United States Patent

Crow et al.

[15] **3,643,048**

[45] **Feb. 15, 1972**

[54] ROLLER-BAND DEVICE

[72] Inventors: **Herman L. Crow**, River Falls, Wis.; **Andrew Lu Conic**, New Port; **Patrick Martin Maloney**, St. Paul; **Gary Raymond Bluem**, Golden Valley, all of Minn.

[73] Assignee: **Kroy Industries, Inc.**, Minneapolis, Minn.

[22] Filed: **Feb. 6, 1970**

[21] Appl. No.: **9,349**

[52] **U.S. Cl.**.....**200/153 R**, 200/166 BB, 308/6, 74/89.2

[51] **Int. Cl.**.....**H01h 3/00**, F16c 17/00, F16c 27/00

[58] **Field of Search**.....200/166 BB, 153 R; 308/6, 202, 308/209; 73/515; 74/89.2

[56] **References Cited**

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3,167,962	2/1965	Scotto	73/515 X
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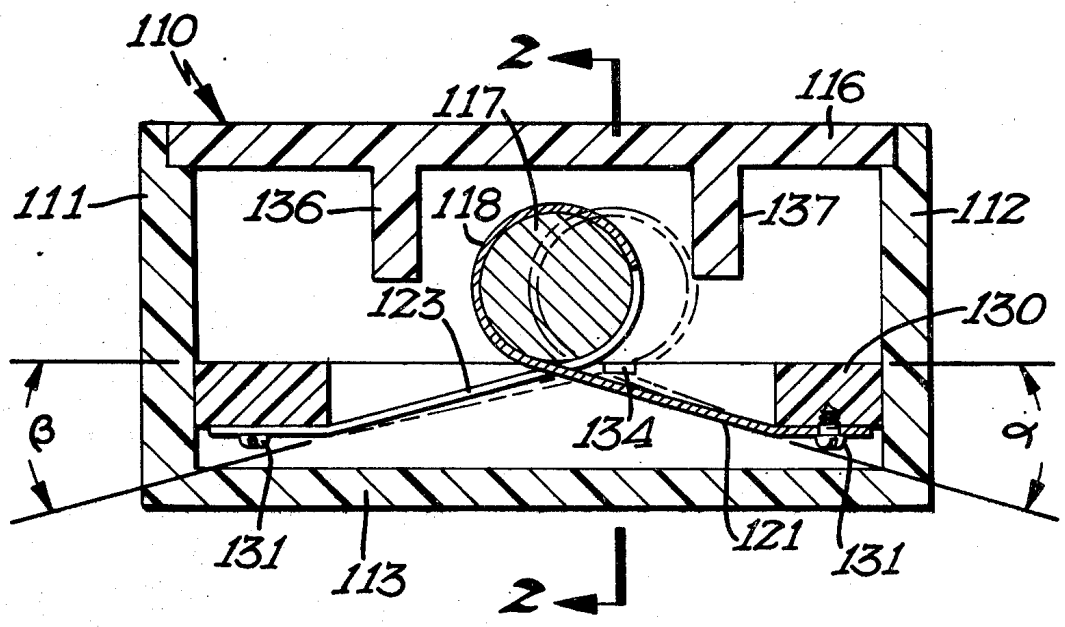
Wilkes (I); *Rolamite: A New Mechanical Design Concept;* Research Report SC-RR-67-656A, Dec., 1967; publication of AEC; pp. 71, 89, 168, 172, 173, 194, & 195 included; copy in group 210.

Primary Examiner—Robert K. Schaefer
Assistant Examiner—Robert A. Vanderhye
Attorney—Frederick E. Lange, William C. Babcock and David N. Fronek

[57] **ABSTRACT**

A roller-band device which utilizes a single roller with a flexible band encircling it and having its ends extending generally in opposite directions therefrom. The band has complimentary cutout and solid portions, preferably a pair of spaced leg portions at one end of the band and a tongue portion disposed between and having a width somewhat less than the space between the two leg portions at the other end whereby the band is wrapped around the roller and the tongue passes between the spaced legs without touching them. The roller and band are movable together along a predetermined path and may be used for performing various electrical switching functions. Opposite ends of the band decline from the plane on which the roller moves and form an acute angle therewith so that a high-contact force is obtained between contact surfaces on the roller and on the frame. A unique frame and housing means renders the device easily assembled and calibrated and then encloses the device. Also disclosed is a roller-band device with multiple rollers spaced along a common band.

