United States Patent

Wilkes

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[45] **June 20, 1972**

[54] **CYCLIC APPARATUS**

[72] Inventor: **Donald F. Wilkes**, Albuquerque, N. Mex.

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

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[21] Appl. No.: **32,808**

[52] **U.S. Cl.** **74/63,** 74/202, 74/204, 74/640

[51] **Int. Cl.** **F16h 9/00**

[58] **Field of Search**......................74/63, 640, 202, 206, 203, 74/204; 267/1.5

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Primary Examiner—Milton Kaufman
Attorney—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

The apparatus includes a guide surface and a thin, resiliently flexible endless band. The guide surface provides a continuous cyclic path for the band. The length of each cycle of the guide surface is substantially less than the cyclic length of the band and the band is arched away from the guide surface in a lobe. Portions of the band on opposite sides of the lobe frictionally engage the surface to prevent the lobe from collapsing. The lobe is capable of progressing along the band to displace the lobe relative to the guide surface. Each cycle of the band relative to the guide surface advances the band a predetermined distance along the guide surface.

14 Claims, 17 Drawing Figures

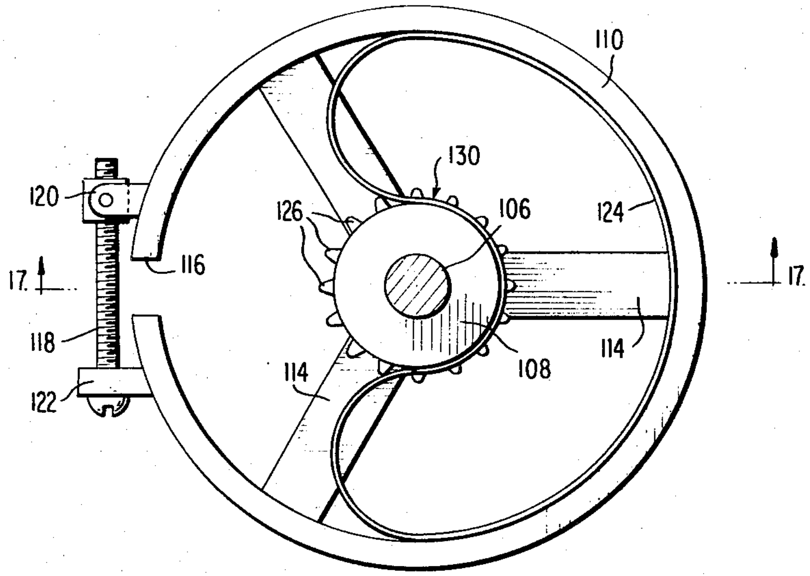


FIG. 1

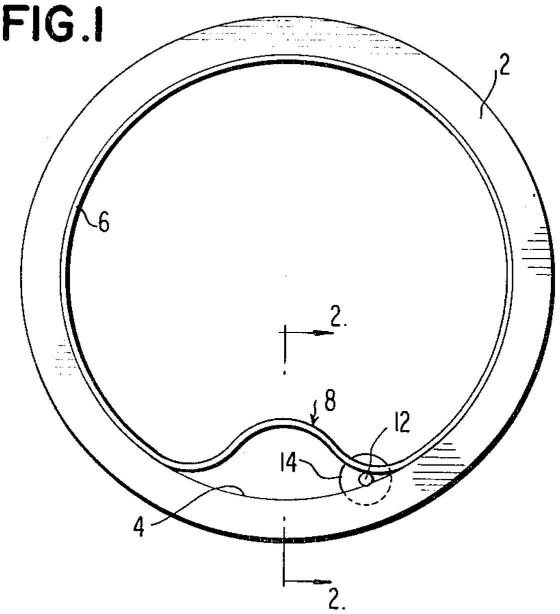
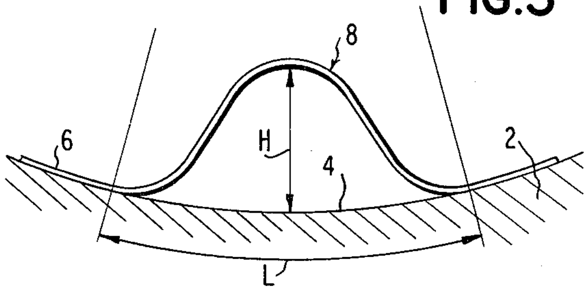


