United States Patent

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[54] **ROLAMITE APPARATUS**
18 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **200/153 R,** 184/29
[51] **Int. Cl.** **H01h 3/32**
[50] **Field of Search** ..... 200/153 R; 184/29; 335/207; 308/6

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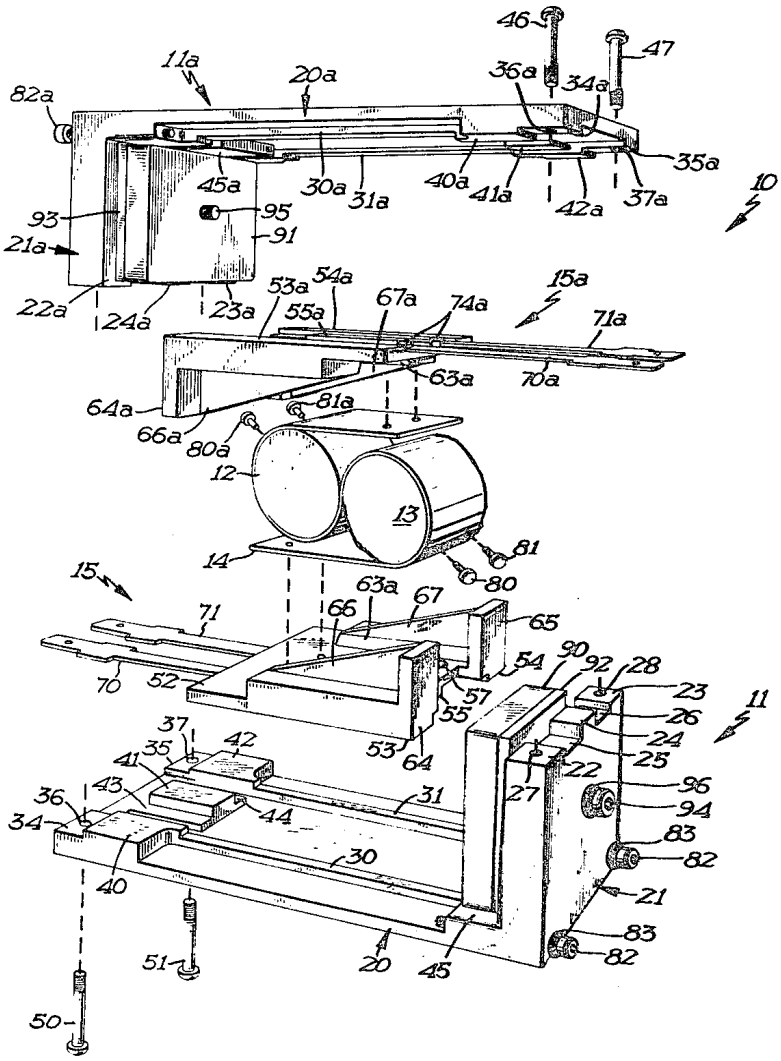
ABSTRACT: Rolamite apparatus including a pair of rollers entrapped in the loops of a generally S-shaped band with each of the rollers being electrically conductive and having electrical contacts extending radially outward therefrom and through the band and having an enlarged head portion which secures the band to the rollers. A housing for the rolamite apparatus has a pair of slide members longitudinally movable therein, one of them cooperating with each of the rollers and providing a guide and an end stop for the cooperating roller and having one end of the flexible band fixed to it whereby the slide members can be moved longitudinally relative to each other to affect tensioning of the band. The slide members also have fixed thereto contacts cooperable with the electrical contacts which are carried by the rollers in predetermined positions of the rolamite device. In the disclosed arrangement the band applies no substantial bias to the rolamite device and calibration is accomplished by longitudinally movable permanent magnets disposed on each end of the frame and establishing a magnetic coupling with the rollers which are formed of magnetically attractable material. In an alternative form the band provides an internal bias urging the rollers to one position while a permanent magnet establishes a magnetic coupling with the rollers and is adjustable longitudinally to provide adjustment of this coupling force.



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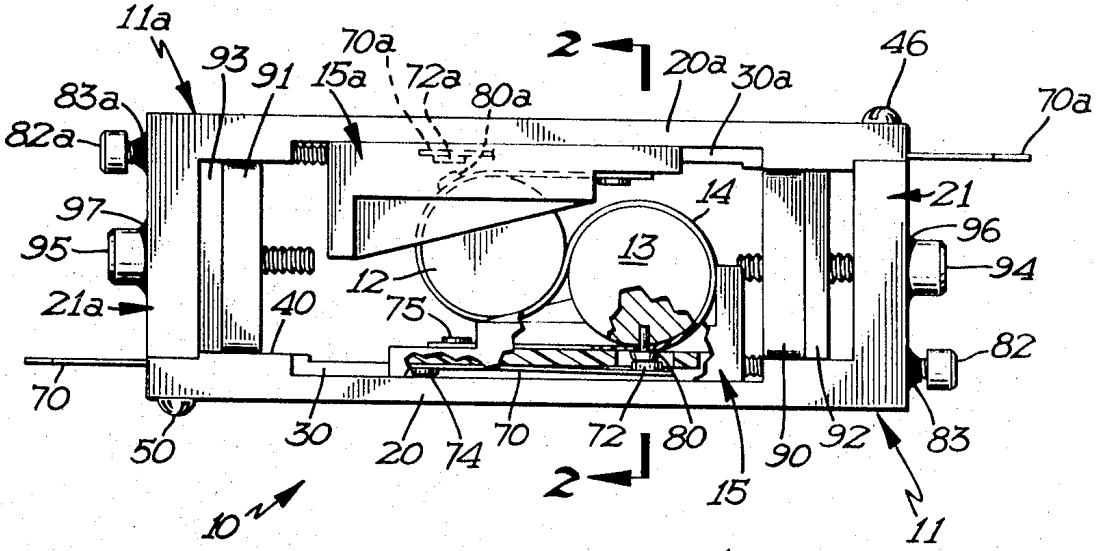


