United States Patent [19]

Jones

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[45] **Jan. 7, 1975**

[54] **POINT CONTACT ROLLER BAND SWITCH**

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[52] **U.S. Cl.**........... **200/153,** 200/DIG. 45, 200/277

[51] **Int. Cl.**.. **H01h 1/16**

[58] **Field of Search**.... 200/153 R, 166 BB, DIG. 45

[56] **References Cited**

UNITED STATES PATENTS

3,643,048 2/1972 Crow et al. .... 200/166 BB X

OTHER PUBLICATIONS

Wilkes; "Rolamite: A new Mechanical Design Concept"; AEC publication SC-RR-67-656B; 3/1969; copy in Gr.210; pp. 60,65,86, & 164 included.

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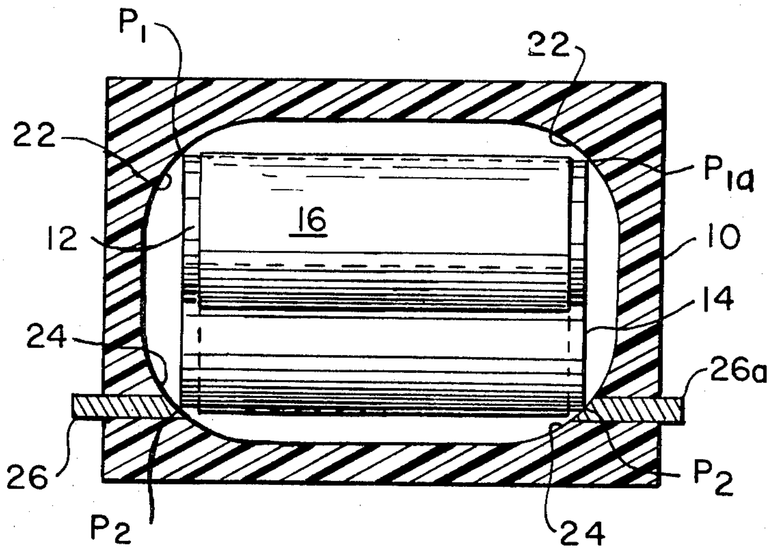
[57] **ABSTRACT**

A roller band electrical switching mechanism wherein one or both of the rollers serves as a movable contact, the roller or rollers functioning as a contact being supported and guided directly by the case. The roller support and guide surfaces, or races, of the case are concavely curved and incorporate fixed contacts which have exposed surfaces which lie flush with the roller guide surface of the case. The roller, with its ends in substantial rolling point engagement with the races, closes or opens electric circuits as it rolls along the guide surfaces. The roller band in most cases does not touch the case. By thus suspending the roller so that it can serve as a movable contact, exerting great localized pressure on embedded contacts flush with the roller support surface while producing minimal switching friction, a substantial increase of switching quality and utility is achieved.

