

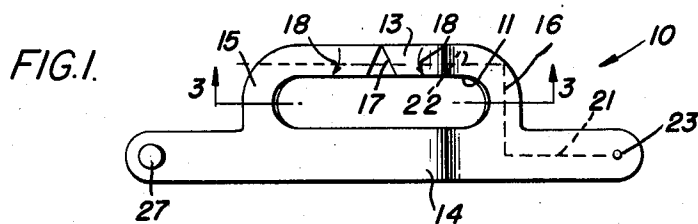
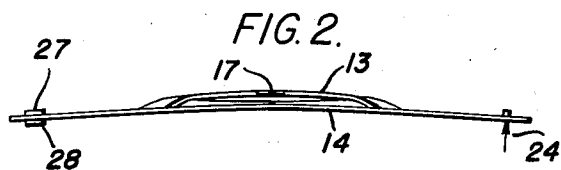
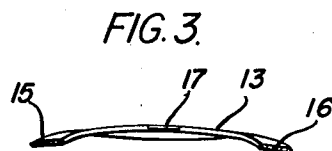
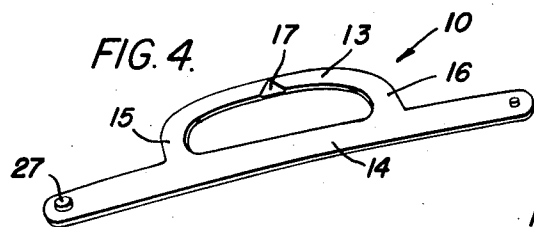
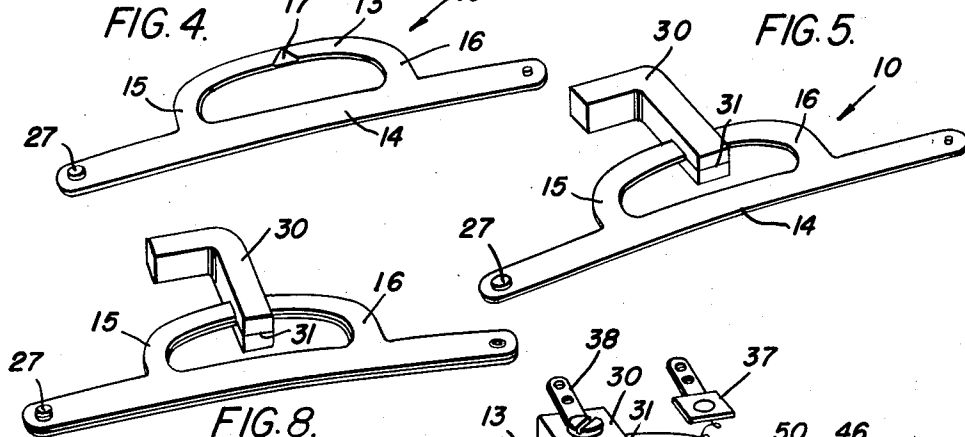
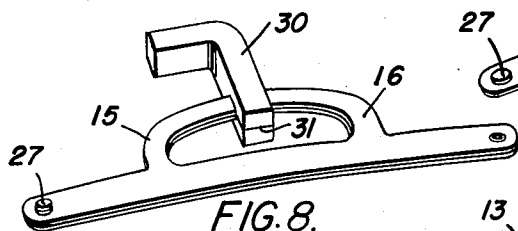
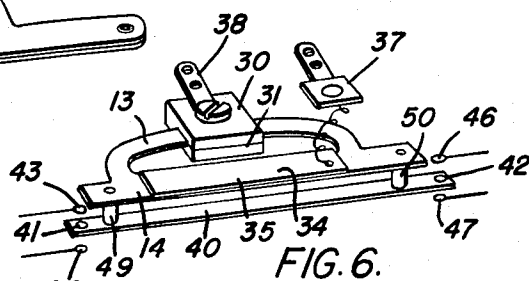
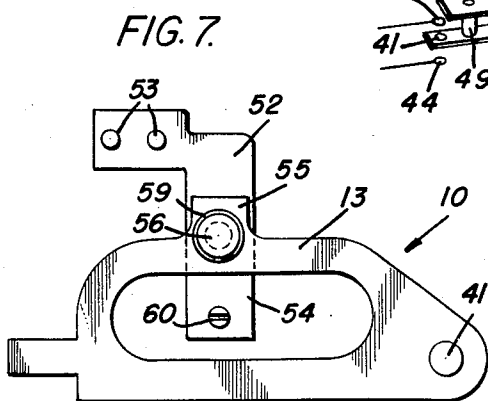
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2,882,678