FIG 1

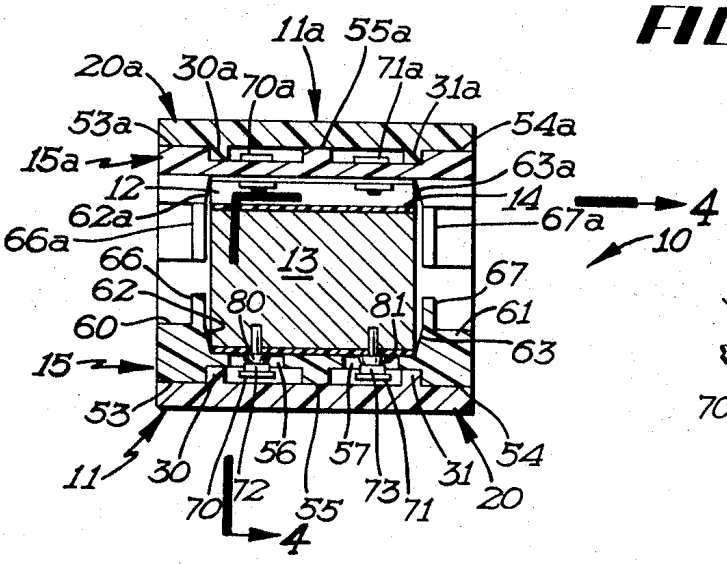


FIG 2

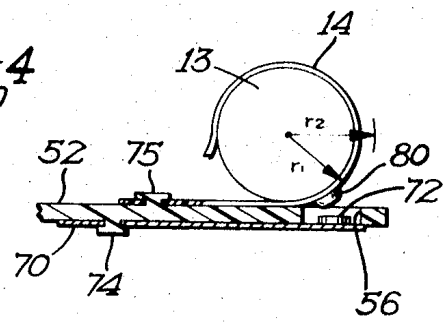


FIG 4

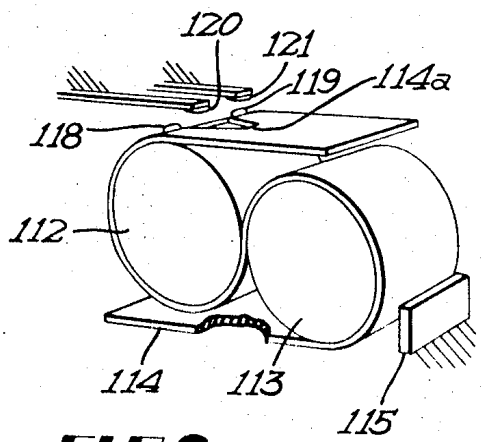


FIG 6

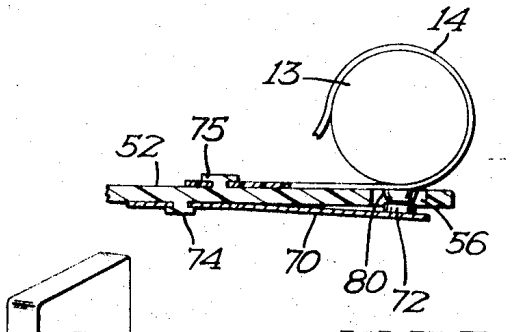
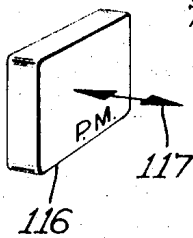


FIG 5



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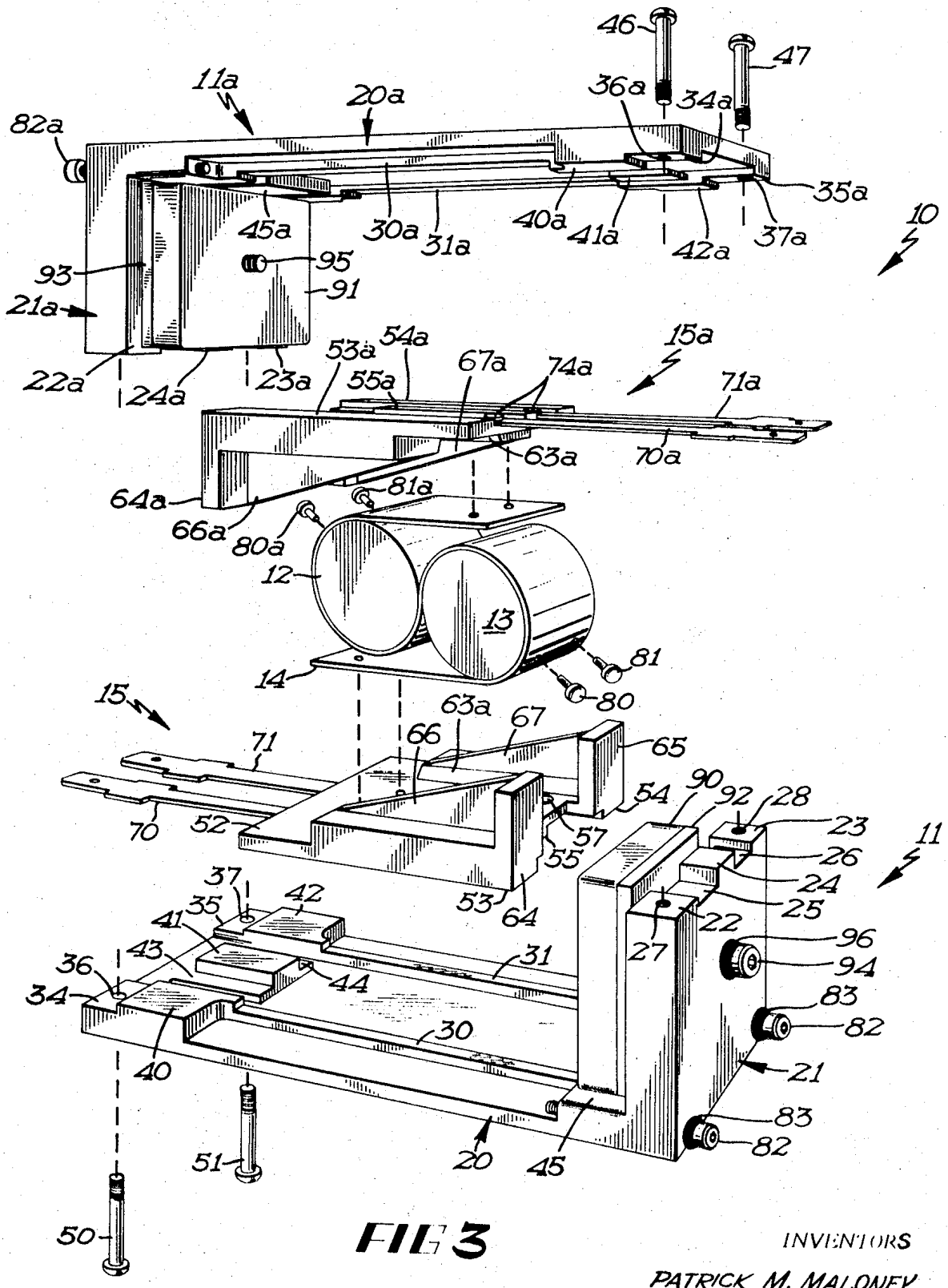