24 Claims, 17 Drawing Figures



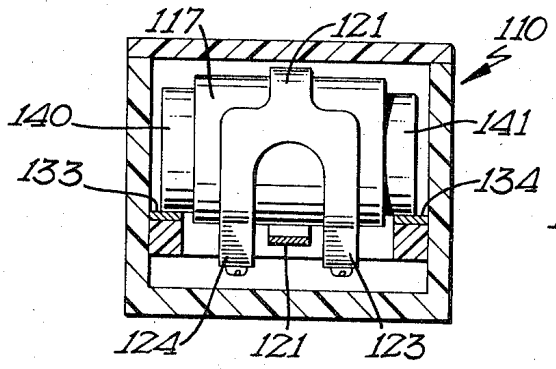


FIG 3

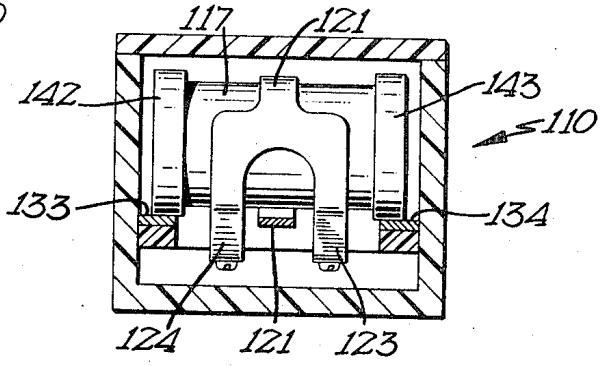


FIG 4

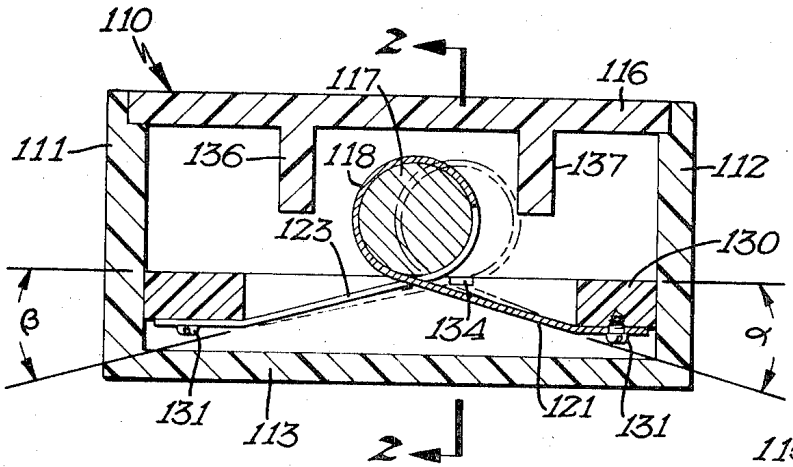


FIG 1

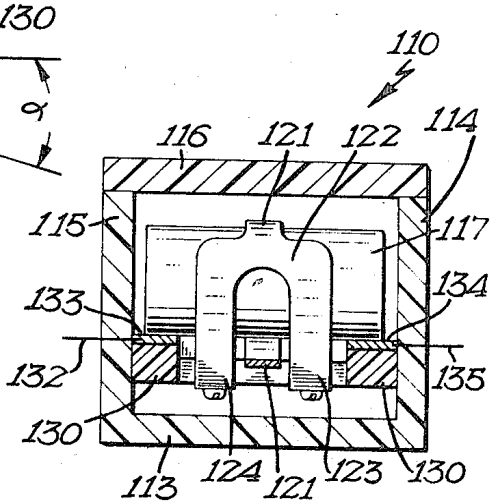


FIG 2

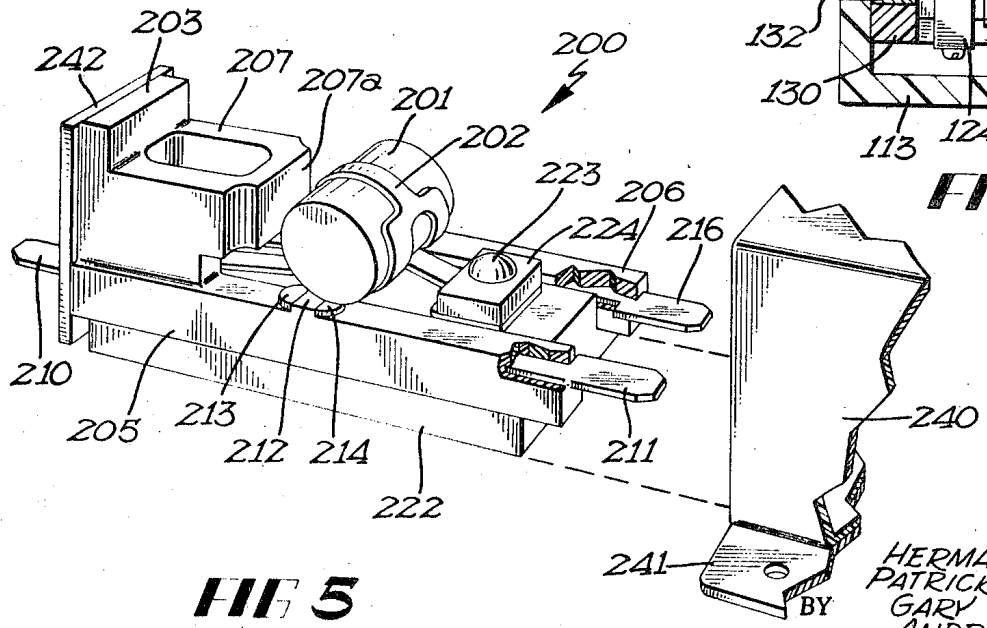


FIG 5

INVENTORS
HERMAN L. CROW,
PATRICK M. MALONEY,
GARY R. BLUEM,
ANDREW LUCONIC
BY
Donald R. Strobel
ATTORNEY

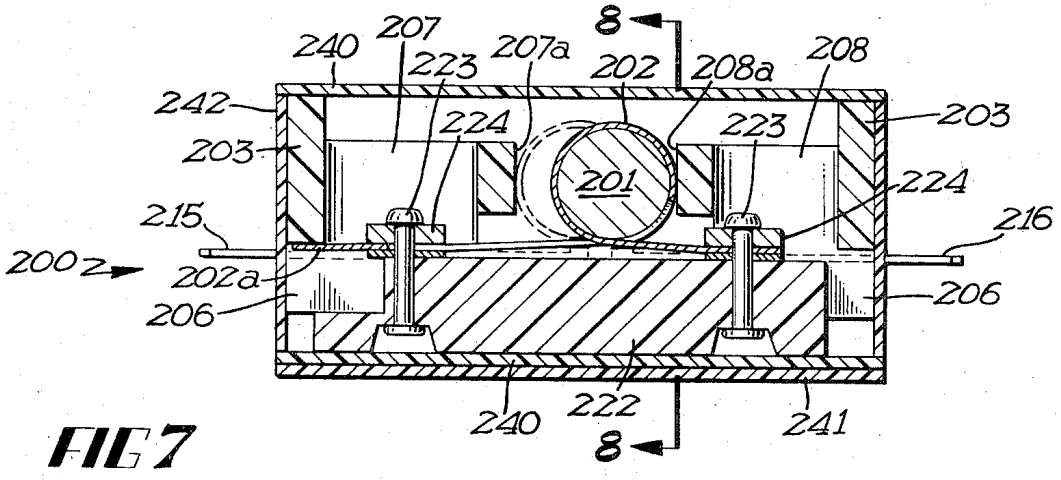


FIG 7

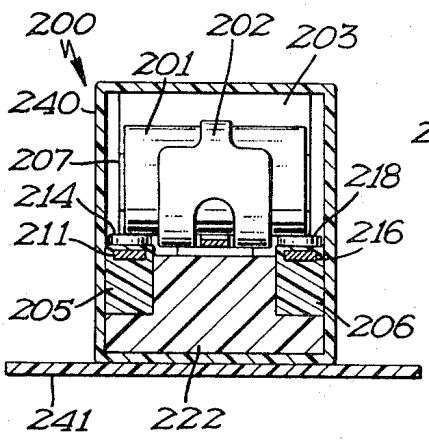


FIG 8

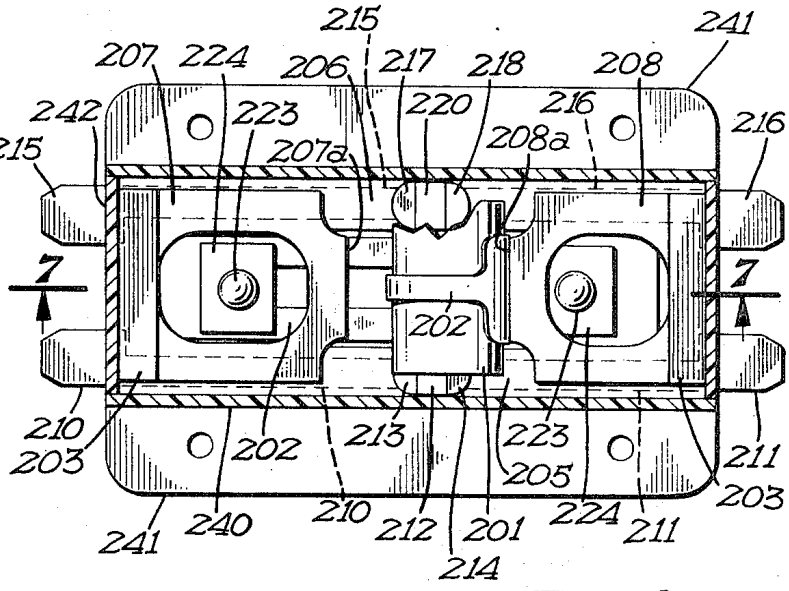


FIG 6

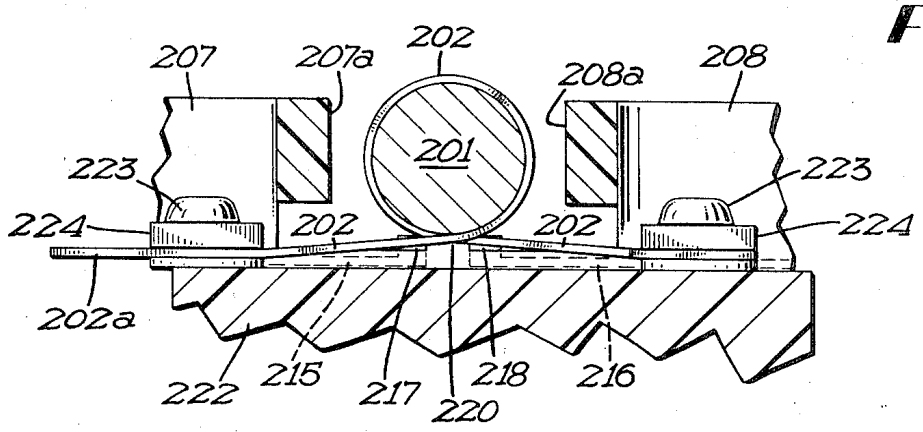


FIG 9

INVENTORS
HERMAN L. CROW,
PATRICK M. MALONEY,
GARY R. BLUEM,
ANDREW LUCONIC
BY Donald R. Gjostrom
ATTORNEY

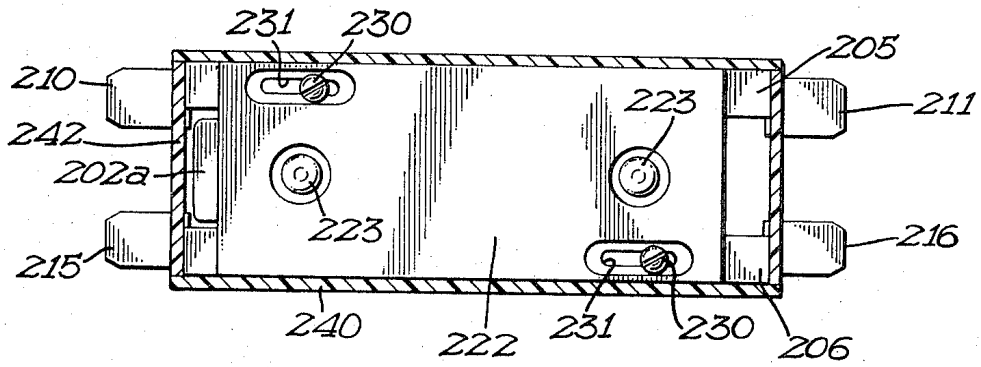


FIG 10

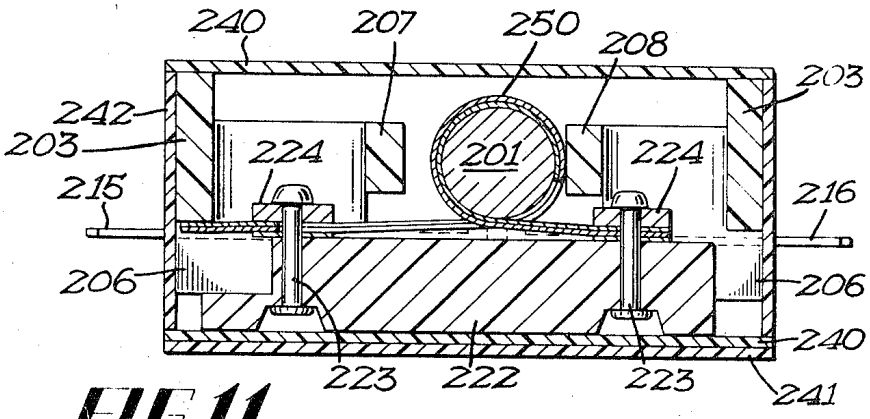


FIG 11

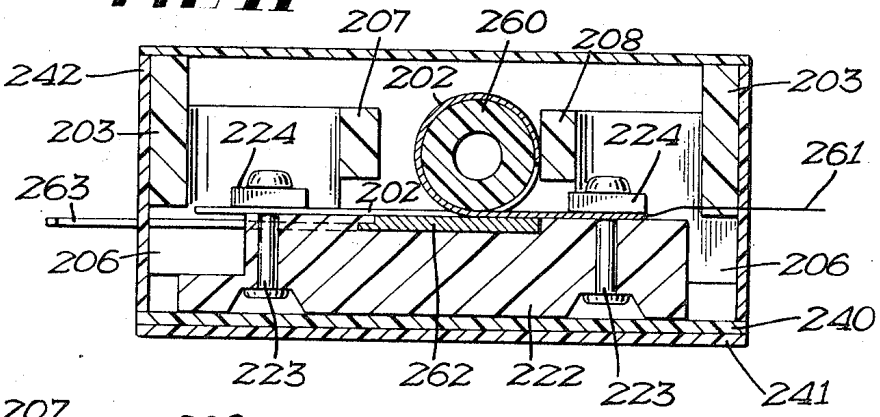


FIG 12

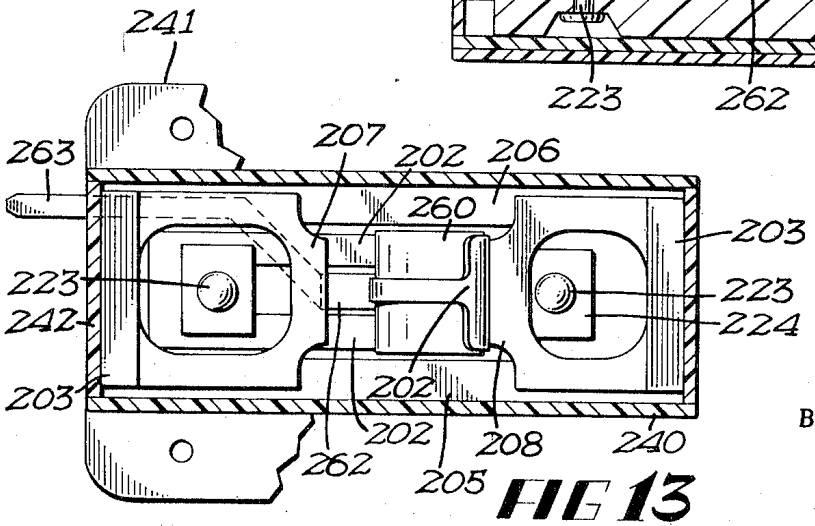


FIG 13

INVENTORS
HERMAN L. CROW,
PATRICK M. MALONEY,
BY GARY R. BLUEM,
ANDREW LUCONIC
Donald R. Gjostrom
ATTORNEY

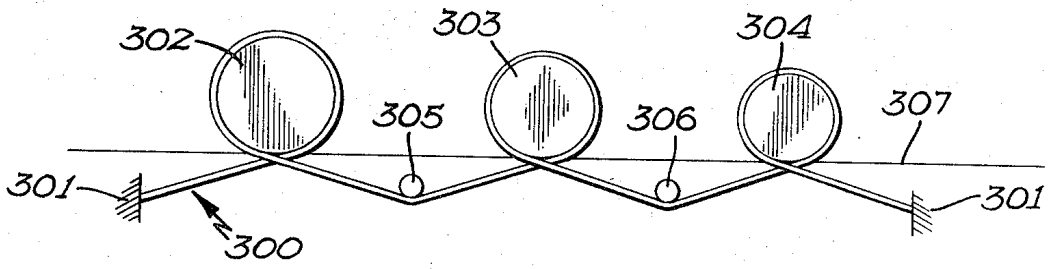


FIG 14

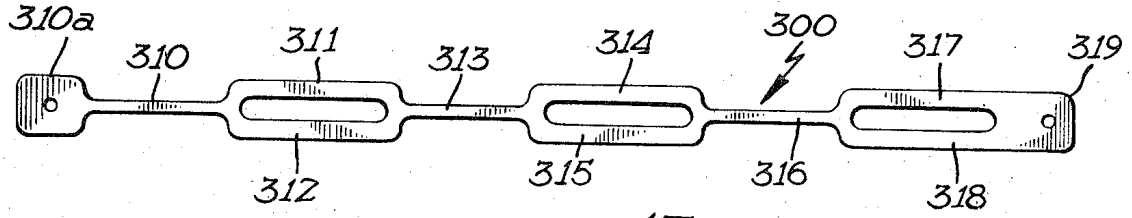


FIG 15

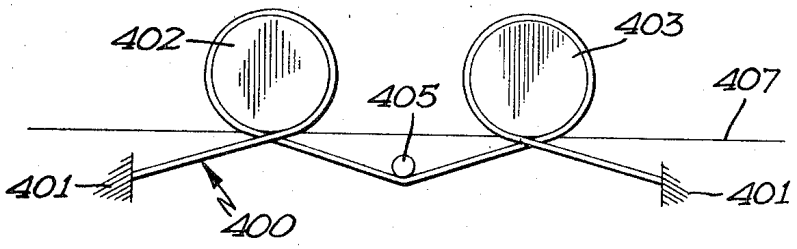


FIG 16

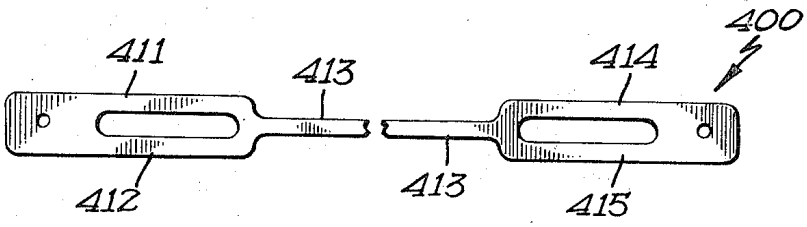


FIG 17

INVENTORS
HERMAN L. CROW,
PATRICK M. MALONEY,
BY GARY R. BLUEM,
ANDREW LUCONIC
Donald R. Gjostrom
ATTORNEY

ROLLER-BAND DEVICE

BACKGROUND OF THE INVENTION

Roller-band devices have become relatively well known in the past few years, particularly since disclosure to the public of the work done by Donald Wilkes on so-called "Rolamite" devices. These devices are shown, for example, in U.S. Pat. Nos. 3,452,175 and 3,452,309, both issued to Donald Wilkes and assigned to the United States of America. Rolamite devices utilize a flexible band formed into a generally S-shaped configuration with two rollers, one disposed on either side of the band and in one of the loops of the S-shape. These devices provide a relatively low-friction mechanism which, it has been suggested, may be utilized to provide a multitude of switching and other functions in response to a relatively small input force.