5 Claims, 8 Drawing Figures



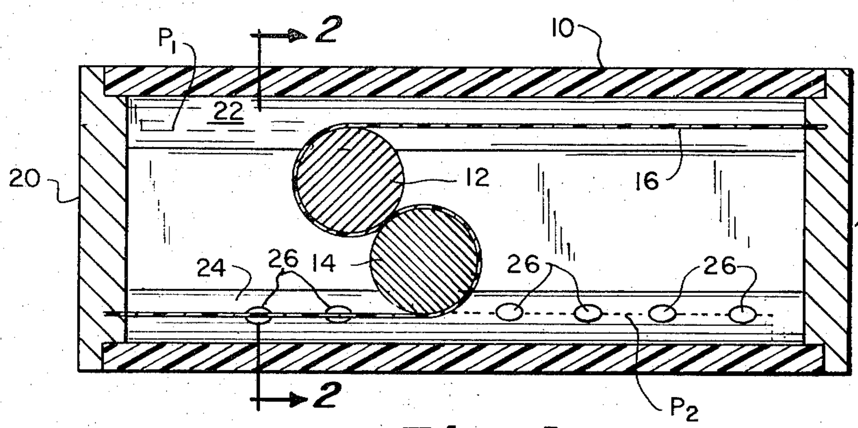


Fig_1

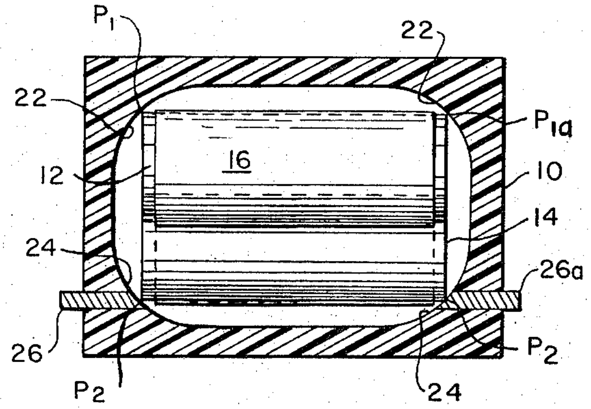


Fig_2

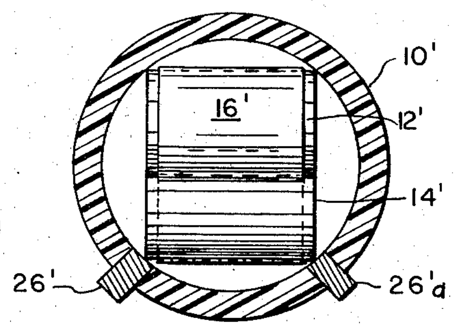


Fig_3

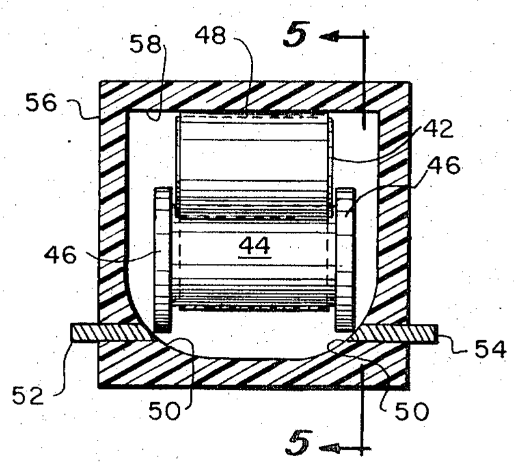


Fig_4

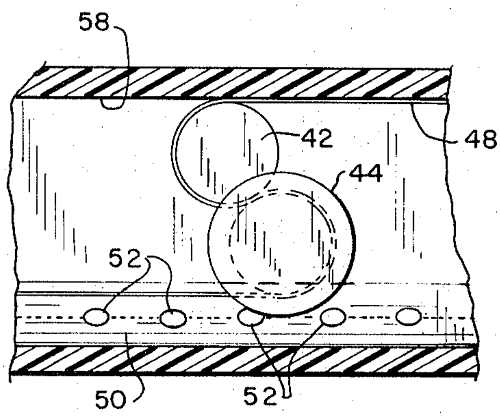


Fig_5

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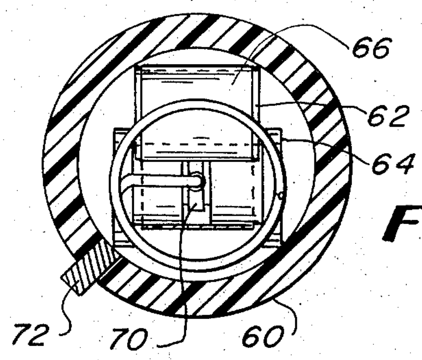