FIG 3

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ROLAMITE APPARATUS

BACKGROUND OF THE INVENTION

Rolamite devices have received a great deal of publicity recently and the invention has been hailed as one of the major technological advances of the current decade. These devices and various applications of them are known. For example, a detailed technical description of various types of rolamite devices and applications therefore are disclosed Government Research Report SC-RR-67-656. The publication discloses such devices used for electrical switching and for many other applications. It is known that these devices offer many advantages, particularly that they operate with extremely low friction and thus can be responsive to extremely small actuating forces. In addition they can be made extremely small because of their simplicity.

In spite of the foregoing, there has been little, if any, commercial application of the rolamite principle although many persons and organizations have been working on such devices. It is believed that this has been due a large part to difficulty in assembling these devices and in accurately calibrating them and maintaining such calibration. In addition, there has been some difficulty in adapting conventional switching apparatus for operation by the rolamite apparatus. One adaption of the rolamite apparatus to electrical switching is disclosing in the copending application, of Gary R. Bluem, Ser. No. 765,297, filed Oct. 7, 1968. This application discloses an arrangement wherein a rolamite apparatus operates an externally mounted snap switch through an appropriate force amplifying linkage. The present invention is deemed to be an improvement over the invention disclosed in the aforesaid application.

BRIEF DESCRIPTION OF INVENTION

The present invention provides a rolamite apparatus wherein assembly and calibration is made extremely simple. One feature of the invention is the utilization of at least one permanent magnet which establishes a magnetic coupling with at least one of the rollers of the rolamite device which is constructed of or contains magnetically attractable material. The permanent magnet is movable toward and away from the cooperating roller to adjust the bias on the rollers urging them in a direction toward the permanent magnet. In the preferred arrangement the permanent magnet is rendered unmovable after this initial calibration. In one form of the invention two of these permanent magnets are utilized, one adjacent to each of the longitudinal ends of the frame of the rolamite apparatus and each cooperating with the rollers to provide a bias force urging them in opposite directions. The operating point of the device is determined by adjusting each of the permanent magnets toward and away from the rollers.

Another feature of the invention is the provision of at least one slide member longitudinally movable within the frame of the rolamite apparatus and having one end of the flexible rolamite band connected thereto while the other end is fixed to the frame. The tension of the band can be readily adjusted by moving the slide member back and forth longitudinally with respect to the frame. In a preferred form for both ends of the band are connected to such slide members which can be moved longitudinally relative to each other to adjust the tension in the band. Again, once the adjustment is accomplished further movement may be precluded by appropriate disabling means. These slide members preferably provide end guide means for the rollers and end stops therefore. In a preferred form the slide members also carry fixed electrical contacts which cooperate with movable contacts themselves carried by the rollers. This permits adjustment of the tension in the band while maintaining the critical placement of the fixed contacts.

In a preferred form the rollers are formed of electrically conductive material and have electrical contacts extending generally radially therefrom and through the flexible rolamite band. These contacts provide an electrical path through the band to the roller and also fix the roller to the band. When this arrangement is utilized with the slide members described above, the slide members, the band and the rollers, as well as the fixed contacts, form a single unit which can be assembled and then placed within the frame member of the rolamite apparatus. Adjustment can readily be accomplished to tension the band while the alignment of the fixed contacts is always maintained. A relatively fast switching action is accomplished with a good wiping action and substantial contact force whereby relatively large amounts of electrical current can be conducted with a very simple apparatus. This provides a simple switching apparatus which is equally capable of conducting very small current loads as well as relatively large current loads without any change in the structure of the apparatus. In the preferred arrangement each of the slide members carries fixed contact members and each of the rollers carries a pair of movable contact members cooperable therewith whereby the apparatus may be utilized to perform two electrical switching functions, one in each of its end positions.

With the structure described above, a very simple frame can be utilized for the rolamite apparatus. This frame may comprise two identical parts which are formed so that the assembly of the slide members, the band, the rollers and the fixed contact members can be placed therein and then the two parts secured together for ease in assembly. Thereafter the position of the slide members may be adjusted to achieve the desired tensioning of the band. If the permanent magnet biasing means as described above are utilized, these magnets are also mounted within the frame members and moved longitudinally therein toward and away from the rollers and can be adjusted to a position to provide the desired bias on the rollers. After these adjustments are accomplished the slide members and the magnets are fixed so that the adjustment is maintained.

DESCRIPTION OF DRAWING

FIG. 1 is a side view of a switch apparatus utilizing the features of the present invention, disclosed with portions broken away to better illustrate the invention.

FIG. 2 is a transverse cross-sectional view taken generally along line 2–2 of FIG. 1.

FIG. 3 is an exploded perspective view disclosing in detail the components of the switching apparatus disclosed in FIGS. 1 and 2.

FIG. 4 is a fragmentary view, partially in cross section, taken generally along line 4–4 in FIG. 2, and disclosing a pair of electrical contacts which form a part thereof in their open position.

FIG. 5 is identical to FIG. 4 except that it discloses the apparatus in a position wherein the electrical contacts are closed.

FIG. 6 discloses schematically and in perspective another embodiment of the invention.