Another form of roller-band device utilizing a single roller has been disclosed, for example, in U.S. Pat. No. 3,167,962 issued to Dominick Scotto and in U.S. Pat. No. 3,488,098 issued to Bernard Sobczak. In this type of device a single roller is utilized with a band having complimentary cutaway portions so that a tongue portion wraps around the roller and extends through a space between the pair of spaced leg portions and the ends of the band extend generally in opposite directions from the roller. They have the obvious advantage of being simpler than the Rolamite device in that they use a single roller and also that there is much less stress on the band since it is not doubled back against itself as is the case in the S-shaped band of the Rolamite devices.

While roller-band devices of the types referred to above have become known and have been suggested as being capable of use in many applications, they have not actually found much commercial use. There has been a need for a simple switching device which provides good contact forces, can be made to respond to relatively small applied forces, is adaptable to operation in response to a variety of different types of forces, and particularly one which can be miniaturized and yet will be reliable, relatively inexpensive, and capable of switching relatively large current loads.

It has been realized that roller-band devices might be utilized in a switch which would satisfy some of these needs. However, attempts have generally been made to utilize some type of conventional switching arrangement operated by the moving roller and band and these have not been completely successful for a number of reasons.

BRIEF SUMMARY OF INVENTION

This invention provides an improvement over the previously proposed roller-band devices. It utilizes a single roller and band, preferably arranged generally like the arrangement disclosed in the previously mentioned Scotto U.S. Pat. No. 3,167,962 and Sobczak U.S. Pat. No. 3,488,098. In this arrangement the band includes complimentary cutaway