SNAP ACTION DEVICE

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2,882,678

SNAP ACTION DEVICE

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11 Claims. (Cl. 60—23)

This invention relates to a snap action device, and particularly to an improved snap action movement utilizing a snap spring which is particularly adaptable for utilization in connection with an electrostrictive or piezoelectric actuator, that is, in an electrical relay, wherein contacts are actuatable by such an actuator. The invention is, however, not limited to this application; it may be utilized in any application wherein snap action is desired. It is particularly advantageous and adaptable in the aforesaid application however, because of the relatively low operating energies developed by the electrostrictive or piezoelectric actuators. These actuators usually take the form of ceramic bi-element units, and the small energies developed necessitate that the snap action mechanism be very sensitive. In the past it has been found that in order to realize this great sensitivity it has been found necessary to use low stress snap springs. In the prior art the snap springs utilized have been quite commonly supported on knife edge mountings, and due to the low stress in the springs they were subject to the defect and deficiency that the springs were easily jarred loose, sliding along the knife-edged supports and thus getting out of adjustment and causing the device to fail. Most modern applications of electrical relays and similar components require that they be built to very rigid specifications; particularly the components must be able to stand jarring, vibration, shocks, severe acceleration forces, and many other relatively harsh conditions. Such conditions occur in such applications as guided missiles, high-speed machinery subject to vibration, devices operated at extremely high velocities, etc.

The prior art has also been subject to the deficiency of deterioration of the snap springs utilized, and particularly that ordinarily the snap member has a crimped or deformed portion which, being subject to repeated flexures is subject to unpredictable failure; that is, stresses are set up at a certain point in a part or member of the snap device by way of a deformation, there being flexure at the deformation each time that the device is snapped. The deformed portion is a weakened area, and after repeated flexures this portion is very apt to fail, and since ordinarily the snap device is subjected to many thousands of flexures, it can be seen that the rate of failures is apt to be high. The present invention provides a snap spring wherein this deficiency is overcome in that the deformed area which sets up the stresses is relatively small and is completely engaged, that is, clamped, by a supporting member such that there is no flexure of the deformed area at all. The snap spring being mounted by a clamp in this manner, precluding flexure of the deformed area, is also characterized in that it has extremely stable operating characteristics. Thus, the invention provides a snap action device which, although it is extremely sensitive, overcomes the major deficiencies of the prior art, and this has been accomplished by way of an extremely simple device as will appear in the detailed specification hereinafter. Generally the device takes the form of a strip of metal having a longitudinal slot forming two

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spaced reaches. The deformation is provided at an intermediate point of one of these reaches near one edge thereof, and the deformation is characterized in that it constitutes a mashing or flattening of the metal without deformation out of the plane of the strip, with the result that stresses are set up in adjacent portions of the strip which are torsional in nature so as to be transmitted to the other reach as a bending moment. The detailed technical characteristics of the device will appear in the specification hereinafter.

It is accordingly an object of the invention to provide an extremely sensitive snap action device having a rigid mounting, but which is operable in response to the low energies developed by such devices as electrostrictive capacitive actuators.

Another object of the invention is to provide a snap action device having spaced parallel reaches, one of which has an intermediate deformation setting up stresses whereby the strip is operable to snap between oppositely bowed positions, the device being rigidly mounted at said deformed portion to preclude flexing at said portion.

Another object of the invention is to provide a snap action device comprising a strip of metal having a longitudinal slot forming parallel reaches, one of the reaches having an intermediate mashed portion adjacent one edge thereof, the strip being mounted and clamped at said portion, and being operable to snap between oppositely bowed positions.

In one form of the invention the device is constructed as a unitary bi-element device wherein an external force is not applied for producing the snap action, but rather, the device snaps by warping in the manner of a bi-element thermostat. In this form of the invention an electrostrictive ceramic element is bonded to one reach of the snap spring, and upon the application of voltage to the electrostrictive element it deforms in a manner such that by reason of its being bonded to the snap spring it causes warping thereof and resultant snapping.