DETAILED DESCRIPTION OF INVENTION

Referring to the drawing, particularly to FIGS. 1, 2 and 3, reference numeral 10 refers generally to a rolamite apparatus including a frame comprising two substantially identical and mating frame members 11 and 11*a*, a pair of rollers 12 and 13, and a generally S-shaped band 14 having one of the rollers entrapped in each of the loops of the S shape. Opposite ends of band 14 are connected to substantially identical slide members 15 and 15*a* which cooperate with frame members 11 and 11*a*, respectively.

Frame members 11 and 11*a*, as indicated, are substantially identical. Preferably they are formed of electrically insulative and nonmagnetic material. In the preferred form they are molded plastic members. Frame member 11 will be described in detail. It is generally L-shaped, as viewed from the side, and includes a long leg 20 and a short leg 21 extending generally perpendicular thereto, Leg 20 extends generally in a longitudinal direction and normally will extend generally horizontally while 21 extends generally vertically. Leg 21 is substantially plain with both the inside and outside surfaces being generally

smooth. At its upper end leg 21 has a pair of equally extending pillars 22 and 23 adjacent the outer edges thereof and at the center has an upstanding piller 24 which extends a distance slightly greater than do pillars 22 and 23. This construction leaves a space or slot 25 between pillars 22 and 24 and a slot 26 between pillars 24 and 23. The upper ends of pillars 22 and 23 may have tapped holes 27 and 28, respectively, as can be seen in FIG. 3.

Longitudinally extending leg 20 has a generally flat bottom or outer surface while the inner surface includes a pair of longitudinally extending rails or ribs 30 and 31 extending generally parallel to each other, spaced on opposite sides of the longitudinal center of leg 20, and spaced inwardly from the outer edges thereof. Adjacent the remote end of leg 20 it has a pair of slightly upstanding pads 34 and 35 and having vertically extending holes 36 and 37 extending therethrough, respectively. Slightly inward are three upstanding and spaced pillars 40 41 and 42 with spaces 43 and 44 between pillars 40 and 41, and between pillars 41 and 42, respectively. Adjacent the point of joinder between legs 20 and 21, on leg 20, is a stepped up or abutment portion 45 the function of which will be described in further detail hereinafter.

Frame member 11*a*, as mentioned, is identical to frame member 11. Similar parts thereon have been given similar letter designations but are followed by the letter *a*. In FIG. 3, the raised portion 45*a* on member 11*a* can be seen in more detail than can portion 45 on member 11. It actually includes three spaced portions, one adjacent each of the outer edges of the frame member and one at the center. As can best be seen in FIGS. 1 and 2, frame members 11 and 11*a* are constructed so that they can be put together with one of them reversed and inverted with respect to the other whereby they fit together to provide a substantially rectangular frame with legs 20 and 20*a* extending parallel to each other and legs 21 and 21*a* also extending parallel to each other. When assembled, pads 34*a* and 35*a* rest on pillars 22 and 23, respectively, with surfaces 40*a* and 42*a* providing an abutment on the inside of pillars 22 and 23, respectively, to locate the two members with respect to each other. The two members are then secured together by appropriate fastening means such as screws 46 and 47 extending trough holes 36*a* and 37*a* in pads 34*a* and 35*a*, respectively. Pillar 24 on leg 21 extends upward to a position where it just engages the inner surface of the under side of leg 20*a* of frame member 11*a*, between pads 34*a* and 35*a*, thereby isolating slots 25 and 26 from each other. At the other end of the frame, pillars 22*a* and 23*a* engage pads 34 and 35 in a similar manner and screws 50 and 51 extend through holes 36 and 37 into tapped holes (not shown) in leg 21*a*.

It will be appreciated that these frame members may be formed so that they completely enclose the rolamite apparatus disposed therein and so that they may be hermetically sealed after assembly and calibration is completed. For illustrative purposes a simple for with open sides disclosing the internal components has been shown here. While the frame members have been secured together by screws in the exemplary embodiment, it will be appreciated that other methods, such as ultrasonic welding or solvent bonding, may be used.

As indicated, slide members 15 and 15*a* are substantially identical. These members are preferably formed of electrically nonconductive and nonmagnetic material and in the preferred form are also moulded plastic parts. By the way of example, slide member 15 will be described in detail. Member 15 includes a generally flat base portion 52 which has a pair of flanges 53 and 54 extending downwardly from the underside thereof and extending longitudinally along each of the outer edges. As can best be seen in FIG. 2, flanges 53 and 54 are generally parallel and are spaced sufficiently so that, when slide member 15 is placed on frame member 11, these flanges just straddle upstanding rails 30 and 31 on leg 20 of the frame member. Also, these flanges have a height substantially equal to the height of rails 30 and 31 while the bottom of flanges 53 and 54 engage the upper surface of leg 20 when slide member 15 is mounted on frame member 11. As can also be seen best in FIG. 2, slide member 15 also has a downwardly and longitudinally extending central flange 55 extending therefrom to a position where it engages the upper surface of leg 20 approximately midway between rails 30 and 31. A pair of circular holes extend through base portion 52 of slide member 15, a first hole 56 being disposed between flanges 53 and 55 and a second such hole 57 being disposed between flanges 55 and 54.

On the upper surface of base portion 52, there are a pair of longitudinally extending flanges 60 and 61 extending along each of the longitudinal edges for the major portion of length of member 15. Flanges 60 and 61 are generally parallel and on their inner surfaces have inclined surfaces 62 and 63, respectively, sloping inward from top to bottom, and joining base portion 52 along a pair of parallel lines spaced a distance approximately equal to the length of the rollers. Adjacent the forward end of member 15 (the right hand end as seen in FIG. 3) there are a pair of spaced upwardly extending post members 64 and 65 extending upwardly and inwardly from the outside edges of the member. These two posts extend inwardly to a position somewhat inside of the upwardly extending flanges 60 and 61. As will be discussed further below, members 64 and 65 provide an end abutment for the roller and band assembly, thus defining one of its end positions. Strengthening ribs 66 and 67 may be provided for posts 64 and 65 respectively.

