suitable means (not shown), the movable reed 1 is bent downwardly by a magnetic pull generated in the gap between the movable reed 1 and the first stationary reed 2. As a consequence, the upper contact 6 on the spring 4 is separated from the contact 8 on the second stationary reed 3 so that the lower contact 5 on the spring 4 is caused to engage the contact 7 on the first stationary reed 2.

With the construction disclosed herein, after the contact 5 initially engages the contact 7, the movable reed 1 continues to advance under the influence of the actuating magnetic field until it engages the first stationary reed 2. This causes the spring 4 to make wiping action between the contacts 5 and 7 and also greatly increases the pressure between these contacts, since the spring 4, which is already biased into contact with the movable reed 1, becomes separated therefrom at the point 4a.

In conventional constructions, when the contacts first engage, they immediately separate for a brief time interval and continue engagement and separation at a rapid rate for a short period, thus producing chatter between the moving reed contact 5 and the first stationary reed contact 7. The amount of chattering is substantially reduced with the construction of this invention, first by the utilization of a spring and further by selecting a spring of low stiffness, thus prolonging the contact time interval period. Moreover, since movement of the movable reed 1 continues in the direction of the first stationary reed 2 after initial closure of the contacts 5 and 7, rebound of the spring mounted contact 5 on the moving movable reed 1 is restrained, further reducing chatter.

Although the movable reed 1 bounces back slightly upon initially colliding against the first stationary reed 2, further rebound of the movable reed 1 is absorbed by the

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spring 4 and the probability of occurrence of chattering between contacts 5 and 7 is thereby minimized, because the contact 5 is forced against contact 7 through a spring 4 of low stiffness and low natural frequency. For this purpose, it is a desirable condition that the stiffness of the first stationary reed 2 be substantially larger than that of the movable reed 1. Another desirable condition is that a suitable irrational number be taken for the ratio of the natural frequency of the spring 4 to that of the movable reed 1. This is necessary for minimizing the probability that both contact pairs 5 and 7, and 6 and 8 open simultaneously.

Upon removal of the applied magnetic field, the movable reed 1 is separated from the first stationary reed 2 by the restoring force of the movable reed 1 to initiate a motion towards the second stationary reed 3. While the movable reed 1 is in contact with the first stationary reed 2, a gap is maintained between the free end of the movable reed 1 and the spring 4. Thus the lower contact 5 of the spring 4 does not initiate separation from contact 7 on the first stationary reed 2 until the movable reed 1 acquires a comparatively large separation speed after passing a distance corresponding to this gap. In addition, the equivalent mass of the spring 4 is comparatively small, and therefore the separation speed of the contact 5 from the contact 7 is comparatively high. The movable reed 1 continues in the direction of the second stationary reed 3, the contact 6 colliding against contact 8.

Since the upper contact 6 is provided at the end of spring 4 and is secured on the movable reed 1 of high stiffness by means of this spring, the contact time interval becomes longer than that which would be obtained if the contact were directly installed on the reed. During this time interval, the kinetic energy of the movable reed 1 is dissipated rapidly by the wiping or sliding friction between contacts 6 and 8, and by the friction between the spring 4 and movable reed 1 at the point 4a, with the result that the vibrations of the movable reed 1 are rapidly attenuated and chattering between contacts 6 and 8 is quickly suppressed.

The numeral 9 denotes an envelope for hermetically sealing the aforementioned reeds, spring, and contacts together with an inert gas.

To apply this invention to a "make" type sealed contact reed switch, it is only necessary to remove the second stationary reed 3 from the construction shown in the figures. Then the make type switch comprising the movable reed 1, spring 4, first stationary reed 2, and the contacts provided thereon are accomplished. It is a desirable condition, in this case also, that a suitable irrational number be selected for the ratio of the natural frequency of the reed 1 to that of the spring 4 so that the maximum amplitude of vibrations of the reed 1 and that of the spring 4 will not occur simultaneously.

To apply this invention to a "break" type sealed contact reed switch it is only necessary to remove the contact 7 on the first stationary reed 2 and the contact 5 on the first stationary reed side of the spring 4 from the construction shown in the figures. Then the "break" type switch comprising the moving reed 1, second stationary reed 3, spring 4 as well as contacts provided thereon, and first stationary reed 2 devoid of contacts, is accomplished.