portions and solid portions on opposite ends thereof and disposed so that when the band encircles the roller, the solid portions thereof extend through the cutaway portions permitting the opposite ends of the band to cross over without touching each other. In the improvement provided by this invention opposite ends of the band decline from the plane on which the roller moves and form acute angles with this plane on the opposite side from the roller. This is particularly useful when the roller itself has one or more contact surfaces engageable with electrical contacts mounted on the frame or guide surface. The contact force may be adjusted by adjusting the band tension or the angle of decline and thereby the downward thrust on the roller. A unique frame structure is provided wherein the roller and band may be arranged so that the band extends from the crossover point in the plane on which the roller rolls or, by utilizing a longer roller, may decline downward from this plane. A housing cooperates with this frame to form a completely enclosed structure which may easily be hermetically sealed.

When electrical contact is made by the roller itself, it may be accomplished in any one of several forms. In one arrangement the contact surface of the roller is the same diameter as the rolling radius of the roller and band so that there is a simple rolling action between the contact surface of the roller and the fixed contacts mounted on the frame. In another arrangement the contact surface on the roller has a larger radius than the rolling radius of the roller and band so that there is a wiping action of the contact surfaces since the contact surface of the roller has a greater velocity than normal rolling action between the two surfaces would require. In still another arrangement the contact surface on the roller has a smaller radius than the rolling radius and this results in a skidding action because there is a lesser velocity than required for normal rolling action. The application of the device will determine which of these arrangements is used.