Disposed on the underside of base portion 52 are a pair of electrical conductor members 70 and 71 extending longitudinally in the spaces between downwardly extending flanges 53 and 55, and between flanges 55 and 54, respectively. These electrical conductors preferably take the form of metal strips, preferably a metal such as beryllium copper whereby they are not only electrically conductive but also have a fairly substantial and relatively unchanging spring constant. At their forward ends conductors 70 and 71 carry upwardly extending electrical contacts 72 and 73, respectively. Conductors 70 and 71 are secured to the underside of slide member 15 with contacts 72 and 73 aligned with openings 56 and 57 in slide member 15, respectively. Preferably these conductor members are secured so that they lie flat along the under surface of base portion 52 with the electrical contacts extending upward into the two openings in member 52. FIG. 4, which is a schematic showing, shows one way in which these conductors may be secured to the slide member. There portion 52 is shown to have a downwardly extending post 74 extending through an opening in conductor 70 and heat staked over to secure the conductor. Further toward opening 56 in slide member 15, portion 52 has an upwardly extending post 75 which extends through band 14 and is heat staked over to secure band 14 to the upper side of portion 52. It will be appreciated that a similar heat staked post extending from portion 52 and through band 14 at a position spaced laterally from post 75. Appropriate washers 77 may be used on the upper surface of band 14 so that the ends of the posts are actually flatted against these washers which in turn provide a substantial bearing surface on the band to prevent it from tearing out.

Because slide member 15*a* is substantially identical to member 15, similar parts thereof have been given identifying numerals similar to those used in the description of member 15 but are followed by the letter *a*. It will be appreciated that slide member 15*a* cooperates with the inner surface of leg 20*a* of frame portion 11*a* in the same manner as slide member 15 cooperates with leg 20 of frame member 11. The opposite end of band 14 is connected to slide member 15*a* by posts 75*a* and electrical conductors 70*a* and 71*a*, having contacts 72*a* and 73*a* adjacent their inner ends, and secured to slide member 15*a* by posts 74*a*.

In a preferred form of the invention, as disclosed in FIGS. 1 through 5, rollers 12 and 13 are electrically conductive members, preferably formed of an electrically conductive metal. If desired they may be formed of some other material and have a surface portion which is electrically conductive. While shown as solid cylinders, the rollers may also be hollow cylinders. As

indicated, these rollers are disposed and actually entrapped in the loops of the S-shaped band **14**. Band **14** may be an electrically nonconductive member formed of a relatively flexible material such as a polyester film or the like which will offer substantially no internal spring force acting upon the rollers. Each of the rollers is physically attached to the band by means of generally radially extending contact members with enlarged heads and with a reduced stem extending through the band and press fitted into radially extending openings in the roller. For example, contacts **80** and **81** have stems extending through the band and into roller **13**. These contacts are disposed in side by side relationship are are spaced apart a distance substantially equal to the distance between fixed contacts **72** and **73** on electrical conductors **70** and **71**. Also, the contacts are disposed longitudinally in a position where they extend through the openings **56** and **56** for cooperation with the fixed contacts. It will be appreciated that when the contacts are in engagement as disclosed in FIGS. **2** and **3** an electrical circuit is completed through conductor **70**, fixed contact **72**, movable contact **80**, roller **13**, movable contact **81**, fixed contact **73** and conductor **71**. Similarly, contacts **80***a*, and **81***a* extend through band **14** and have reduced stem portions extending into roller **12** whereby, when these contacts engage the fixed contacts **72***a* and **73***a*, a circuit is completed between electrical conductors **70***a* and **71***a*, through conductive roller **12**. In some cases a metal band providing an internal bias may be used with the contacts and conductive roller still providing a low resistance current path for connecting two cooperating fixed contacts.

When the flexible band and the conductors have been attached to slide members **15** and **15***a* and the rollers attached to the band as described above, they form a subassembly which can be placed into the frame before the two parts thereof are assembled. Once the electrical conductors and the band are secured to slide members **15** and **15***a* and the rollers secured to the band, the appropriate movable contacts will always be in a position where they are aligned with their mating fixed contacts regardless of the relative position of slide members **15** and **15***a*. Thus, slide members **15** and **15***a* can be placed inside the frame and adjusted longitudinally toward and away from each other to achieve the desired tension in band **14**. By way of example, adjustment screws **82** are shown threaded through leg **21** of frame member **11** and adapted to abut the forward end of slide member **15** so that turning of screws **82** into the frame member results in abutment of slide member **15**, moving it to the left (as seen in FIG. **1**). Similarly, screws **82***a* extend through the leg **21***a* of frame member **11***a* and are adapted to abut the forward end of slide member **15***a* so that screws **82***a* can be screwed into the frame to move slide member **15***a* to the right (as seen in FIG. **1**.) Movement of slide members **15** and **15***a* to the left and right, respectively, will result in increasing the tension in band **14**. The tension of the band itself and the forces exerted by the rollers will maintain the slide members in engagement with their mating frame members. Once an appropriate adjustment of tension is accomplished (generally at the time of manufacture,) it is not desirable that further movement of the slide members be permitted because additional tightening or loosening of the band may affect the operation of the device. Therefore, means may be provided to preclude further movement of these members. A material such as an epoxy may be applied, for example as shown at **83** and **83***a* to lock screws **82** and **82***a* with respect to the frame members so that they cannot be turned further. It will be appreciated that other means may be used to move the slide members and to secure the slide members after adjustment. For example, they may be moved by a means which is removable after the adjustment and may be fixed to the frame by ultrasonic welding or solvent bonding.

As indicated, conductors **70** and **71** are preferably formed of a material which is not only electrically conductive but which also has a fairly substantial spring constant and one which will remain substantially uniform. As can best be seen in FIGS. **4** and **5**, these conductors are formed so that they lie along the underside of base portion **52** of slide member **15** with electrical contacts **72** and **73** extending into the openings **56** and **57**, respectively. The following description is limited to conductor **70** and contact **72**. The structure and function of the other conductors and their contacts are similar. Electrical contact **80** extends radially from roller **13** and when the roller is moved to a position wherein electrical contact is to be made, it extends down into opening **56** to engage fixed contact **72**. It will be appreciated that "fixed contact **72**" is not really fixed in that it can move toward and away from opening **56**. Roller **13** has a rolling radius r_1 is somewhat less than radius r_2, which is the distance of the contact surface of contact **80** from the center of roller **13**. As contact **80** rolls into engagement with fixed contact **72**, fixed contact **72** is deflected downward to a position as disclosed in FIG. **5**. As they roll together, there is a scrubbing or wiping action between the two contacts because of the difference in radius r_2 of contact **80** and radius r_1 about which contact **80** as well as roller **13** is rolling as the two contacts come into engagement. This assures that the contacts are wiped clean of any corrosion or dust that good electrical contact is obtained. The amount of contact force between contacts **80** and **72** will be dependent upon the spring constant of conductor **70** and upon the tension in band **14**.

