United States Patent

Wilkes

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[45] **Aug. 29, 1972**

[54] **SNAP ACTION APPARATUS**

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[73] Assignee: **Rolamite, Incorporated,** San Francisco, Calif.

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[21] Appl. No.: **32,885**

[52] **U.S. Cl.** .... **74/100,** 200/67 D

[51] **Int. Cl.** **F16h 21/44**

[58] **Field of Search** ....74/100, 100 P, 97, 97 P; 200/73, 67 D, 67 DZ, 67 DI; 267/159; 251/75, DIG. 2

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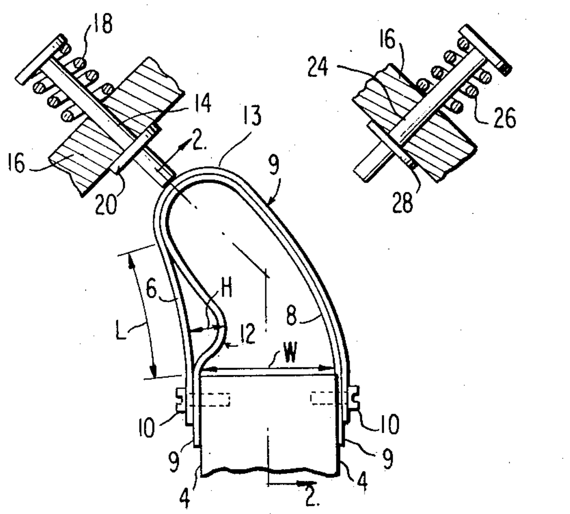
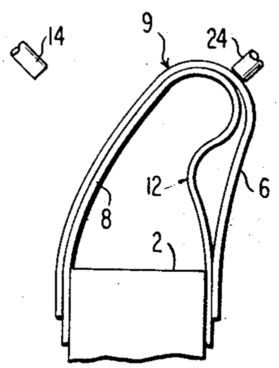
Attorney—Burns, Doane, Benedict, Swecker & Mathis

[57] **ABSTRACT**

A pair of thin flexible bands are arranged in a loop with one band being on the inside of the loop and the other band being on the outside of the loop. The inner band is resiliently flexed in a lobe arching away from the outer band, and the bands are secured together adjacent the ends of the loop. The bending moments in the inner band normally urge the lobe to progress toward one end of the loop. By changing the curvature of the loop, the bending moments in the inner band are changed and the lobe snaps over to the opposite side of the loop.

9 Claims, 11 Drawing Figures





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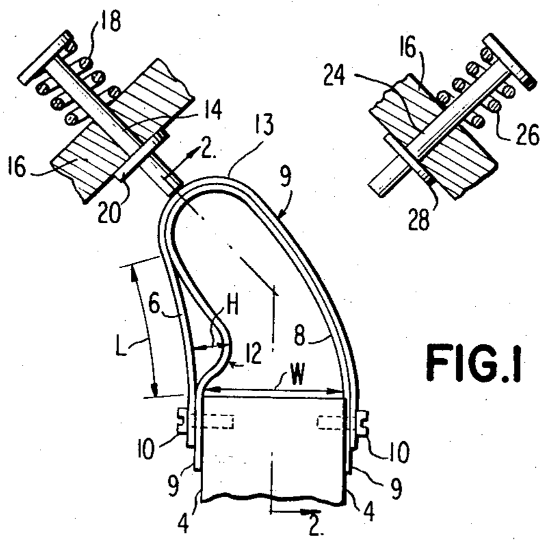