The device is usable for a multitude of functions generally similar to the uses which have been proposed for the Rolamite devices. It is especially useful in connection with electrical or pneumatic switching. The device may be operated in response to gravity, impact, vibration, centrifugal force, acceleration, temperature (by a bimetal band), or may be magnetically operated, hand actuated as in a keyboard switch, or operated in many other ways. A plurality of roller-band devices may be assembled using a single band which encircles each of a plurality of spaced, parallel rollers. The rollers may be of different masses or the band formed with different force characteristics adjacent different rollers so that they respond to different forces.

An object of the invention is to provide a roller-band device which can be easily manufactured and assembled.

Another object of the invention is to provide a roller-band device utilizing a single roller supported by a band with the roller cooperating with fixed means to perform switching functions and with the band arranged to provide a thrust urging the roller toward the fixed means.

Another object of the invention is to provide a roller-band device utilizing a single roller and wherein the contact force between surfaces on the roller and fixed surfaces are readily adjustable.

Another object of the invention is to provide a roller-band device with the band arranged so that the force exerted upon the guide surface by the roller varies as the roller moves from one position to another in its path of travel.

Another object of the invention is to provide a unique frame and housing means for a roller-band device which renders the device easy to assemble and calibrate and then substantially completely encloses the device.

Still another object of the invention is to provide a roller-band device wherein a plurality of spaced rollers cooperate with a common band.

These and other objects of the invention will become apparent upon reading the detailed description thereof which follows.

DESCRIPTION OF DRAWING

FIG. 1 is a longitudinal, cross-sectional view, shown schematically, of an electrical switch utilizing the invention.

FIG. 2 is a transverse cross-sectional view taken generally along line 2—2 in FIG. 1.

FIG. 3 is a transverse cross-sectional view, generally similar to FIG. 2 but disclosing a slightly modified form of the invention.

FIG. 4 is also a transverse, cross-sectional view generally similar to FIGS. 2 and 3, but disclosing another modification of the invention.

FIG. 5 is a perspective view, with portions broken away, of a preferred form of the invention disclosing a roller-band switching device including a unique frame and housing structure therefor.

FIG. 6 is a plan view of the roller-band device of FIG. 5.

FIG. 7 is a longitudinal, cross-sectional view taken generally along line 7—7 of FIG. 6.

FIG. 8 is a transverse cross-sectional view taken generally along line 8—8 in FIG. 7.

FIG. 9 is an enlarged fragmentary view disclosing in detail a contact arrangement which forms a part of this invention.

FIG. 10 is a bottom view, with the housing removed, of the roller-band device of FIGS. 5 through 9.

FIG. 11 is a longitudinal cross-sectional view generally similar to FIG. 7 but disclosing a modified form of the invention utilizing a bimetal band as part of the device.

FIG. 12 is a longitudinal cross-sectional view generally similar to FIG. 7 but disclosing another modification of the invention wherein the device is constructed to operate as a slide wire potentiometer.

FIG. 13 is a top view of the device disclosed in FIG. 12.

FIG. 14 discloses schematically an embodiment of the invention wherein a plurality of roller-band devices utilize a common band.

FIG. 15 discloses schematically a band which may be used in a device as disclosed in FIG. 14.

FIG. 16 discloses schematically another arrangement wherein a plurality of roller-band utilize a common band.

FIG. 17 discloses schematically a band used in the device of FIG. 16.

DETAILED DESCRIPTION

Referring to FIGS. 1 and 2 of the drawing where the invention is shown schematically, numeral 110 generally designates a casing or housing having end walls 111 and 112, a bottom wall 113, sidewalls 114 and 115 and a cover 116. A roller 117 operates within the casing and is electrically conductive or at least has conductive portions. It is encircled by a band 118 which has a tongue portion 121 and a pair of spaced leg portions 123 and 124. Leg portions 123 and 124 are spaced a distance greater than the width of tongue portion 121 so that when the band is wrapped around the roller, tongue 121 passes between the legs without touching them and extends from the roller, generally in an opposite direction from the ends of the legs. A generally flat member 130 is mounted within the casing at a position spaced above bottom wall 113. Member 130 has a center portion removed in order to allow the tongue and the legs of the band to extend there through to the underside of member 130. However, the width of this opening is small enough so that the ends of roller 117 engage the upper side of it, this upper side providing guide surfaces along the opening for the roller to roll upon band 118, encircles the roller as described and the opposite ends of the band decline from the plane on which the roller moves (the top surface of member 130) and extend to the underside of member 130, and thus form an acute angle with this plane. For example, tongue 121 of the band extends through the opening to the underside of member 130 and extends downwardly making an angle with respect to the plane defined by the upper surface of member 130. Similarly, legs 123 and 124 extend downwardly and form an acute angle with the plane defined by the upper surface of member 130. The band is then attached by appropriate means 131 to the underside of member 130 and is maintained in tension. The angles α and β are preferably identical when the roller is in a centered position and generally will be relatively small. For example, it has been found that angles of 5° or 10° are generally sufficient to accomplish the purpose to be described for this type of device.

Roller 117 and band 118 are movable together, with roller 117 rolling back and forth along the top surface of member 130, in a direction normal to the axis of the roller, which direction may be termed the "longitudinal direction" of the device. This movement is limited by end stops 136 and 137.

In the arrangement disclosed, at least the surface of roller 117 is electrically conductive. Band 118 may also be conductive but it need not be. Casing 110 and member 130 are electrically insulative. An electrical conductor 132 is connected to an electrical contact surface 133 on the upper side of member 130 in an area where it will be engaged by the extending left end of roller 117 (as seen in FIG. 2) as it moves along its path of travel. A similar electrical contact surface 134 is provided on the opposite side of the casing to be engaged by the other end of roller 117. Contact 134 is connected to an appropriate electrical conductor 135.

In the position shown solid lines in FIG. 1, and as disclosed in FIG. 2, the roller occupies a position substantially midway between its end positions. It will be appreciated that at this point there is the least tension in the band and thus the least force urging the roller down onto the surface of member 130. As the roller moves in either direction from the midpoint this force increases. Thus, if roller 117 is moved to the right, towards stop 137, the force urging it downward into engagement with member 130 increases and at the point where the roller engages electrical contact surface 133 and 134, it is at a maximum force thereby tending to reduce the contact resistance between the roller and the contact surfaces. However, since there is less force as the roller occupies other positions, the effect of the surface smoothness of the roller and of the guide surface on the upper side of member 130 will be less as the roller is in positions between the end positions of its travel. Thus, the roller can move relatively freely but has a maximum contact pressure when it rolls into engagement with the contact surfaces. When the roller engages contacts 133 and 134 a circuit is completed between them.

It will be appreciated that this embodiment may be modified, for example, by having contact surfaces disposed at each of the end positions so that one circuit is completed in one of the end positions and circuit is completed in the other end position. Band 118 may also be a part of the circuit if desired. The surface or contact pressure and the variation therein as the roller moves between its midpoint and the end positions can be adjusted by varying the angles α and β and/or tension in band 118.