Fig_6

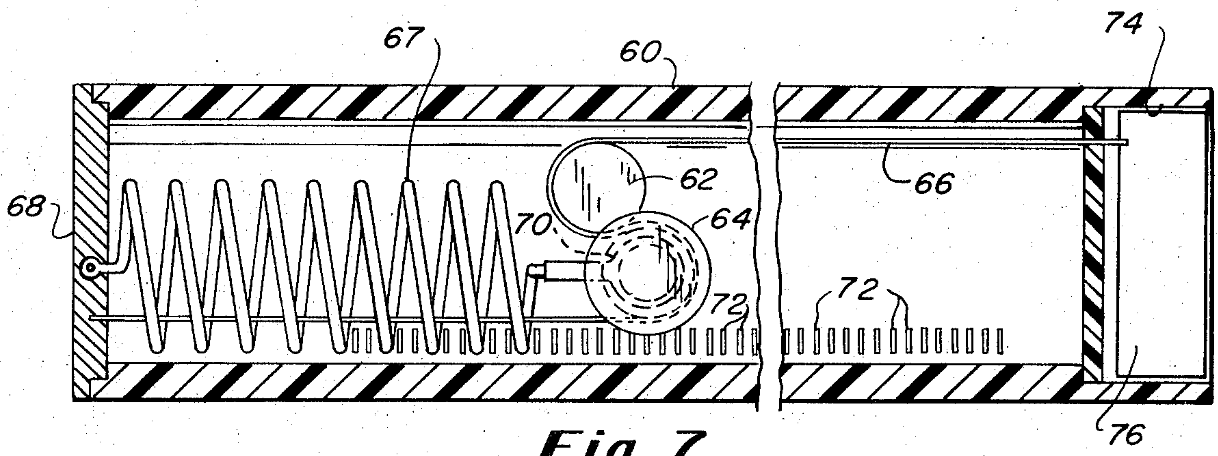

Fig_7

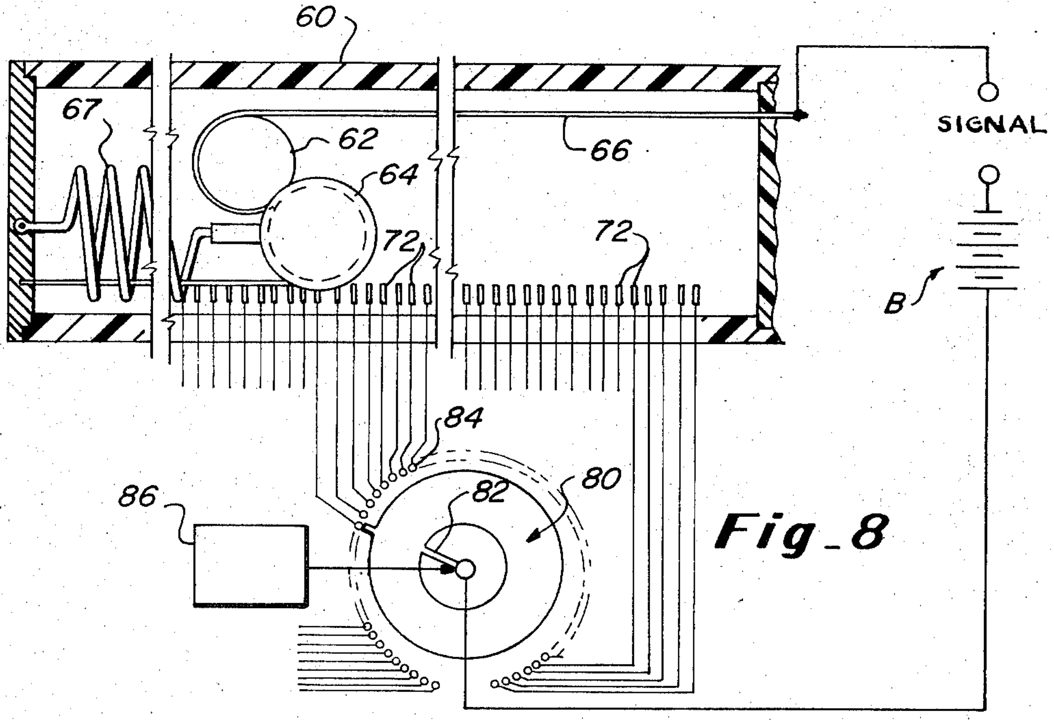

Fig_8

POINT CONTACT ROLLER BAND SWITCH

BACKGROUND OF THE INVENTION

Roller band mechanisms are generally considered to be one of the most basic developments in the field of mechanisms to have been made in recent years. The basic mechanism is the invention of Donald F. Wilkes and is described in detail in U.S. Pat. Nos. 3,452,175; 3,452,309; 3,471,668; 3,567,881 and others. The basic mechanism consists of two right cylindrical rollers, a flexible band trained partially around the roller circumferences in a generally S-shaped configuration and a case having spaced parallel flat upper and lower support surfaces against which portions of the band lie. The band is placed under tension and the spacing between the upper and lower support surfaces is chosen to be greater than the diameter of either roller but less than the sum of the diameters of the rollers so that under the tensioning of the band, the two rollers are forced to assume a position in which their axes lie in a plane inclined to the plane of the support surfaces.