FIG.1

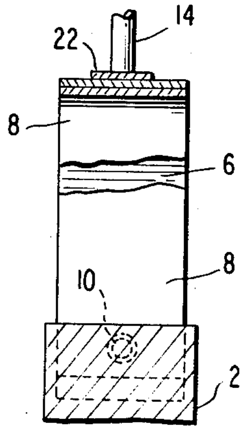

FIG.2

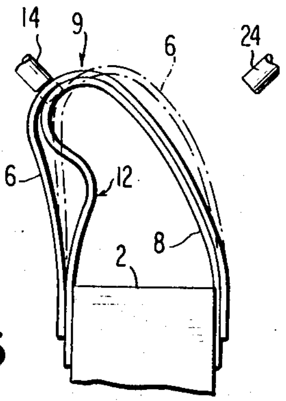

FIG.3

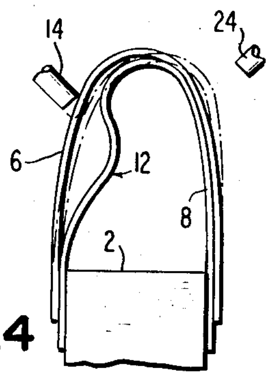

FIG.4

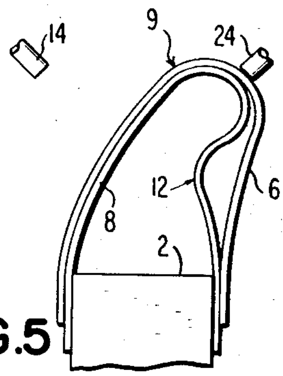

FIG.5

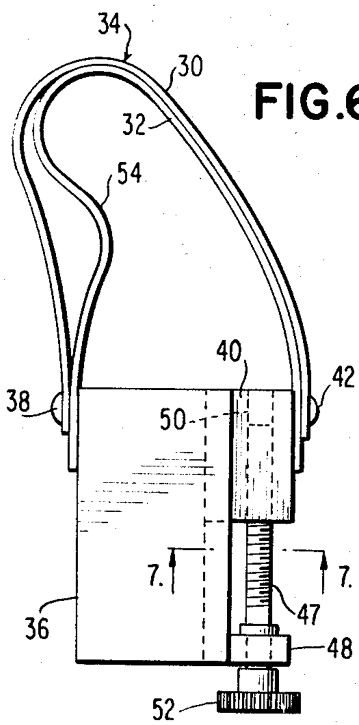

FIG.6

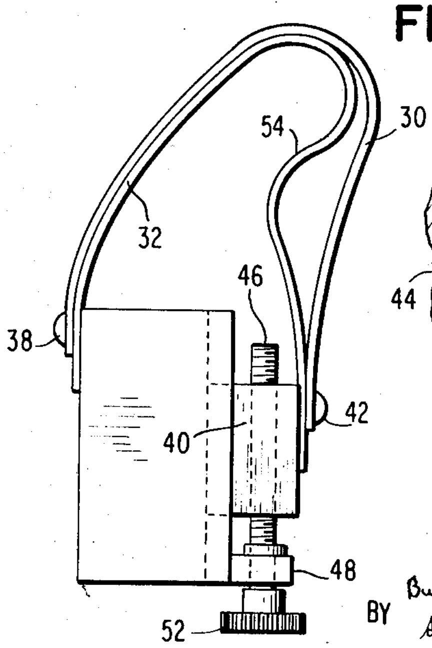

FIG.8

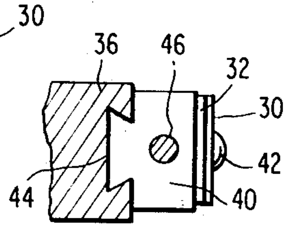

FIG.7

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FIG.9

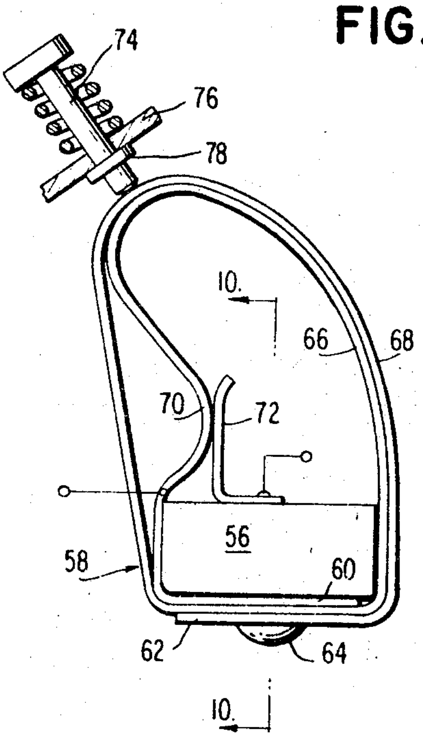
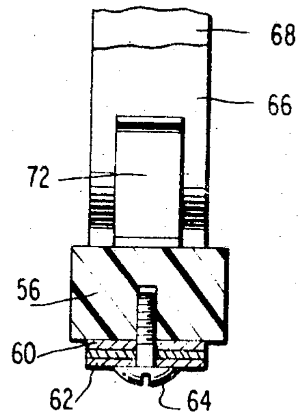


FIG.10



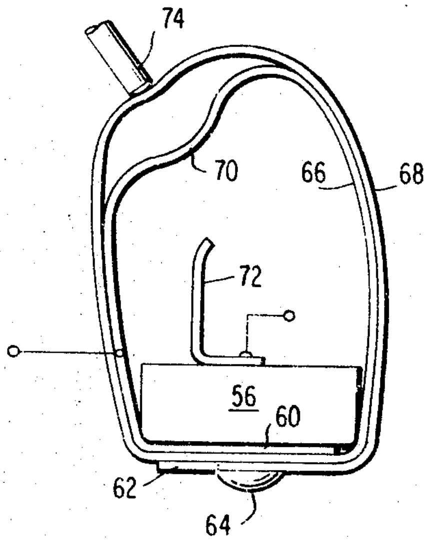


FIG.11

SNAP ACTION APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

Two related applications of Donald F. Wilkes entitled respectively "Mechanical Apparatus" Ser. No. 32,886 and "Cyclic Apparatus" Ser. No. 32,808 are being filed concurrently herewith. Both applications disclose related subject matter, and the disclosures thereof are incorporated herein by reference.

BACKGROUND OF THE INVENTION

This invention relates to snap action apparatus, and more particularly, to apparatus for rapidly transporting an operative element from one position to another.

Various kinds of snap action devices are presently known. One common type utilizes a blade that is permanently deformed, so that it is biased toward stable positions on either side of an intermediate unstable position. When an actuating member deflects the blade toward its intermediate position, the resistance of the blade to further deflection decreases as the blade approaches the intermediate position. When the blade has been deflected as far as the intermediate unstable position, further deflection by the actuating member causes the blade to snap over to the opposite stable position.

Since the resisting force exerted by the blade just before snapping over is very small, the degree of deflection necessary to cause the blade to snap is uncertain. The point at which the blade will snap can be affected by vibration or other external factors.

Another disadvantage of many snap action devices is that the permanently deformed blade is not capable of snapping across a large distance. Typically, the blade is circular or elongated and to increase the displacement of the blade, it is necessary to strengthen the blade. This adds to the cost of the snap action device and increases the error in displacement that is required for snapover. A stronger blade also requires higher actuating forces.

Snap action blades are typically subjected to high stresses and therefore are usually made of high quality steel. Heavy metal stamping machines are then required to form the blades, and as a result the blades are expensive to produce.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide improved snap action apparatus.

Another object of this invention is to provide snap action apparatus that is capable of snapping over a large distance.

It is a further object of this invention to provide snap action apparatus in which the resistance to deflection by the actuator increases until the snapping element snaps over to the opposite position.

A further object of this invention is to provide snap action apparatus in which the movement of the actuator is relatively small in relation to the displacement of the snapping element.

A still further object of this invention is to provide snap action apparatus that can be fabricated efficiently and inexpensively.