As indicated, in the arrangement disclosed in FIGS. **1** through **5**, band **14** is formed of a material which has substantially no internal spring force acting to bias rollers **12** and **13** to any particular position. The particular switching apparatus disclosed in these figures has special application as a switch whereby the rollers will move from one end to the other in response to tilting of the frame a predetermined number of degrees about a horizontal axis generally through the center of the device. It is well known to use metal bands with various internal spring bias arrangements urging the rollers to one position or another with a predetermined amount of force. However, it has been difficult to calibrate these devices because a very small variation in the material of the band results in rather large variation in the forces applied. Therefore, it is desirable that a means by provided for applying a calibrated force to the roller assembly. In the arrangement of FIGS. **1** through **5**, rollers **12** and **13** are not only electrically conductive but also magnetically attractable being constructed of material such as iron. A pair of permanent magnets **90** and **91** are mounted inside of the frame, magnet **90** being disposed generally adjacent the right hand end and magnet **91** generally adjacent the left hand end of the device, as seen in FIG. **1**. Preferably magnet **90** is backed by a nonmagnetic member such as a plastic member **92** secured thereto and magnet **91** is backed by a similar plastic member **93**. Permanent magnet **90** is movable longitudinally within frame **11** generally toward and away from the rollers. By way of example, a screw **94** is shown threaded through the center of the magnet and may be used to move the magnet back and forth from the exterior of the frame. A similar adjustment screw **95** is provided at the other end of the device for moving permanent magnet **91**. Permanent magnet **90** establishes a magnet coupling with the rollers **12** and **13** urging them to the right against the end stop provided by posts **64** and **65** of slide member **15**. At the same time, permanent magnet **91** established a magnetic coupling with the rollers urging them to the left into engagement with the end stop provided by posts **64***a* and **65***a* on slide member **15***a*. The strength of each magnetic coupling will be determined by the longitudinal position of the permanent magnet. In FIG. **1** permanent magnet **90** has been moved longitudinally inward to a position where it is substantially closer to the right hand end position of the rollers than is permanent magnet **91** with respect to the left hand end position. Thus, a greater force will be tending to move the rollers to the right than to the left. By adjusting the position of these magnets, the angle of tilt at which the rollers will move from one end position to the other can be very accurately selected. Generally this adjustment will be made at the time of manufacture and a means will then be provided for locking the adjustment so that it cannot be changed. Again an appropriate means as for example,

an epoxy at points 96 and 97, can be used to preclude further adjustments. Obviously other means may be used for moving the permanent magnets and for securing them. For example, they may be secured by ultrasonic welding or solvent bonding the backing members to the frame.

It will be appreciated that a single permanent magnet biasing means may be used in various switch applications. For example, if the angle of tilt is only critical in one direction, a single permanent magnet can be used to determine the position in which gravity will move the rollers away from that magnet. Similarly, in acceleration switches a single magnet can be used and adjusted to a position where it exerts a force sufficient to maintain the rollers in a position adjacent the permanent magnet until a specific acceleration force opposes it. Various other applications and variations of this arrangement will be apparent.

While it has not been pointed out specifically, the apparatus is constructed so that the movable contacts carried by roller 13 will engage the cooperating fixed contacts when the rollers occupy the right hand end position and at which time the contacts on roller 12 will be out of engagement with the cooperating fixed contacts. Similarly, the contacts on roller 12 engage their cooperating fixed contacts when the rollers are in the left hand end position, at which time the contacts on roller 13 are out of engagement with their mating fixed contacts. The rollers can move relatively freely back and forth within the limits defined by the slide members 15 and 15*a* and lateral movement is substantially precluded by the sloped surfaces 62 and 63, nd 62*a* and 63*a*, on these slide members.

As has been indicated above, metal bands having internal spring bias are often used in rolamite devices. Calibration of such devices has been difficult. However, such an arrangement may be used to provide a return force for the rollers while the actual calibration is accomplished by means of a movable permanent magnet. FIG. 6 illustrates schematically such a construction. Here rollers 112 and 113 are entrapped within the loops of an S-shaped metal band 114. Band 114 has formed therein a cutout 114*a* to provide an internal bias to urge the rollers into engagement with a fixed stop 115. The exact amount of force exerted by the internal bias will not be important just so that it is sufficient to always return the rollers. However, in order to obtain calibration of the device, a permanent magnet 116 is provided and is movable along an axis 117 towards and away from end stop 115 so that the magnetic attractive force between magnet 116 and the rollers may be varied. By so doing, an apparatus such as an impact responsive device can be constructed wherein the amount of force required to move the rollers away from the end stop can be very carefully calibrated. Since a metal band will normally be used where the band is to apply a spring force, such bands will normally be electrically conductive. Thus, the band itself may serve as a part of an electrical circuit as for example is disclosed schematically in FIG. 6. Here a pair of movable contacts 118 and 119 are carried by band 114 and are cooperable with fixed contacts 120 and 121, respectively. A predetermined impact, acting in a direction to move the rollers away from fixed stop 115, will cause them to move to a position wherein these contacts are closed and an electrical circuit is completed between the two fixed contacts.

It will be appreciated that this invention offers substantial improvements in rolamite devices, particularly switching devices. First of all, the use of the slide members to effect the securing and tensioning of the band overcomes what has been a substantial problem in devices of this type in the past. If desired one end of the band can be secured directly to the frame and the other secured to a slide member which can be moved back and forth to obtain the desired amount of tension. However, assembly is considerably easier and calibration more easily accomplished if two slide members are used. It will also be appreciated that these slide members will offer advantages even where they do not carry fixed electrical contacts as they do in the embodiment of FIGS. 1 through 5. However, where there are fixed electrical contacts and mating contacts carried by the rollers, the slide members provide even greater advantages because once the assembly is put together, the fixed and movable contacts are always in alignment regardless of the position of the slide members.