Because of its extremely low friction, this basic device represents a significant advancement of mechanical technology. The low friction attribute suggests desirability of using the mechanism in inertial switching applications. As applied to inertial switching applications the conventional roller band mechanism's design intent has been to have the roller cluster serve as the inertial mass, and to have its entwining band serve as the movable contact. As a movable contact the band may incorporate insulated and laminated printed circuitry and may have compliant-type contact tabs which incline from and coincide with the band surface, depending on switching action. Fixed contacts are usually compliant.

Several problems have impeded development of inertial switches incorporating the prior art features and intents described above. One problem is that of varying sliding friction between the ends of the rollers and the side walls of the case caused by axial displacement of the rollers relative to each other and relative to their tightly entwining band. This particular problem is conventionally referred to as (axial) "run out" and will occur when the roller surface is not truly cylindrical, i.e., tapered, or where a misalignment between rollers, band or guide surfaces occurs during assembly of the device. Because the response of the system is dependent upon the surface area of contact between the band and rollers, it is apparent that this response will vary when run out occurs, thus reducing the accuracy or precision of response of the device.

Further, increased sensitivity of the device to external forces when the band controls the deflection versus force relationship of the roller cluster requires an increased degree of tensioning of the band. High band tensions tend to increase the propensity of the system to run out.

Another problem encountered in the conventional roller band arrangement due to the parallel flat support and guide surfaces is experienced when slight surface irregularities or foreign materials are present on the roller support and guide surfaces. Irregularities of this type cause variations in band tension and thus variations in the response of the system.

Another problem is the inertial force sensing error caused by the force required for the roller cluster to depress compliant contacts during sequential switching functions.

Other problems are of an electrical nature in that the above described switching features will not satisfy switching capacity and reliability requirements of many of the systems for which roller band inertia switches have been intended. The necessarily thin band, made of metal having relatively low current conductivity, incurs arcing damage which can change its spring characteristics, and the band also acquires oxide deposits which increase contact resistance. Printed circuit laminations on the band have proved unsatisfactory because of adhesive problems and because they tend to null the spring characteristics of spring bands. Thus, prior art switches cannot accommodate low or high switching current requirements with sufficient reliability in applications requiring a great number of switching cycles.

Another main problem of prior art roller band inertia switches is one of utility limitation. The above-described geometry, while satisfying many mechanical application requirements, imposes limitations on use of the mechanism in sequential inertial switching. Again, the problem derives mainly from use of the band as a movable contact. Whereas the band can serve as a common circuit and sequentially close and hold closed pick off circuits as it passes over compliant-type contacts, there appears to be no reliable means by which the band can momentarily sequentially close and open closely spaced circuit contacts of either the same pickoff circuit or independent circuits as the roller cluster displaces in its sensing axis.

The present invention is specially designed to eliminate or minimize the switching problems referred to above and to thus enable the achievement of roller band mechanism switches having reduced friction and switching force error and greater switching capacity, reliability and utility.

SUMMARY OF INVENTION

The problems referred to above are largely overcome in the present invention by providing electric contacts embedded in roller support and guide surfaces in the form of races with which the rollers make only rolling point contact (as contrasted with the conventional roller band mechanism's rollers' line contacts on flat support surfaces with the band in between), thereby enabling the rollers, rather than the band, to serve as movable switching members.

In accordance with the present invention, the cylindrical rollers are formed with an axial dimension slightly exceeding the width of the band. In some applications requiring the band to be maintained out of contact with the race surfaces, the rollers are slightly recessed to take a spool shape, with the recess slightly wider than the band width.

In some applications the present invention's improvement of quality, capacity and utility of electric switching otherwise limited in conventional roller band switches can be obtained by using only one roller as a movable switching member, having rolling point engagement with contact embedded races. As designed for these applications the present invention's other roller can be controlled either by races not containing contacts or by separate flat roller support and roller guide surfaces. In all designs, the switching rollers are supported by the interior walls of the case, their support and guidance being obtained only via rolling point engagement of their ends with surfaces of contacts embedded races inclined relative to the roller axes. Other objects and features of the invention will become apparent to the following specification and to the drawings.