It is, accordingly, an object of my invention to provide a snap action device having characteristics as in the foregoing, wherein the device includes an electrostrictive ceramic element bonded to a part thereof in such manner as to cause snapping of the device in response to the application of voltage to the ceramic element.

Further objects and numerous of the advantages of the invention will become apparent from the following detailed description and annexed drawings, wherein:

Fig. 1 is a plan view of a preferred form of snap action device of my invention;

Fig. 2 is a side elevation of the device of Fig. 1;

Fig. 3 is a detail sectional view taken along line 3—3 of Fig. 1;

Fig. 4 is a perspective view of the snap action device of the previous figures;

Fig. 5 is a perspective view of the snap action device showing the manner in which it is mounted;

Fig. 6 is a view of a modified form of my invention;

Fig. 7 is a view of a modified form of mounting of the snap spring; and

Fig. 8 is a view of a form of the invention wherein the spring is formed of bi-element, or bi-metal material.

Referring to Fig. 1 of the drawings, the snap action device is shown in the form of a metal strip as indicated at 10, which may be formed of any of the metals or alloys used in the prior art as snap springs. The strip has a longitudinal slot as shown at 11, having arcuate ends. The longitudinal slot provides two parallel reaches as indicated at 13 and 14, the reach 14 being somewhat longer as shown, to form a contact carrying portion and an actuator, as will be described.

The two reaches are joined by rounded transverse portions of the strip as indicated at 15 and 16.

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The strip is characterized by having certain permanent stresses provided therein such that the strip can snap between oppositely bowed positions of stable equilibrium. The particular way in which the permanent stresses are set up and the effect of these stresses upon the various portions of the device, are an important feature of the invention. The reach 13 has an intermediate deformed portion as shown at 17, which is a mashed or flattened portion, that is, this portion is mashed such as by pounding or hammering it against an anvil or the like, without actually deforming the portion out of the plane of the reach 13. The deformed portion 17 is largely adjacent one edge of the reach 13; that is, more of the deformed area is adjacent the inner edge of the reach 13. The effect of this mashing or compacting of the metal is to set up certain stresses in the portions of the reach 13 adjacent the mashed area 17. The effect of the mashing is to cause a flow of the metal which tends to make the inner edges of the portions of reach 13 adjacent the area 17 elongate. This tendency manifests itself actually as a torsional stress in the portions of reach 13 adjacent the area 17. This torsional stress in the metal is represented by the curved arrows 18, and it transmits itself through the transverse portions 15 and 16 as a bending moment to the longer reach 14. In order to more explicitly explain this torsional stress and its effect as a bending moment in reach 14, the broken line 21 represents a crank whereby a torque or twist can be exerted about the axis through the center of reach 13 represented by line 22. In other words, the torsion represented by the curved arrow 18 is transmitted as a bending moment to the reach 14 which is in effect equivalent to a downward force being exerted at the point 23. The effect becomes more clearly understandable when the effect of a counterrotation as applied to the crank 21, is observed. For example, if an upward force, as indicated at 24, is applied to the end of the reach 14, it will be observed that the crank as diagrammatically illustrated at 21, tends to apply torque or rotation about the axis 22 opposite to the arrow 18. In other words, the effect of the upward force 24 through the crank 21 is to apply a countertorsional stress to the portion of reach 13 adjacent the area 17. The original effect of the torsional stress as described is to cause the strip to bow into a conformation as shown in Fig. 2. When a reverse force, as indicated at 24, is applied setting up the countertorsional stresses, the effect is that the strip will snap to a reverse position of stable equilibrium.

The reach 14 of the strip has contact members 27 and 28 at its left end, which may operate between fixed contacts not shown. The mounting of the strip is an extremely significant feature of the invention for reasons which will be pointed out. The strip is mounted by way of a rigid mounting or clamping bracket 30 having a slot 31 as shown, which engages the reach 13 of the device, and rigidly engages over and clamps the area of reach 13 embracing the mashed or deformed portion 17. Thus, when the strip snaps from a bowed position as shown in Fig. 2, to an upwardly bowed position, while there is bending action of the metal, it can be seen that there is no flexing of the mashed area 17 since it is wholly within the clamping area of the bracket 30. Thus, even if the deforming of this area structurally weakens it, this is of no concern since the area, if it is weakened, is wholly within the rigid clamping bracket and is supported thereby. From Fig. 5 the operation described above can be readily understood as related to the mounting bracket 30. As described, the force as exerted at 24 to one end of the reach 14 applies countertorsional stresses such that the strip as a whole snaps to a reversely bowed position wherein the torsional stresses in the portions of reach 13 adjacent the area 17 are in a direction opposite to that indicated by

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the arrow 18 and with a resultant reverse bending moment applied to the reach 14.