These objects are accomplished in accordance with a preferred embodiment of the invention by supporting a pair of elongated flexible bands in a loop, with one of the bands on the inside of the loop and the other band on the outside of the loop. The inner band is resiliently flexed in a lobe arching inwardly from the outer element. The bands are secured together at opposite ends of the loop. The lobe snaps over from one side of the loop to the other in response to a change in curvature of the bands. The change of curvature is accomplished by an actuator which engages the outer band. By displacing the actuator element inwardly, the curvature of the bands changes until the lobe snaps over to the opposite side of the loop. In another preferred embodiment, one end of the loop is displaced relative to the other end of the loop. This causes a change in the curvature of the loop and the lobe snaps over to the opposite side of the loop.

DESCRIPTION OF THE DRAWINGS

These preferred embodiments are illustrated in the accompanying drawings in which:

FIG. **1** is a side elevational view, partially schematic showing an electrical switch incorporating the apparatus of this invention;

FIG. **2** is a cross-sectional view of the switch along the line **2—2** in FIG. **1**;

FIG. **3** is a schematic view of the switch showing the initial deflection of the loop by the actuator;

FIG. **4** is a schematic view of the switch showing deflection of the loop to an intermediate position by the actuator;

FIG. **5** is a schematic view of the switch showing the position of the lobe after snapping over;

FIG. **6** is a side elevational view, partially schematic of a snap action device in accordance with this invention, showing the lobe at one stable position;

FIG. **7** is a cross-sectional view of the device along the line **7—7** in FIG. **6**;

FIG. **8** is a side elevational view of the device of FIG. **6** showing the lobe in the opposite stable position;

FIG. **9** is a side elevational view of a spring biased switch in accordance with this invention;

FIG. **10** is a cross-sectional view of the switch along the line **10—10** in FIG. **9**; and

FIG. **11** is a side elevational view of the switch in open circuit position.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. **1**, the snap action apparatus of this invention is shown as incorporated in an electrical switch. The switch includes a base **2** having opposite sides **4**. A pair of thin flexible bands **6** and **8** are arranged in a loop and are joined together at opposite ends of the loop to prevent longitudinal movement of one band relative to the other.

This is accomplished by a pair of screws **10** which extend through holes in the respective bands and the screws are secured in the base **2**.

The inner band **8** has a greater length between the screws **10** than does the band **6**, and the inner band is resiliently flexed in a lobe **12** that arches inwardly from the outer band **6**. The outer band may be formed of any suitable material that is capable of supporting tensile streeses imposed by the inner band and is sufficiently flexible to rapidly change its shape without plastic deformation. Examples of materials that are suitable for the band 6 include polyethylene and other plastic materials, and metal foil. The inner band 8 is formed of a thin, resiliently flexible material that is capable of flexing without permanent deformation. The material of the band 8 should also resist becoming permanently set when it remains in a flexed shape for a long period of time. Examples of materials that can be used for the inner band include Mylar (polyethylene terephthalate), and steel.

The lobe 12, when it is in the position shown in FIG. 1, extends from the base 2 where the inner band is clamped between the outer band and side 4 to the point where the inner band engages the outer band, which is near the point of maximum curvature of the outer band in FIG. 1. Movement of the lobe 12 relative to the outer band 6 from the position shown in FIG. 1 to the opposite side of the loop 9 is accomplished by progressively displacing the inner band 8 outwardly into engagement with the outer band 6 at the rear end of the lobe 12, which is adjacent the base 2. At the same time the front end of the lobe 12 is progressively peeled away from the outer band 6 and the lobe progresses along the inner band from the position shown in FIG. 1 to the opposite side of the loop where its movement is stopped by the base 2.