IN THE DRAWINGS

FIG. **1** is a cross-sectional view taken in a central longitudinal plane of a roller band switch embodying the present invention;

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

FIG. **3** is a cross-sectional view, similar to FIG. **2**, showing a modified form of casing;

FIG. **4** is a cross-sectional view, similar to FIG. **2**, showing a further modification of the invention;

FIG. **5** is a partial cross-sectional view taken on line **5—5** of FIG. **4**;

FIG. **6** is a transverse cross-sectional view of another embodiment of the invention;

FIG. **7** is a longitudinal cross-sectional view of the embodiment of FIG. **6**; and

FIG. **8** is a schematic diagram of the device of FIG. **6** showing an exemplary application.

In the drawings, various exemplary forms of the invention have been illustrated as applied to a simplified form of roller band mechanism. The invention has been illustrated and will be described as applied to an inertia switch in which movement of the roller cluster longitudinally in its case is induced by longitudinal acceleration of the case, with switching contacts being located along the path of movement of the roller cluster to generate electric signals in accordance with the displacement of the roller cluster from an initial position. The mechanical properties and response characteristics of roller band mechanisms are well known, and will not be described in detail. Reference may be had to U.S. Pat. Nos. 3,452,175; 3,542,309; and 3,471,668 for such details. As illustrated and described in this application, the invention is disclosed in terms of a basic roller cluster configuration, however, it will be apparent that the invention is not limited to the specific two roller arrangement illustrated.

Referring now to the drawings, in FIG. **1** there is shown a longitudinal cross-sectional view of a roller band mechanism which includes a case **10**, a roller cluster defined by rollers **12** and **14** maintained in the illustrated relationship by a tensioned band **16** anchored at its opposite ends to end caps **18** and **20.** In contrast to conventional roller band mechanisms, band **16** does not contact case **10** and is in contact with a fixed point only at its opposite ends at end caps **18** and **20.**

Referring to FIG. **2,** it will be seen that rollers **12** and **14** are of right circular cylindrical configuration and are supported and guided in movement within case **10** by rolling contact between the peripheral axial end edges of the rollers and concave guide surfaces or races **22—22** and **24—24** on the interior wall of the case. Preferably, the tangents of the surfaces of races **22—22** and **24—24** at the points of contact with rollers **12** and **14** are inclined at an angle of 45° to the respective axes of rollers **12** and **14** to provide the optimum combination of support of the rollers in both horizontal and vertical directions as viewed in FIG. **2.** The circular peripheral axial end edges of rollers **12** and **14** engage their associated guide surfaces in substantial point contact, this contact being maintained by the tension of band **16** which attempts to move the axes of rollers **12** and **14** into a vertical relationship with each other as viewed in FIG. **1,** but which is prevented from doing so by the relationship between the diameters of rollers **12** and **14** and the curvature and vertical spacing between guide surfaces **22** and **24.**

Because of the fact that rollers **12** and **14** engage their guide surfaces or races **22** and **24** only in substantial point contact, the contact pressure between the rollers and races is quite high. This high contact pressure affords certain advantages from both the mechanical and electrical standpoint which will be discussed below, but must be taken in account in chosing the materials from which rollers **12** and **14** and case **10** are constructed. In the inertial switch application disclosed in the drawings, it is usually desired that case **10** be constructed of an electrically insulative material so that electrical contacts such as **26** embedded in the case along the path of movement of one or both of the rollers may be conveniently electrically insulated from each other. In this switching application, one of the rollers must act as a movable contact and thus must be formed from an electrically conductive material.

A preferred material for the construction of case **10** is diallyphthalate, a glass filled epoxy having high electrical insulative characteristics which can be molded, machined and lapped to an extremely smooth hard finished surface. Rollers **12** and **14** are preferably formed of beryllium copper alloy which possesses high electrical conductivity and which can be formed with a hard surface. Electrical contacts **26,** embedded in the case wall, are likewise preferably formed of the beryllium copper alloy.

The geometry of the system of FIGS. **1** and **2** is such that rollers **12** and **14** during movement within case **10** contact the case wall only along line paths **P1** and **P2** (FIG. **1**) engaging the paths at the opposite axial end edges of the respective rollers, as at **P1**, **P1*a***, **P2**, **P2*a*** (FIG. **2**).