As will be observed from the foregoing, the structure is one wherein the snap strip or device is mounted at an intermediate point with portions extending in each direction therefrom. This is to be distinguished from the prior art type of cantilever device wherein a snap acting member is rigidly mounted at one end. The nature of a cantilever type of mounting is such that a greater amount of space is required to provide a device having comparable capacity to interrupt an electrical circuit or the like, since a considerable part of the beam is utilized by its mounting.

It will be observed that in each of the oppositely bowed positions of the strip it is in a condition of stress equilibrium, that is, a stable condition. The device readily adapts itself to varying or controlling the force-displacement ratio; that is, the ratio as between the operating force required and the displacement or movement imparted to the electrical contacts 27 and 28. The bending moment transmitted to the reach 14 by the torsional stresses in the reach 13 depends on the relative lengths of the portions of reach 13 on each side of the area 17, and thus the bending moment and consequently the operating force required can be varied by varying the lengths of these portions relative to the overhang of the reach 14. In other words, if the overhang is increased, the operating force ratio is reduced and the displacement is increased.

The invention lends itself readily to production and fabrication inasmuch as the strips can be simply stamped out of suitable metal. The deformation 17 is easily provided in the reach 13, and the resultant snap action device is extremely rugged, stable, and possesses highly satisfactory snap action characteristics. The device can be manufactured very satisfactorily in miniature sizes, and as pointed out in the foregoing, is particularly useful with electrostrictive capacitive actuators in view of the low operating energies required. Even in miniature sizes however, the device is capable of interrupting currents of considerable magnitude.

Referring to Fig. 6 of the drawings, there is shown a modified form of my invention wherein it is unnecessary to provide an external operating force for causing snapping operation of the spring. In the form of the invention shown in Fig. 6, the snap spring 10 is similar to that of the previous embodiment. It has a similar intermediate deformed portion as in the previous embodiment, and it is similarly mounted in a mount 30. In Fig. 6, however, there is bonded to the reach 14 an electrostrictive ceramic element designated by the numeral 34. The element 34 may be of various materials having electrostrictive properties, but may preferably be formed of a barium titanate ceramic of the type shown in my previous Patent No. 2,800,551. The material of the element 34 has the characteristic that when a voltage is applied across the thickness of the element it expands in thickness and contracts in length irrespective of the polarity of the applied voltage in the manner described in the previous applications. The member 34 has an electrode 35 formed on its outer face, which may be simply by painting its outer surface with an electrically conductive paint, as silver paint. The reach 14 of the spring 10 forms an electrode bonded to the opposite face of the member 34. Numeral 37 designates a contact bracket from which electrical connections are made as shown, to the electrode 35. A second contact 38 is attached to the mount 30 as shown, so that the reach 14 of the snap spring 10 forms the second electrode of the electrostrictive unit. By applying an appropriate potential between the contact members 37 and 38, this potential may be applied across the thickness of the element 34. When a potential is so applied, the element 34 expands in thickness and contracts longitudinally. It thus operates to cause warping of itself and the reach

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14 in the manner of a bimetal thermostat. The operation is then substantially the same as in the previous embodiment. The warping of the reach 14 reflects a torsional or twisting moment back into the parts of the reach 13 adjacent the mount 30, and when the warping is sufficient, the spring 10 will snap between oppositely bowed positions as in the previous embodiment. Thus, the snap device requires no separate actuating or operating mechanism capable of developing an operating force. The device is thus completely unitary, integrated and fully operative within itself, simply by the application of an appropriate voltage thereto.