The use of electrically conductive rollers which themself form a part of the electrical circuits controlled by the rolamite switching device also provide significant advantages. With the arrangement disclosed in FIGS. 1 through 5, the amount of current which can be controlled by the switching apparatus can be extremely substantial. In fact, a single switch may be usable for switching applications between very low fractional ampere applications all the way to applications where perhaps twenty or thirty amperes, for example, are being controlled. Also, where the rollers are actually secured to the band, it is assured that there is no sliding between them and a minimum amount of fiction is thus assured. When this arrangement of conductive rollers and extending contacts securing them to the band is used in combination with the slide members, alignment problems are eliminated. The slide members also define the end positions so that once the unit is assembled it is assured that the end positions will always be the positions where full contact is made between fixed and movable contacts.

The use of one or more adjustable permanent magnets to calibrate a rolamite device also provides significant advantages. Where the internal bias in the band is used to provide calibration, significant difficulties may be encountered because very minor variations in the band material may result in significant changes in calibration. With the permanent magnet biasing arrangement disclosed herein, very simple and quick calibration can be accomplished after the device is assembled. Once the calibration is made, the adjusting means can be disabled so that the adjustment is maintained. Again, the use of this biasing arrangement in combination with the slide members and conductive rollers provides significant advantages but the adjustment means may also find application in other types of rolamite devices.

The embodiments disclosed herein have been disclosed by way of example since various modifications have been suggested and many others may become apparent to those skilled in the art in view of the disclosure herein. It is therefore emphasized that the detailed description herein is by way of example and not by way of limitation.

The embodiments of the invention in which an exclusive property or right is claimed are defined as follows:

1. Rolamite apparatus comprising: frame means defining a longitudinal direction; a flexible band looped into a generally S-shaped configuration with first and second ends extending generally in opposite directions; a pair of rollers, one entrapped in each of the loops of said S-shaped band, said rollers movable in the longitudinal direction; means for adjustably connecting the ends of said band to said frame means and including slide means mounted on said frame means for movement back and forth substantially along a first line generally parallel to one of said ends of said band, means connecting said one end of said band to said slide means; means connecting the other end of said band to said frame means, said slide means being movable along said first line to adjust the tension in said band; one of said frame means and said slide means including at least one elongated slot extending in a direction generally parallel to said first line; and the other of said frame means and said slide means including a cooperating elongated rail or rib which extends into said slot, said cooperating slot and rail rendering said slide means movable on said frame means in a direction parallel to said first line while precluding substantial lateral movement of said slide means with respect to said frame means.

2. Rolamite apparatus comprising: frame means defining a longitudinal direction; a flexible band looped into a generally S-shaped configuration with first and second ends extending generally in opposite directions; a pair of rollers, one entrapped in each of the loops of said S-shaped band, said rollers movable in the longitudinal direction; means for adjustably connecting the ends of said band to said frame means and in-

cluding slide means mounted on said frame means for movement back and forth substantially along a first line generally parallel to one of said ends of said band, means connecting said one end of said band to said slide means; means connecting the other end of said band to said frame means, said slide means being movable along said first line to adjust the tension in said band; said slide means including abutment means defining an end position for said rollers and spaced side means extending generally in the longitudinal direction; and at least a portion of one of said rollers being disposed between said side means and said side means providing a guide limiting axial movement of said rollers with respect to said frame means.

3. Rolamite apparatus comprising: frame means defining a longitudinal direction; a flexible band looped into a generally S-shaped configuration with first and second ends extending generally in opposite directions; a pair of rollers, one entrapped in each of the loops of said S-shaped band, said rollers movable in the longitudinal direction; means for adjustably connecting the ends of said band to said frame means and including slide means mounted on said frame means for movement back and forth substantially along a first line generally parallel to one of said ends of said band, means connecting said one end of said band to said slide means; means connecting the other end of said band to said frame means, said slide means being movable along said first line to adjust the tension in said band; said first line extending generally in the longitudinal direction, said frame means and said slide means including cooperating slot and rib means rendering said slide means movable with respect to said frame means substantially in the longitudinal direction but precluding substantial lateral movement of said slide means with respect to said frame means, said slide means including spaced, longitudinally extending, guide means having at least a portion of one of said rollers disposed therebetween, said guide means being engageable by at least a portion of the ends of said roller to limit axial movement of said roller laterally of said frame means; and said slide means further including means defining the end position of said roller.

4. The apparatus of claim 3 wherein the means for connecting the other end of said band to said frame means comprises a second substantially identical slide means movable along said longitudinal direction, substantially parallel to said first slide means, said first and second slide means being movable toward and away from each other to effect adjustment of the tension of said band.

5. Rolamite apparatus comprising: frame means defining a longitudinal direction; a flexible band looped into a generally S-shaped configuration with first and second ends extending generally in opposite directions; a pair of rollers, one entrapped in each of the loops of said S-shaped band, said rollers movable in the longitudinal direction; means for adjustably connecting the ends of said band to said frame means and including slide means mounted on said frame means for movement back and forth substantially along a first line which extends generally in the longitudinal direction and is generally parallel to one of said ends of said band, means connecting said one end of said band to said slide means, said frame means and said slide means including cooperating slot and rib means rendering said slide means movable with respect to said frame means substantially in the longitudinal direction but precluding substantial lateral movement of said slide means with respect to said frame means, said slide means including spaced, longitudinally extending, guide means having at least a portion of one of said rollers disposed therebetween, said guide means being engageable by at least a portion of the ends of said roller to limit axial movement of said roller laterally of said frame means, and said slide means including further means defining the end position of said roller; a second substantially identical slide means movable along said longitudinal direction, substantially parallel to said first slide means, means connecting the other end of said band to said second slide means, said first and second slide means being movable toward and away from each other to effect adjustment of the tension of said band; and electrical contact means operably engaged by one of said rollers in a predetermined position of said rollers, said electrical contact means being mounted on said slide means and movable therewith, whereby movement of said slide means to adjust the tension of said band simultaneously adjusts the position of said contact means.