In the examples shown in FIGS. **1** and **2**, a switching arrangement is shown in which roller **14** is employed as a movable contact with a series of electrical contacts **26** and **26a** embedded in the case wall along the linear paths **P2** and **P2*a*** which roller **14** traverses during movement within case **10.** The location and arrangement of contacts **26, 26*a*** are chosen as desired. One typical arrangment might find a single contact **26*a*** continuously extending the entire length of linear path **P2*a*** with uniformly spaced contacts **26** being located along path **P2** to sequentially complete successive electrical circuits as roller **14** moves along its linear path.

Due to the fact that roller **14** engages its races **24** and the exposed surfaces of contacts **26** in substantial point contact, an electrical switching system employing contacts spaced from each other such as contacts **26** illustrated in FIG. **1**, can indicate the position of roller **14** within casing **10** with an extremely high degree of precision. The disadvantage of a relatively small area of electrical contact between contacts **26** and the axial end edge of roller **14** is compensated for by the extremely high contact pressure obtained by the point contact support of roller **14.**

It will be appreciated that the term "point contact" in reference to the engagement between the rollers and races is used not in its strict geometrical sense in that the actual contact between the rollers and races occurs over a finite area. By minimizing the area of contact between the stationary and moving parts of the system, increased contact pressure is achieved which improves the make and break aspects of the electrical switching and achieves a further mechanical advantage in that the high contact pressures tend to reduce surface irregularities as the device "wears in," thus producing more uniform and precise mechanical response characteristics. In the construction of the device, the exposed surface of contacts **26** are finished flush with the guide surface or race **24** and the combined surfaces finished to a high degree of smoothness to minimize initial surface regularities.

In FIG. **3**, a second embodiment of the invention is shown which differs from the previously described embodiment primarily in that its case **10** takes the form of a hollow cylindrical tube.

In FIGS. **4** and **5**, another exemplary embodiment of the invention is shown which includes both modifications to the case and to the rollers. In the embodiment of FIGS. **4** and **5**, the upper roller **42** is formed as a right circular cylinder, while the lower roller **44** is formed with a reduced diameter central section and radially projecting flanges **46** at its opposite end edges to provide what is conveniently termed a "spool" shaped configuration. As best seen in the cross-sectional view of FIG. **4**, the axial spacing between flanges **46** of roller **44** slightly exceeds the width of band **48** which in turn is substantially equal to the axial dimension of upper roller **44**. Thus, the flanges **46** provide a constraint against axial movement of band **48** and roller **42** relative to each other or to roller **44**.

The outer peripheral edges of flanges **46** are supported upon a pair of concave inclined guide surfaces or races **50** in the same manner as rollers **12** and **14** of the FIGS. **1** and **2** embodiment are supported. However, upper roller **42** of the FIGS. **4** and **5** embodiment does not contact the case **56** and the upper surface **58** of the inner wall of the case is formed as a flat guide surface against which band **48** lies as in conventional roller band mechanisms.

Like the previously described embodiments, electrical contacts **52** and **54** may be embedded in case **56**, case **56** being made of electrical insulating material, while roller **44** is of electrically conductive material to function as a movable contact.

While the embodiments of FIGS. **1** through **3** provide a mechanical restraint against runout, that is, axial shifting of the rollers relative to the band or to each other, the embodiment of FIG. **5** not only provides a similar constraint against runout but further provides a positive restraint against twisting of the band and roller cluster about the longitudinal axis of the casing. The embodiment of FIG. **5** is thus somewhat more desirable for use in applications where a relatively long excursion or roller cluster path length is required.

In FIGS. **6, 7** and **8** there is shown another form of the invention in which the displacement of the roller cluster is proportional to the acceleration imparted to the assembly which may be employed in combination with a programmer in an exemplary circuit shown in FIG. **8** to trigger or transmit a signal when a preselected acceleration occurs.