As shown in FIG. 1, the band 8 at the upper end of the lobe 12 has a greater curvature than the band at the opposite end of the lobe. The difference in curvature in the inner band 8 urges the lobe to progress downwardly toward the base 12, but since the opposite end of the lobe is clamped between the outer band 6 and the side 4, the lobe cannot progress further downwardly. The outer band 6 supports the inner band in tension and therefore seeks to assume the shortest length between the screws 10. The bending of the inner band 8 adjacent the upper end of the lobe 12 urges the outer band 6 upwardly to the left, as viewed in FIG. 1.

The dimensons of the lobe and loop include the height H, which is the shortest distance between the apex of the lobe 12 and the outer band 6. The length L of the lobe is measured along the inner surface of the outer band 6 and the width of the loop W is measured between the leg portions 9 of the inner band 6. The curved portion 11 of the loop is indicated at 13 in FIG. 1.

A plunger 14 is mounted for reciprocating movement in a housing 16. A coil spring 18 on the plunger urges the plunger away from the band 6, while a shoulder 20 on the plunger engages the housing 16 for positioning the end of the plunger to be engaged by the outer band 6 When the plunger is retracted. As shown in FIG. 2, the outer band 6 includes a conductor 22 which engages the end of the plunger 14 for completing a circuit when the conductor 22 is in engagement with the plunger.

Another plunger 24 is similarly mounted for reciprocating movement in the housing 16 and has a coil spring 26 for retracting the plunger. A shoulder 28 on the plunger positions the end of the plunger for engagement by the band 6 when the lobe is at the opposite side of the loop 9.

The sequence of snapping the lobe from one side of the loop to the other is shown in FIGS. 3, 4 and 5. As shown in full lines in FIG. 3, the lobe 12 is at the left side of the loop 9. As the plunger 14 is displaced inwardly, the curvature of the outer band 6 decreases and at the same time, the curvature of the inner band 8 decreases. Due to the tension in the outer band, the frictional force between the outer and inner bands during displacement to the position shown in dotted lines in FIG. 3 is sufficient to prevent sliding of the bands relative to each other. Therefore, energy builds up in the lobe 12 as deflection of the loop 9 continues. When the loop has been deflected to the position shown in FIG. 4, the curvature of the outer band 6 is larger, and as a result the frictional forces resisting longitudinal sliding of the inner band relative to the outer band are reduced. When the energy stored in the inner band tending to cause sliding relative to the outer band overcomes the frictional resistance between the bands, sliding occurs suddenly at the front end of the lobe while the flexing of the outer band 6 adjacent the rear end of the lobe urges the lobe to progress rapidly to the opposite side of the loop until it reaches the position shown in FIG. 5. The progression of the lobe occurs extremely rapidly to carry the curved portion of the lobe 9 into engagement with the plunger 24. As soon as sliding occurs between the bands, much less force is required to continue the sliding because the coefficient of sliding friction is less than the coefficient of static friction for all materials. The progression of the lobe along the outer band 6 is inhanced by air that may be trapped momentarily between the bands as the lobe progresses from one side of the loop to the other.

In operation, with the loop 9 in the position shown in FIG. 1, when the plunger 14 is depressed, the lobe 12 snaps over to the opposite side of the loop, bringing the outer band 6 into engagement with the plunger 24. As a result of the movement of the outer band 6, the electrical circuit is disconnected from the plunger 14 and connected with the plunger 24. Subsequently, by depressing the plunger 24, the bands in the loop 9 are displaced in the manner described with respect to FIGS. 3 to 5, causing the lobe 12 to snap over to the position shown in FIG. 1. Release of the plunger 24 allows the spring 26 to return the plunger to the outward position.

Another embodiment of the snap action apparatus is illustrated in FIGS. 6 to 8. A pair of thin flexible bands 30 and 32 are arranged in a loop 34. One end of the loop is secured to a base 36 by a fastener 38 which extends through holes in the bands 30 and 32. The opposite end of the loop 34 is secured to a slide 40 by a fastener 42 which extends through holes in the bands 30 and 32. As shown in FIG. 7, the slide 40 is received in a dove-tail slot 44 in the base 36. A screw 46 is mounted on a bracket 48 on the base 36 and extends through a threaded bore 50 in the slide 40. The end of the screw 46 has a knob 52 for turning the screw.