It will be appreciated that in this embodiment the radius of the surface on member 117 which engages the contact surfaces is the same as the rolling radius of the band and roller. Thus, there is no relative motion between the roller and the contact surfaces, there is only rolling contact. This is not necessarily essential as can be seen by referring to FIGS. 3 and 4. FIG. 3 discloses a structure generally similar to that disclosed in FIGS. 1 and 2 except that here roller 117 has portions 140 and 141 at its ends which have a reduced radius from the rest of the roller. Portions 140 and 141 roll along the surface of member 130 but here this guide surface has been raised upward so that actually the plane in which the band and roller move is disposed below this surface. In FIG. 3 contact surfaces 133 and 134 can be seen as engaged by portions 140 and 141, respectively. It will be appreciated that in this instance the radius of the surfaces which engage these contacts is less than the rolling radius of the band and roller. Thus, the velocity of the surface of portions 140 and 141 is less than that required for simple rolling along the upper guide surface and there is a skidding action, resulting in wiping between the surfaces of portions 140 and 141 and the contact surfaces 133 and 134.

A wiping action can also be obtained by having the guide surface lowered as it is in FIG. 4 and with the portions of roller 117 which engage this guide surface, these being designated by numerals 142 and 143, having a radius larger than the radius of the rest of the roller. In this case, this radius is substantially greater than the rolling radius of the roller and band and therefore the velocity of the surface of portions 142 and 143 is greater than would result in normal rolling motion along the guide surface and this results in a wiping action with the contact surfaces also. Thus, in addition to the increased contact pressure provided by the manner in which the band is attached, good electrical contact is further assured by this skidding or wiping action between the mating contact surfaces.

FIGS. 5 through 10 disclose in considerable detail a structure especially adaptable for utilizing the principles disclosed in schematic form in FIGS. 1 through 4. Referring to FIGS. 5 through 10, reference numeral 200 refers generally to a roller-

band device utilizing a single roller **201** and a single band **202** generally as described previously herein. The frame on which the roller and band are mounted includes frame member **203** which includes a pair of spaced rails **205** and **206** extending longitudinally of the device and in generally spaced parallel relationship. They are connected by a pair of abutment members **207** and **208** which preferably are molded integrally with the rails. Molded into rail **205** are a pair of electrical conductors **210** and **211** each of which extend all the way from beyond the ends of the device into a position nearly reaching the center of the device where they have raised electrical contact portions **213** and **214**, respectively, extended upward to the surface of rail **205** where they are separated by a portion **212** of frame member **203**. Similarly, conductors **215** and **216** are molded into rail **206** and have disposed thereon generally similar electrical contacts **217** and **218**, respectively, separated by an insulative portion **220**. Abutment portions **207** and **208** have inwardly extending abutment surfaces **207***a* and **208***a*, respectively. These define the end or the limits of travel for roller **201** which is mounted on a second frame member **222**. As best seen in FIG. **8**, member **222** has an inverted T-shaped cross section with the leg of the T disposed between the rails **205** and **206** and with the crossbar extending outwardly so that it is disposed beneath these two rails.

Band **202** is mounted on the top surface of the leg of T-shaped member **222**. This is accomplished by fixing it thereto by appropriate means such as rivets **223** at opposite ends thereof. An appropriate enlarged bearing surface **224** acting somewhat like a washer may be utilized beneath the heads of rivets **223** at the ends of band **202**. The band encircles roller **201** in the manner described previously with the tongue portion extending between the spaced leg portions of the band and with opposite ends extending generally in opposite directions. The leg of member **222** is somewhat shorter than the height of the rails so that the top surface thereof is dipsosed below the top of the rails so that the ends of the band decline.

The device may be assembled by securely attaching one end of the band, for example, the right-hand end as seen in FIGS. **6** and **9**, to member **222** and then looping the band and securing it loosely at the left-hand end. The left-hand end of band **202**, designated **202***a*, is allowed to extend beyond the end of member **222**. At this point member **222** is inserted in the space between rails **205** and **206**. The overall width of the band is less than the space between these rails so it can easily be inserted. The band is now loose and the roller may be inserted in the loop. Roller **201** is longer than the space between rails **205** and **206** and therefore rests on top of these rails. Now end **202***a* or band **202** is grasped by an appropriate means and pulled until the desired tension is obtained in the band. Then rivet **223**, at the left-hand end of band **202** is tightened. Openings may be provided in abutment portions **207** and **208**, for instance as can be seen particularly in FIG. **6**, to facilitate insertion and crimping of these rivets. It will be appreciated that while rivets have been disclosed, other appropriate means may be utilized for securing the band to member **222**. This may be accomplished, for example, by having an upstanding post on member **222** adjacent each end of the band and then having end **202***a* slotted and secure the band by heat staking, if desired.

As shown in FIG. **10**, frame member **222** is secured to frame member **203** by appropriate means such as screws **230** extending up from the bottom of the crossbar portion of member **222** into rails **205** and **206**. An adjustment is provided by the provision of elongated slots **231**, extending in a longitudinal direction, through which these screws extend. This permits adjustment of the position of the band with respect to its end positions as defined by abutment surfaces **207***a* and **208***a*. When the band is designed to have an internal bias, and especially when a nonuniform band (for example one with tapered legs) is used, this adjustment will vary the bias applied in various positions of the band. It will also vary the position at which the greatest contact pressure will be exerted since, as can be clearly seen in FIGS. **7** and **9**, the ends of the band do decline in the manner which was described in connection with FIGS. **1** through **4** to exert a downward force of the roller upon the contact surfaces. Instead of screws **230**, solvent bonding may be used to secure member **222** in its adjusted position, or an appropriate adhesive may be used.

As indicated, the ends of roller **201** extend outward beyond the width of the band and engage the upper surfaces of the electrical conductor members mounted on top of the rails. Generally, as has been shown in the embodiment of FIGS. **5** through **10**, the amount of movement of roller is actually relatively small. In this embodiment, the roller, then in its right end position as disclosed in FIGS. **6**, **7**, and **8**, for example, is in engagement with fixed contacts **214** and **218** and thus completes a circuit between electrical conductors **211** and **216**. In its other end position it engages electrical contacts **213** and **217**, completing a circuit between electrical conductors **210** and **215**. In FIG. **9** the roller is shown passing through its center position and here it engages only the electrically insulative members **212** and **220**.

A third frame member **240** cooperates with frame members **203** and **222** to provide an enclosure for the entire device. As can be seen in FIGS. **5** through **10**, frame member **240** comprises a casing or housing which is enclosed on all but one end and which has mounting flanges **241** extending on opposite sides thereof. On the left-hand end of frame member **203**, as best seen in FIG. **5**, there is a member **242** which serves as an additional side or end for casing **240** so that when the roller-band device is slid into the casing, this member **242**, which is secured to frame member **202** or may be an integral molded part thereof, serves as the final side or end of the casing to substantially completely enclose the roller-band device. Appropriate openings are provided so that the ends of electrical conductor members **211** and **216** may extend outward through the closed end of the casing.