6. Rolamite switching apparatus comprising: a pair of rollers entrapped in the loops of an S-shaped flexible band, one of said rollers being electrically conductive, said rollers being movable back and forth along a given path; a pair of fixed contact means disposed for simultaneous cooperation with said one roller in one position of said roller to complete an electrical circuit between said contact means through said one roller; and a pair of generally radially extending electrically conductive contact members extending from the surface of said one roller, through openings in said band, and disposed for simultaneous engagement with said pair of fixed contact means in one position of said one roller.

7. The switching apparatus of claim 6 wherein said pair of contacts extending from said roller include means fixing said band to said one roller.

8. The apparatus of claim 7 including frame means supporting said switching apparatus; means fixing one end of said band to said frame means; slide means mounted on said frame means for movement thereon along a line generally parallel to the path of said rollers; means fixing the other end of said band to said slide means whereby movement of said slide means along said line changes the tension in said band.

9. Rolamite switching apparatus comprising: frame means supporting the switching apparatus; a pair of rollers entrapped in the loops of an S-shaped flexible band, one of said rollers being electrically conductive, said rollers being movable back and forth along a given path; means fixing one end of said band to said frame means; slide means mounted on said frame means for movement thereon along a line generally parallel to the path of said rollers; means fixing the other end of said band to said slide means whereby movement of said slide means along said line changes the tension in said band; a pair of fixed contact means are fixedly mounted on said slide means and movable therewith along said line and disposed for simultaneous cooperation with said one roller in one position of said roller to complete an electrical circuit between said contact means through said one roller; and a pair of generally radially extending electrically conductive contact members extending from the surface of said one roller, through openings in said band, and disposed for simultaneous engagement with said pair of fixed contact means in one position of said one roller, said pair of contacts extending from said roller including means fixing said band to said one roller.

10. The apparatus of claim 9 wherein said slide means includes abutment means for said rollers defining an end position for said rollers and wherein said band, said rollers and the contacts thereon said fixed contacts and said slide means are so related that said end position is a position wherein the contacts on said one roller engage said fixed contacts means.

11. In rolamite apparatus of the type including frame means, a flexible band looped into a generally S-shaped configuration with opposite ends operably connected to the frame means, and a pair of rollers, one entrapped in each of the loops of the S-shaped band, the rollers being movable by a rolling action back and forth in a given path, the improvement comprising: one of said rollers being magnetically attractable; permanent magnet means; and means movably mounting said permanent magnet means on said frame means for movement generally toward and away from said one of said rollers and generally along an extension of the path of movement of the rollers, said permanent magnet means being mounted in a position to establish a magnetic coupling with said one roller to bias said roller toward a predetermined position, said permanent magnet means being movable toward and away from said one roller to adjust the bias thereby on said roller.

12. The apparatus of claim 11 wherein the band is constructed so that it applies no substantial bias to the rollers, and

said permanent magnet means provides a bias urging said rollers to a normal position and is adjustable toward and away from said one roller to selectively determine the force urging said rollers to said normal position, and thereby the opposing force required to move said rollers from said normal position.

13. The apparatus of claim 11 wherein said band is constructed with an internal bias whereby it urges said rollers to a normal position, and said permanent magnet means provides a force additive to the force provided by the internal bias in said band, the movement of said permanent magnet means towards and away from said one roller providing selective adjustment of the force required to move said rollers from said normal position.

14. The apparatus of claim 13 further including means fixing sad permanent magnet means to render said permanent magnet means unmovable after said adjustment has been completed.

15. The apparatus of claim 11 wherein each of said rollers is magnetically attractable; second permanent magnet means is disposed in a position to establish a force substantially in opposition to the first named permanent magnet means and effective to establish a magnetic coupling with said rollers to bias said rollers toward a second predetermined position; and said second permanent means is movable toward and away from said rollers to adjust the bias on said rollers, whereby the opposing permanent magnet means may be adjusted to select the forces urging said rollers to each of said predetermined positions, and thereby the external forces required to move said rollers from one of said predetermined positions toward the other.

16. Rolamite apparatus comprising: frame means; a pair of rollers; a flexible band with oppositely extending ends and looped in a generally S-shaped configuration between said ends, said rollers being disposed on opposite sides of said band with one of them entrapped in each of the loops of said S-shaped band; slide means mounted on said frame means and comprising a pair of members movable relative to each other and to sad frame means, generally in the direction of extension of the ends of said band; means connecting one of said ends to a first of said members; means connecting the other of said ends to the other of said members whereby the tension in said band is adjustable by relative movement of said slide means; said frame means and said slide means including at least one elongated slot extending generally in the direction of extension of the ends of said band; and the other of said frame means and said slide means including a cooperating elongated rail or rib which extends into said slot, said cooperating slot and rail rendering said slide means movable back and forth on said frame means in the direction of extension of the ends of said band while precluding substantial lateral movement of said slide means with respect to said frame means.

17. The rolamite apparatus of claim 16 further including means fixing said slide members to preclude relative movement thereof after an adjustment of the band tension is made,

18. Rolamite apparatus comprising: frame means defining a longitudinal direction; a flexible band looped into a generally S-shaped configuration with first and second ends extending generally in opposite directions; a pair of rollers, one entrapped in each of the loops of said S-shaped band, said rollers movable in the longitudinal direction; slide means mounted on said frame means for movement back and forth substantially along a first line which extends generally in the longitudinal direction and is generally parallel to one of said ends of said band, means connecting said one end of said band to said slide means; means connecting the other end of said band to said frame means; said frame means and said slide means including cooperating slot and rib means rendering said slide means movable with respect to said frame means substantially in the longitudinal direction but precluding substantial lateral movement of said slide means with respect to said frame means, said slide means including guide means cooperable with one of said rollers to limit axial movement of said roller laterally of said frame means, said slide means including further means defining the end position of said roller; and electrical contact means disposed to be operably engaged by said one of said rollers in a predetermined position of said rollers, said electrical contact means being mounted on said slide means and movable therewith, whereby tension of said band may be adjusted by movement of said slide means and such movement simultaneously adjusts the position of said contact means.

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