Numerals 40 designates a contact bar or member having electrical contactors 41 and 42 at its ends. The contact 41 moves between fixed electrical contacts 43 and 44, and the contact 42 moves between fixed electrical contacts 46 and 47. The contact bar 40 is attached to and spaced from the snap spring 10 by stand-off insulators 49 and 50. In the present embodiment of the invention as will be observed, both ends of the snap spring 10 are available for the actuation of contacts of a contactor member. Thus, the device readily adapts itself for the actuation of multiple contacts as shown in Fig. 6. It is apparent that the device adapts itself to extremely compact construction even though multiple circuit controlling functions are present.

In the device of Fig. 6 the elements 34 and 14 may have the same or different coefficients of thermal expansion. If they are the same the effect is to compensate for temperature changes and the device is responsive only to voltage. Otherwise, the device responds at a temperature dependent on the applied voltage.

Referring to Fig. 7 of the drawings, there is shown another form of the invention which adapts itself favorably to production techniques. The modification of Fig. 7 embodies a snap spring 10, as in the previous embodiments. The embodiment of Fig. 7 utilizes a mounting bracket 52 which is slightly different than that of the previous embodiments permitting easy and simplified fabrication and assembly, and having certain other advantages. The bracket 52 is mounted by rivets as shown at 53, and has a resilient extending portion 54. The reach 13 of the snap spring has an extending tab 55 at the mashed or flattened area, which, in the present embodiment, is adjacent the outer edge of the reach 13. The snap spring is attached to the portion 54 by a bolt 56 extending through the aperture in the tab 55 and through a washer 59, the washer completely covering the mashed area. Thus, the washer provides a rigid member over the mashed area such that as in the previous embodiment, there can be no flexing of the mashed area. In the present embodiment the necessity of milling a slot in the mounting bracket is eliminated, and the use of solder in attaching the snap spring is avoided. Thus, the possibility of any solder running down onto the reach 13 and changing its characteristics, is avoided. At the end of the portion 54 is an adjusting screw 60 which bears against a rigid surface so that the portion 54 can be adjusted toward and away from the surface to thereby adjust the mounting position of the snap spring 10, and accordingly, the position of the contact 41 relative to the fixed contact with which it cooperates. In the present embodiment the operating force is applied to the left end of the reach 14 as in the first embodiment.

Fig. 8 shows a form of the invention wherein the spring is formed of conventional bi-element or bi-metal material so that a temperature responsive snap acting device is formed. The characteristics of the device are otherwise the same as previous embodiments.

The foregoing is a representative disclosure of preferred forms of my invention. It is intended that the disclosure be interpreted as being illustrative rather than limiting upon the invention, and it is also intended that all variations and modifications which may be made by

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those skilled in the art come within the scope and meaning of the claims appended hereto.

I claim:

1. A snap action device, comprising: a strip of spring material having a longitudinal slot whereby two parallel reaches are formed, one of said reaches having a deformation at an intermediate portion thereof, rigid mounting means engaging said strip at said deformation whereby flexing of the material at said deformation is precluded, the deformation being of such character as to produce stresses in the device, causing it to bow out of a plane whereby upon the application of a reversely bowing force to one end of the device it bows in the reverse direction with a snap action.

2. A snap action device, comprising: a strip of spring material having a plurality of portions, the material having a deformation intermediate its ends; mounting means engaging the strip and clamping the deformed area so as to preclude any flexing of the deformed material, the deformation being of a character to produce deforming stresses in portions of the material adjacent the mounting means, whereby the strip deforms out of a plane, the deformed strip having the characteristic that upon applying a counterdeforming force to one end of the strip it deforms in the opposite direction with a snap action.

3. A snap action device, comprising: a strip of spring material having a plurality of portions, the material having a permanent deformation intermediate its ends, the deformation comprising a relatively small area wherein the material is mashed to a lesser thickness than adjacent portions such that deforming stresses are set up in the adjacent portions, said area being located adjacent an edge of said strip; means rigidly supporting said strip at said area, said stresses producing a bending deformation in said strip, the strip having the characteristic that upon the application of a reverse bending moment the strip deforms in the opposite direction with a snap action.

4. The structure of claim 3, wherein said supporting means engages the area of said deformation so as to preclude any flexing of the deformed area.

5. A snap action device, comprising: a strip of spring material having a plurality of portions, the material having a permanent deformation intermediate its ends, the deformation comprising a relatively small area wherein the material is mashed to a lesser thickness than adjacent portions such that deforming stresses are set up in the adjacent portions; and means rigidly supporting said strip at said area, including a washer clamped over the deformation to preclude flexing of the material at said deformation, said stresses producing a bending moment in said strip, and the strip having the characteristic that upon the application of a reverse bending moment the strip deforms in the opposite direction with a snap action.