FIG. **11** discloses an arrangement wherein the structure is substantially identical to that described in connection with the foregoing FIGS. **5** through **10** except that band **202** has been replaced by a band **250** which is constructed of bimetallic material responsive to temperature change. Thus, the internal bias in the band, urging the roller and band to one direction or another, will vary with temperature so that the roller and band will be moved upon a predetermined temperature change. For convenience, the same switching arrangement has been disclosed in FIg. **11** as was disclosed in the foregoing embodiment but it will be appreciated that various types of switching arrangements may be utilized depending upon the control function to be performed by the thermostatic switch. By way of example, bimetallic band **250** may be constructed so that under certain conditions the roller and band will be disposed in the position disclosed in FIG. **11**, adjacent abutment member **208**. Upon a predetermined increase in temperature band **250** will be deformed so that the roller and band will be urged to the left and into engagement with abutment **207**. Obviously many modifications of this are possible and this one embodiment has been disclosed by way of illustration only.

FIGS. **12** and **13** disclose still another embodiment of the invention utilizing the unique frame structure disclosed in FIGS. **5** through **10**. Here, however, the roller does not ride on top of rails **205** and **206** but rather a shorter roller **260** has been substituted which has a length such that it can be disposed between rails **205** and **206**. In this arrangement, the band and roller move directly along the upper surface of the leg of member **222** and there is no angle between the ends of the band and this surface. By way of illustration a hollow roller **260** has been shown but this is not necessary since a solid one may also be used. In the disclosed embodiment an insulative roller has been utilized. Band **202**, however, is conductive and one end thereof, the right-hand end as disclosed in FIG. **12**, is connected to an appropriate conductor **261**. Band **202** and roller **260** roll along the upper surface of the leg of frame member **222** between the stops provided by abutments **207** and **208**. Member **222** may still be adjusted longitudinally with

respect to frame member **203** so that the relative position of the band with respect to its end stops may be adjusted.

In this embodiment, any desired type of switching arrangement may be utilized. However, an arrangement has been disclosed wherein the device acts like a slide wire potentiometer. In order to accomplish this a conductive member **262** has been embedded in the upper surface of the leg of member **222** in a position where it will be engaged by band **202** as it rolls between its two end positions. Member **262** is connected to an appropriate electrical conductor **263**. Now, as the roller and band move from one position toward the other, the resistance through the circuit between conductors **261** and **263** will vary depending upon the position of the roller and band.

As can be seen from foregoing, the frame and housing structure disclosed may be utilized in numerous variations of the roller-band device. By simply changing the length of the roller, the roller can be made to roll along the top of the rails or with a shorter roller it may roll directly upon member **222**. Various types of switching may be utilized and in each instance the entire unit can usually be sealed within the housing provided by the third frame member **240**. Obviously the housing can be hermetically sealed if desired.

A roller-band device, generally of the type described previously herein may also utilize a plurality of rollers operating with a common band. For example, FIGS. **14** and **15** disclose schematically an arrangement wherein a plurality of rollers cooperate with the band to provide a like plurality of independent roller band device all movable along a common plane and utilizing a common band. Here the common band **300** is connected to an appropriate base **301** at each of its ends and therebetween encircles rollers **302**, **303**, and **304**. Intermediate rollers **302** and **303**, band **300** is restrained by appropriate means **305** and between rollers **303** and **304**, band **300** is restrained by appropriate means **306**. The rollers are all movable along plane **307**. The band may be formed as disclosed in FIG. **15** wherein it includes a plurality of cooperating leg and tongue sections. By way of example, the band in FIG. **15** has a first tongue portion **310** with an end member **310***a* adapted to be connected to base **301**. Tongue portion **310** cooperates with spaced leg portions **311** and **312**, and is followed by another tongue portion **313** cooperating with spaced leg portions **314** and **315**, and still another tongue portion **316** cooperating with leg portions **317** and **318**. Finally, another portion **319** is adapted to be fixed to the base surface **301**. It will be appreciated that any number of roller-band devices may be utilized in an arrangement of this type by simply increasing the number of rollers and the number of tongue and leg portions. It will also be appreciated that since the band is secured between adjacent rollers, the rollers operate independently of each other. In the arrangement disclosed in FIG. **14**, the three rollers are all of different sizes. This illustrates an arrangement wherein each of the rollers has a different mass and therefore will respond to a different force applied. For example, in an impact-type switch, a plurality of rollers each with a different mass may be utilized and different ones of the rollers will respond to an impact, depending upon the amount of force exerted upon it by the impact. Also, the band may be formed so that it has a different internal bias acting upon different ones of the rollers so that they will respond to different forces. Obviously, an appropriate readout system can be provided which will indicate which roller has been operated and thereby indicate the severity of the impact.

FIGS. **16** and **17** disclose a variation of the embodiment of FIGS. **14** and **15**. Here a band **400** includes two pairs of leg portions on opposite sides of a long tongue portion **413**. The first paid of leg portions **411** and **412** cooperate with a portion of tongue portion **413** and encircle a roller **402** to provide a first roller-band device urged toward the center by the band. Legs **414** and **415** cooperate with another part of tongue portion **413** and encircle a roller **403** to provide a second roller band device, also urged toward the center. Thus, rollers **402** and **403** are biased toward each other and are responsive to oppositely acting forces and can readily be used to provide a bidirectional switch by simply adding a switch means operable by each of the rollers.

Multiple roller-band devices of the type described may be constructed generally similarly to the embodiments of FIGS. **5** through **13** with provisions made for two or more spaced rollers in a single housing. The many uses for this type of device will be apparent.

The invention described provides a simple and practical roller-band switch device. The structure is simple and can be made very small without impairing its effectiveness. Assembly is relatively easy and good contact pressures are easily obtained because of the downward thrust provided by the declining band. This thrust is greatest at the ends of travel where the contacts are preferably disposed. This thrust can be varied by changing the tension in the band or by changing the angle of decline of the ends of the band. The preferred frame and housing structure renders assembly and adjustment relatively simple and provides a complete enclosure which can be hermetically sealed. Multiple rollers used with a common band may increase the versatility of the device. A few of the various embodiments in which the invention may be utilized and the functions for which it may be used have been disclosed but it will be appreciated that many other arrangements and variations may be utilized and many other functions may be accomplished by it. It is not even essential that the rollers be round although this is the preferred arrangement. An internal bias in the band is referred to but an external bias, as by a spring, magnetic force, or the like may be used. Many modifications of the illustrative embodiments disclosed herein may become apparent in view of this disclosure and may be made without departing from the spirit of the invention. Therefore, these embodiments are disclosed by way of illustration and not by way of imitation and it is intended that the invention should be limited solely by the appended claims.

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

1. A roller-band device of the single roller type comprising frame means, a roller, a flexible band having a width substantially greater than its thickness encircling said roller and having first and second ends extending from said roller, the roller being movable back and forth on said frame means generally in a single plane, and means connecting the ends of said band to said frame means in a position thereon whereby the ends of said band decline from said plane on which the roller rolls and each forms an acute angle with said plane on the opposite side thereof from said roller, each of said acute angles being changed as said roller moves back and forth on said frame means and each of said acute angles being less than 20° when said roller is in a position such that the two acute angles are equal.