The roller band switch assembly of FIGS. **6** through **8** includes a hollow cylindrical case **60** within which is mounted a roller cluster which includes a smooth ended cylindrical roller **62** and a flanged roller **64.** The band **66** is trained about rollers **62** and **64** with generally the same dimensional relationship between the band width, spacing of flanges on roller **64** and the axial dimension of roller **62** as is present between the rollers **42** and **44** and band **48** of the embodiment of FIGS. **4** and **5.** A tension spring **67** is coupled between one of the end caps **68** and a bearing member **70** which is rotatably retained on roller **64,** spring **67** exerting a resilient bias on the roller cluster tending to urge the roller cluster toward its left hand limit of movement as viewed in FIG. **7.** A series of electrical contacts **72** are embedded in the case along the line path of contact of the flanges of roller **64** with the case wall. A recess **74** at one end of the case is preferably provided to receive various elements of an electrical circuit schematically shown in FIG. **8.** Certain of the circuit elements may be contained in a capsule **76** fixedly secured by similar means, not shown, in recess **74.**

In the system shown in FIGS. **6** and **7**, the displacement of the roller cluster from the position it assumes when spring **67** is undistorted is determined by the following relationship

$$x = ma/k$$

where x equals the roller cluster displacement from the rest position of spring **67,** m equals the mass of the roller cluster, a equals the acceleration imparted to the roller cluster and k equals the spring constant. Thus, the various contacts **72** which extend along a path of displacement of the roller cluster may be employed to give a signal or indication of the magnitude of acceleration imparted to the device.

In FIG. **8** an exemplary application is schematically illustrated in which one set of contacts **72** and band **66** are employed as parts of an electrical circuit. Each of the various contacts **72,** as explained above, represents a given acceleration when contacted by roller **64** and the individual contacts **72** are connected in sequence to stationary contacts on a stepping switch designated generally **80** having a movable contact **82** which may be manually positioned or alternatively driven in step by step movement along stationary contacts **84** in sequence by a drive designated **86.** Drive **86** in some instances may be actuated by a timer or by some other condition responsive mechanism. An electric power source B is electrically connected to movable contact **82** while band **66** is in electrical contact with roller **64** and is electrically connected at one end to the opposite side of power source B via an output device schematically illustrated as "Signal" in FIG. **8.**

The arrangement shown in FIG. **8** is operable to apply an electrical output at SIGNAL unit when the measurement of a given acceleration, represented by the displacement of the roller cluster from its rest position coincides with another variable condition represented by the position of the pointer **82.**

Prior to use in any given application, the movable contact **82** would be stepped to a position representing the desired switching acceleration value. This would be done by the conventional selector programming method.

For example, if it is desired that a signal be generated when the device is subjected to an acceleration of **20**g, pointer **82** would be positioned to be electrically connected to the contact **72** engaged by roller **64** when the cluster senses a **20**g acceleration.

While various examples of the invention have been described in detail, it will be apparent to those skilled in the art that the embodiments described above may be modified. Therefore, the foregoing description is to be considered exemplary rather than limiting, and the true scope of the invention is that defined in the following claims.

I claim:

1. In a roller band mechanism having a case, a pair of cylindrical rollers mounted within said case for guided movement along a passage in said case, and a tensioned flexible band anchored at it opposite ends to opposite ends of said passage and trained partially about the circumferences of said rollers in a generally S-shaped configuration to maintain said rollers in a roller cluster; the improvement wherein at least one of said rollers contacts a race surface in said passage only along the periphery of the ends of said one roller so as to establish substantially a point contact at opposite axial ends of said one roller with the race surface during movement of said roller cluster along said passage, said points of contacts **55** along the race surface of said passage occuring only along two separated predetermined line paths, and a plurality of electrical contacts embedded in the race surface of said case having inner ends flush with the surface of said passage at selected locations along said line paths, said one of said rollers being of electrically conductive material and said contacts being electrically insulated from one another.

2. The invention defined in claim **1** wherein the race surfaces of said passage contacted by said one of said rollers are concavely curved and have tangents oppositely inclined at an angle of 45° to the axis of said one of said rollers at the points of contact between the race surfaces and said one of said rollers.

3. The invention defined in claim **1** wherein said passage is of circular transverse cross-sectional configuration.

4. The invention defined in claim **1** wherein one wall of said passage is flat, the portion of said band between the other of said rollers and one end of the band lying in face to face engagement with said one wall of said passage.

5. The invention defined in claim **1** wherein said one roller has a reduced diameter central section and radially projecting annular flanges at opposite axial ends thereof, said flanges being axially spaced from each other by a distance slightly exceeding the width of said band and the axial length of said other of said rollers whereby said flanges restrain axial displacement of said band and said rollers relative to each other.

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