These "make" type and "break" type switches to which this invention can also be applied will have all the features possessed by the above described transfer type sealed contact switch including simplicity of construction.

Among the advantages of this invention are considerably reduced chattering of the contacts, increased initial contact separating acceleration and speed, prevention of arc due to electrical break down in the gap, and low and stable contact resistance, without sacrificing the features of immunity to dirt or gas laden atmospheres, miniaturized size, or short actuating and release times. Additionally, this invention is advantageous in constructing a sealed

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metallic contact switch capable of switching "on" and "off" a comparatively large current a great many times. Accordingly, this invention is well suited for use with such applications as automatic exchange equipment, where improved reliability is particularly advantageous.

While the foregoing description sets forth the principles of the invention in connection with specific apparatus, it is to be understood that the description is made only by way of example and not as a limitation of the scope of the invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A transfer type sealed metallic contact switch comprising a movable reed of ferromagnetic material and a first stationary reed also made of a ferromagnetic material which overlap each other and are separated by a small gap, a spring having a stiffness less than that of said movable reed fixed at one end to said movable reed and having a bend therein such that a part of said spring in proximity to a free end thereof exerts a biasing pressure engagement against said movable reed, said bend in said spring being characterized in that a portion of said spring intermediate its fixed end and its point of bias engagement with said movable reed is spaced a substantial distance from said movable reed, a contact on the end of said spring, a contact on said first stationary reed to mate with the contact on said spring, said movable reed being magnetically actuatable from a normal position to cause said contact on said spring to first engage said contact on said first stationary reed, said movable reed thereafter continuing to move under said magnetic actuation to thereby become disengaged from said pressure engagement with said spring and become engaged with said first stationary reed in the region of overlap to thereby impart wiping action and a substantial contact pressure between said contact on said first stationary reed and said contact on said spring, a second stationary reed provided with a contact for engaging the contact on said spring when the movable reed is in a normal or deactuated position, and means for producing contact pressure between said spring contact and said second reed contact as a result of said bend in the spring by cooperation of said movable reed and said second stationary reed when said movable reed is in said normal position, the stiffness of said movable reed being different from that of said stationary reeds, whereby chatter between the various contacts upon closure thereof is substantially reduced.

2. An electric "make" type switch comprising a movable reed of ferromagnetic material and a stationary reed also of ferromagnetic material which overlap each other and are separated by a small gap, a spring having a stiffness lower than that of said movable reed fixed at one end to said movable reed and having a bend therein such that a part of said spring in proximity to a free end thereof exerts a biasing pressure against a free end of said movable reed, said bend in said spring being characterized in that a portion of said spring intermediate its fixed end and its point of bias engagement with said movable reed is spaced a substantial distance from said movable reed, a contact on the free end of said spring, and a contact on said stationary reed for engagement with the contact on said spring, said movable reed being actuatable from a normal position to first close said contacts, said movable reed thereafter continuing to move under said magnetic actuation to cause the same to become separated from said spring at the point of pressure engagement therewith and to become engaged with said stationary reed in the region of overlap to thereby produce wiping action and substantial pressure between said contacts, said substantial pressure resulting from a combination of the biasing pressure between said spring and the free end of said movable reed and the flexure of said spring produced by said separation between said spring and said movable

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reed, whereby chatter between said contacts upon closure thereof is substantially reduced.

3. An electric "break" type switch comprising a movable reed of ferromagnetic material and a first stationary reed also made of ferromagnetic material which overlap each other and are separated by a small gap, a spring having a stiffness lower than that of said movable reed fixed at one end to said movable reed and having a bend therein such that a part of said spring in proximity to a free end thereof exerts a biasing pressure against a free end of said movable reed, said bend in said spring being characterized in that a portion of said spring intermediate its fixed end and its point of bias engagement with said movable reed is spaced a substantial distance from said movable reed, a contact on the free end of said spring, 15

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and a second stationary reed provided with a contact for wiping action and substantial pressure engagement by the contact on said spring when the movable reed is in a normal or deactuated position, said wiping action and substantial pressure between said contact on said spring and said contact on said second stationary reed being produced as a result of the free end of said movable reed bearing against said spring at the point of biasing pressure engagement therewith when said movable reed is in said normal position, whereby chatter between said contacts upon closure thereof is substantially reduced.

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