2. A device of claim **1** wherein said band has complementary solid and cutaway portions comprising a pair of spaced legs in one portion and a tongue in another portion, said tongue being aligned with the space between said legs and having a width less than the width of the space between said legs, whereby the band encircles the roller with the tongue extending between the legs and with said tongue extending in one direction from the roller and the legs in the other.

3. The device of claim **1** wherein the frame means includes first and second end stops defining the limits of travel of said roller and band on said frame means, and the device further includes electrical contact means disposed for engagement by said roller in at least one of the end positions of said roller.

4. The device of claim **3** wherein said roller has an electrically conductive surface engageable with said contacts, said frame means has mounted thereon electrical contact means disposed for engagement by said roller at each of its end positions, and said frame further includes an electrically insulative surface engageable by said roller intermediate the electrical contact surfaces at said end position.

5. A roller-band device comprising frame means, a plurality of rollers each spaced along a flexible band and being movable back and forth on said frame means generally in a singular

plane, a flexible band encircling each roller and having first and second portions extending from said roller, and means connecting said portions of said band to said frame means between adjacent ones of said rollers in a position thereon, whereby said portions of said band decline from the plane on which the rollers roll and each forms an acute angle with said plane on the opposite side thereof from the roller from which it extends, whereby each of said rollers cooperates with said band independently of the others.

6. The device of claim 5 wherein said plurality of rollers are rollable substantially on a common plane and are responsive to different applied forces.

7. The device of claim 5 including at least two rollers, and the band being formed of a resilient material providing an internal bias urging each of said rollers in opposite directions whereby the device provides a bi-directional force responsive roller-band device.

8. A roller-band device comprising frame means, a roller being movable back and forth on said frame means generally in a singular plane, a flexible band encircling said roller and having first and second ends extending from said roller, said frame means including first frame means providing a rolling surface for said roller and second frame means movably mounted with respect to said first frame means for generally back and forth movement in the direction of the movement of said roller to permit adjustment of the device, and means connecting the ends of said band to said second frame means in a position spaced below said rolling surface whereby the ends of said band decline from said rolling surface and each forms an acute angle with said rolling surface on the opposite side thereof from said roller.

9. The device of claim 8 further including third frame means comprising a housing member adapted to receive said first and second frame means therein and cooperating with said first and second frame means to substantially enclose said roller-band device.

10. A roller-band device comprising frame means including a first frame member having a pair of spaced rail portions, a second frame member movably mounted with respect to said first frame member such that said second frame member is movable in a direction generally parallel to said rail portions whereby said roller and band may be moved with said second frame member and with respect to said first frame member, said second frame member including a portion disposed between and recessed from said rail portions, a roller, a flexible band encircling said roller and having first and second ends extending from said roller, means connecting said ends of said band to said second frame member, and means for fixedly securing said second frame member with respect to said first frame member.

11. The roller-band device of claim 10 wherein said roller extends generally transversely to said rail portions and is of sufficient length so that it engages each of said rail portions and is rollable therealong, said band is disposed between said rail portions, and the opposite ends of said band are connected to said second frame means in a position recessed from the plane in which said roller rolls along said rail portions and on the opposite side thereof from said roller whereby the ends of said band each form an acute angle with said plane and whereby, when said band is held in tension, it applies a downward force on said roller urging it into engagement with said rail portions.

12. The roller-band device of claim 10 including fixed contact means mounted on said first frame member and engageable by said roller, said roller being electrically conductive, and means for connecting said roller and said fixed contact means into an electrical circuit whereby said circuit is completed through said roller and said contact means in certain positions of said roller wherein it is in engagement with said contact means.

13. The roller-band device in claim 10 wherein said first frame member further includes stop means defining first and second end positions limiting the travel of said roller, fixed contact means on said first frame member, generally on the surface of said rail portions, and disposed for engagement by said roller in at least one of its end positions.

14. The roller-band device of claim 10 wherein said roller has a length less than the distance between said rail portions and rolls directly on said second frame member between said rail portions.

15. The roller-band device of claim 10 further including a third frame member comprising a housing having one open side and adapted to receive said first and second frame members and said roller and band therein, said first frame member having a portion cooperable with said third frame member to close the open side thereof when the rest of said roller-band device is disposed therein and to thereby provide a substantially complete enclosure of said roller-band device.

16. The device of claim 10 further including electrical contact surface means on said frame means, and a contact portion on said roller for engagement with said contact surface, said frame means defining a longitudinal direction, said band and roller being movable together along the longitudinal direction upon their rolling together about the axis of the roller, the roller and band rolling together with a first radius determining their longitudinal velocity, the contact portion of the roller having a second radius, different from said first radius, whereby the velocity of said contact portion with respect to said contact surface is greater or less than will provide simple rolling contact therebetween.

17. The device of claim 16 wherein said first radius is greater than said second radius, thus causing the velocity of said contact portion with respect to said contact surface to be less than will provide simple rolling contact, thereby causing a skidding action of said contact portion on said contact surface.

18. The device of claim 16 wherein said first radius is less than said second radius, thus causing the velocity of said contact portion with respect to said contact surface to be greater than will provide simple rolling contact, thereby causing a wiping action of said contact portion on said contact surface.

19. Combination of claim 10 wherein at least a portion of said band is constructed of a bimetallic, temperature-responsive material arranged to move said roller in response to temperature change.

20. The combination of claim 10 further including an electrically conductive member mounted on said support means and extending generally longitudinally thereon and disposed in the path of one of said roller and said band whereby said one of said roller and band will move along and engage said conductive member as said roller and band move back and forth in said longitudinal direction, said one of said roller and band being electrically conductive, means for connecting said conductor member and said one of said roller and band into an electric circuit and in an arrangement whereby said conductive member and said one of said roller and band act as a slide wire potentiometer so that the resistance of said circuit varies with the position of said one of said roller and band with respect to said conductive member.

21. A roller-band device comprising: frame means including at least one guide member for guiding a roller back and forth along a predetermined path; a roller being movable back and forth on said guide member along said path; band means for biasing said roller against said guide member including at least one flexible band member encircling said roller and having first and second ends extending from said roller, one of said frame and bias means having two of its respective members spaced laterally from each other and the other of said frame and bias means having at least one respective member extending between the laterally spaced members of said one means; and means connecting the ends of said flexible band member to said frame means in a position thereon whereby each forms an acute angle with said predetermined path on the opposite side thereof from said roller.

22. The roller-band device of claim 21 including two guide members spaced laterally from each other and a single flexible band member extending between said guide members.

23. The roller-band device of claim 21 wherein each of said bands have complimentary solid and cutaway portions comprising a pair of spaced legs in one portion and a tongue in another portion, said tongue being aligned with the space between said legs and having a width less than the width of the space between said legs, whereby each of said bands encircles the roller with the tongue extending between the legs and with said tongue extending in one direction from the roller and the legs in the other.

24. The roller-band device of claim 21 wherein said guide member includes electrical contact means disposed for engagement by said roller.

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