The loop 34 is initially positioned as shown in FIG. 6 with a lobe 54 on one side of the loop 34. When the screw 46 is turned, the slide 40 is displaced along the slot 44, drawing the bands 30 and 32 downwardly. This movement of the bands changes the shape of the loop 34 in the same manner as shown in FIGS. 3 to 5, until slippage of the inner band 32 relative to the outer band

30 occurs and the lobe **54** progresses rapidly to the position shown in FIG. **8**. The height of the lobe above the base **36** is substantially less in FIG. **8** than it is in FIG. **6** because the right end of the lobe is displaced downwardly relative to the left end of the lobe. By turning the screw **46** in the opposite direction, the slide **40** is displaced upwardly until it reaches a position at which the lobe **54** snaps over to the position shown in FIG. **6**.

Another embodiment of the invention is illustrated in FIGS. **9** to **11** in the form of a spring biased single pole, single throw switch. The switch includes a base **56** and an elongated thin flexible strip or band **58**. Both ends **60** and **62** of the band are secured to the bottom of the base **56** by a screw **64**. The band extends continuously from the end **60** around the opposite side of the base in an inner loop **66** and then across the end **60** in overlapping relation. The band further extends around the inner loop **66** to form an outer loop **68** and the opposite end **62** is secured to the base, so that the inner and outer loop portions of the band are unable to slide longitudinally relative to each other.

The inner loop **68** has a length that is sufficiently greater than that of the outer loop **68** to form a lobe **70** which projects inwardly. A contact element **72** is mounted on the base **56** in position to engage the surface of the band adjacent the apex of the lobe **70**. Preferably, the portion of the band that engages the contact element **72** is electrically conductive, so that when the lobe **70** is in the position shown in FIG. **9**, an electrical circuit is completed through the element **72** and through the conductive portion of the band.

A reciprocating plunger **74** is mounted on a fixed support **76**, and the end of the plunger engages the outer band portion **68**. There is sufficient resilience in the loops **66** and **68** to urge the plunger **74** outwardly until the flange **78** on the plunger engages the support **76**. When the plunger **74** is displaced inwardly, both of the loops **66** and **68** are flexed inwardly. This displacement of the loops causes the lobe **70** to progress from the position shown in FIG. **9** to the position shown in FIG. **11**. The lobe **70** remains in the position shown in FIG. **11**, since the inner band **66** must be flexed to a greater degree at opposite ends of the lobe **70** to cause the lobe to progress in either direction away from the position shown in FIG. **11**. As soon as the plunger **74** is released, the resilience of the inner and outer loops displaces the plunger outwardly to the position shown in FIG. **9** and since the inner lobe has a greater curvature at the right-hand end of the lobe **70**, as viewed in FIG. **11**, the lobe snaps quickly back to the position shown in FIG. **10**.

The switch of FIGS. **9** to **11** is easily operated merely by depressing the plunger **74** against the spring bias of the loop **66** and **68** to disconnect the electrical circuit between the brackets **72** and the lobe **70**, while the band portion **66** and **68** provide the bias to return the plunger **74** as soon as it is released and also to displace the lobe **70** back to its original position. Since there is virtually no sliding between the components of the switch, wear is minimized. Also, since both the inner and outer loops are formed of a single band the assembly of the unit is simplified.

The snap action apparatus in accordance with this invention may be easily manufactured from thin flexible strips or bands. Since the bands are not permanently deformed, but are merely stressed and flexed during assembly, these devices may be efficiently and economically manufactured. Also, the snap action apparatus may be provided in various sizes according to the displacement or force required. Although sliding occurs between the bands, there is very little wear because most of the motion takes place by the lobe progressing along the inner band and the outer band merely flexes to accommodate the movement of the lobe along the band.