6. A snap action device, comprising: a strip of spring material having a longitudinal slot whereby two parallel reaches are formed, at least one of said reaches having a permanent deformation intermediate its ends, the deformation comprising a relatively small area wherein the material is mashed to a lesser thickness than adjacent portions; means for mounting said strip at the area of said deformation, the deformation causing torsional stresses to be set up in the adjacent portions of the said one reach which are transmitted as a bending moment to the other reach, causing bowing of the strip, the strip having the characteristic that upon the application of a reverse bending moment, counter-torsional stresses are set up in the portions adjacent the mounting means whereby the strip bows in the opposite direction with a snap action, the mounting means engaging the strip in such manner as to preclude any flexing of the permanently deformed area.

7. A snap spring, comprising: a strip of metal having an intermediate permanently deformed area, the defor-

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mation comprising a relatively small area in which the metal is mashed to have a lesser thickness than other portions of the strip, without the deformed area being otherwise out of the plane of the strip, the deformation setting up stresses in the strip such that if the strip is fixed it will flex with a snap action between first and second positions and supporting means for the said strip, the supporting means engaging the deformed area so as to preclude any flexing of material at said deformed area.

8. A snap spring, comprising a strip of metal having a longitudinal slot forming parallel reaches, one of said reaches having an intermediate permanently deformed area, the deformation comprising a relatively small area adjacent one edge of the said one reach in which the metal is mashed to have a lesser thickness than other portions of the strip without the deformed area being otherwise out of the plane of the strip, the deformation setting up torsional stresses in the material adjacent to the deformation, which are transmitted to the other reach as a bending moment causing bowing of the strip out of a plane, the strip having the characteristic that upon the application of a reverse bending moment thereto counter-torsional stresses are set up, causing the strip to move to a reversely bowed position with a snap action; and mounting means for the said strip, the mounting means engaging the permanently deformed area so as to preclude any flexing of the deformed area.

9. A snap action device, comprising: a strip of spring material having a longitudinal slot to form first and second laterally spaced reaches, one of said reaches being fixedly mounted at an intermediate point between the ends of the said slot and its ends being free, one of said reaches having a deformed portion adjacent and intermediate the ends of the slot such that adjacent portions of said one reach tend to deform out of a plane by twisting, setting up torsional stresses therein, which are transmitted through said one reach to said other reach as a bending moment causing bowing of the other reach, whereby upon applying a reverse bowing moment to said other reach a counter torsion is applied to said portions, causing them to deform in the opposite direction with a snap action and similarly reversing the bowing in said other reach.

10. A snap action device, comprising: a strip of spring material having a longitudinal slot whereby two parallel reaches are formed, one of said reaches having a perma-

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nent deformation intermediate its end and intermediate the length of the slot, the deformation comprising a relatively small area wherein the material is mashed to a lesser thickness than adjacent portions; mounting means fixedly engaging said one reach at the area of said deformation, and the ends of the strip being free, the deformation causing torsional stresses to be set up in the adjacent portions of the said one reach which are transmitted through said reach as a bending moment to the other reach, causing bowing of the said other reach, the strip having the characteristic that upon the application of a reverse bending moment counter torsional stresses are set up in the portions adjacent the mounting means whereby the strip bows in the opposite direction with a snap action.

11. A snap spring comprising: a strip of metal having a longitudinal slot forming parallel reaches, one of said reaches having an intermediate permanently deformed area, the deformation comprising a relatively small area adjacent one edge of the said one reach in which the metal is mashed to have a lesser thickness than other portions of the strip without the deformed area being otherwise out of the plane of the strip, the deformation setting up torsional stresses in the material adjacent the deformation, which are transmitted to the other reach as a bending moment causing bowing of the strip out of a plane, the strip having the characteristic that upon the application of a reverse bending moment thereto counter-torsional stresses are set up causing the strip to move to a reversely bowed position with a snap action, and mounting means comprising a bracket, the snap spring having an aperture therein adjacent the deformed area and means comprising a bolt extending through the aperture and the bracket and having a washer completely covering the deformed area to provide a rigid backing therefor.

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