Since the change in shape of the lobe is accompanied by an increase in flexing of the bands, resistance to further displacement of the lobe increases as the point of snapover is approached. As soon as slippage begins, however, the resistance to further deflection of the loop drops dramatically and the lobe progresses rapidly to the opposite side of the loop. Thus, the snap action apparatus of this invention produces a snapping action which is not adversely affected by vibration and the displacement required for snapover remains substantially constant for each particular device.

While this invention has been illustrated and described in several preferred embodiments, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

I claim:

1. Apparatus comprising a pair of elongated flexible elements, support means, said elements being arranged in a loop and held by said support means, one of said elements being on the outside of said loop and the other element being on the inside of said loop, said inner element being resiliently flexed in a lobe arching inwardly from said outer element, said loop having opposite leg portions joined together by a curved portion, said lobe being movable between said leg portions by progressing along said inner element relative to said outer element, said lobe being stable when adjacent either of said leg portions while the inner element forming said lobe has a greater curvature adjacent one end of said lobe than adjacent the opposide end of said lobe, whereby said lobe is biased away from said curved portion and toward said leg portions.

2. The apparatus according to claim **1** including stop means for limiting the progression of said lobe along one of said leg portions away from said curved portion, whereby said lobe is biased toward a predetermined position relative to said outer element.

3. The apparatus according to claim **1** including means for changing the curvature of said inner element at opposite ends of said lobe, whereby the direction of bias of said lobe is reversed and said lobe tends to progress away from said one leg portion toward the other leg portion.

4. Apparatus comprising a pair of elongated flexible elements arranged in a loop, one of said elements being on the outside of said loop and the other element being on the inside of said loop, said inner element being resiliently flexed in a lobe arching inwardly from said outer element, said loop having opposite leg portions joined together by a curved portion, said lobe being movable between said leg portions by progressing along said inner element relative to said outer element, means supporting said loop ends in fixed relation to each other, said supporting means including means holding said inner and outer elements against relative longitudinal movement at opposite ends of said loop, said lobe when adjacent said leg portions having a greater curvature adjacent one end of said lobe than adjacent the other end of said lobe, and means for changing the curvature of said inner element at opposite ends of said lobe, whereby said curvature change occurs between said opposite ends of said loop and the direction of bias of said lobe is reversed by said changing means, and said lobe tends to progress away from said one leg portion toward the other leg portion.

5. The apparatus according to claim **4** wherein said loop ends are spaced apart from each other, and including actuator means adjacent said curved loop portion and including means for engaging said outer element and flexing said loop relative to said loop ends, whereby the shape of said curved portion changes and said lobe is biased away from said one leg portion toward the other leg portion.

6. The apparatus according to claim **5** wherein said supporting means includes a base on which said loop ends are secured in spaced apart relation, and said flexible elements are in the shape of bands having a substantially greater width than thickness.

7. The apparatus according to claim **1** wherein said flexible elements are in the shape of bands having a substantially greater width than thickness, said outer band flexes upon movement of said lobe from one stable position to the other, said outer band yieldably flexing said inner band at the end of said lobe that is spaced from said loop end.

8. The device according to claim **3** wherein said curvature changing means includes means for displacing the ends of said loop longitudinally relative to each other, whereby said lobe is displaced from one stable position to the other.

9. A method of rapidly displacing one flexible longitudinal element relative to another flexible longitudinal element comprising:

arranging said elements in a loop with said one element on the inside and the other element on the outside of the loop,

resiliently flexing said inner loop in a lobe arching inwardly from said outer element,

holding said elements adjacent the opposite ends of said loop against longitudinal movement realtive to each other,

progressively reducing the flexing of said inner element at the end of said loop lobe closest to the curved portion of said loop, and

sliding a portion of said inner element relative to said outer element as said lobe progresses from one side of the loop to the other, whereby said lobe ultimately snaps over to the opposite side of said loop.

* * * * *