FIG. 3



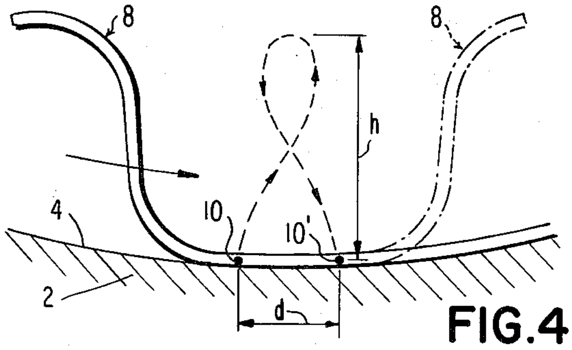
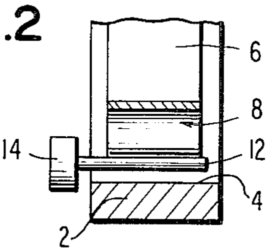


FIG. 4

FIG. 2



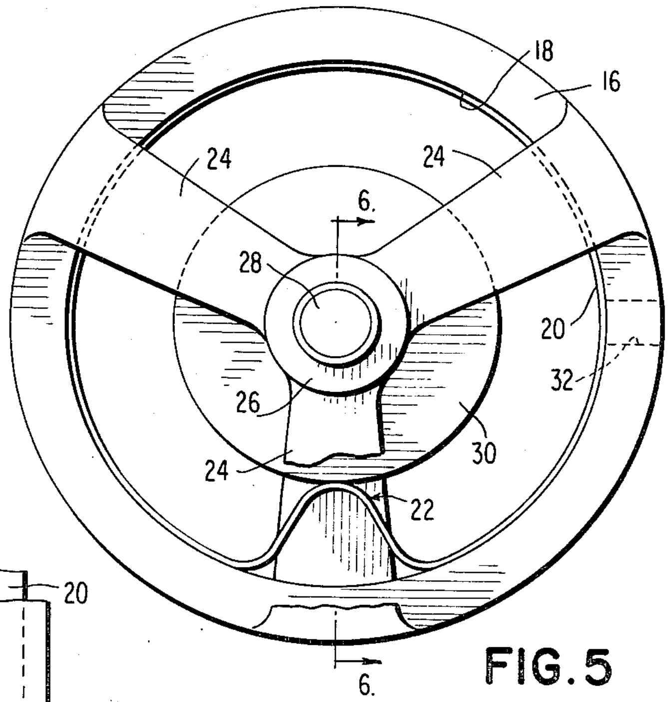


FIG. 5

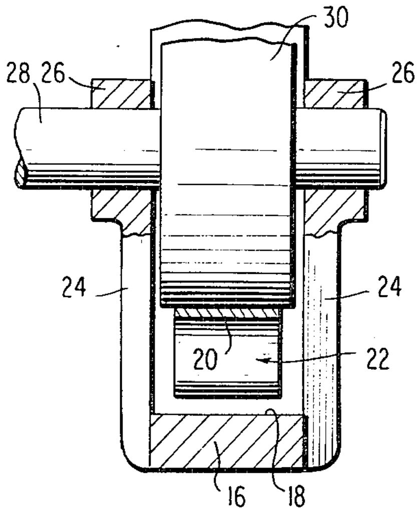


FIG. 6

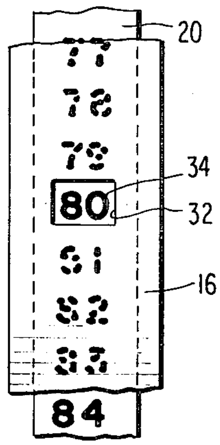


FIG. 7

INVENTOR

DONALD F. WILKES

BY Burns, Doane, Benedict, Swecker & Mathis

ATTORNEYS

FIG. 8

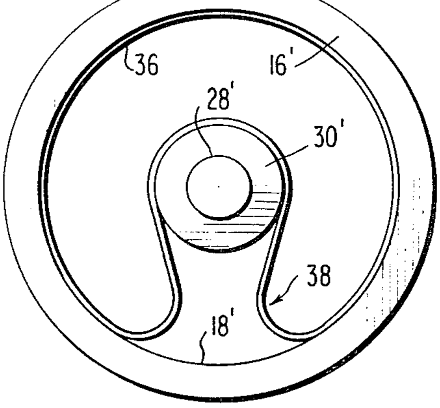


FIG. 9

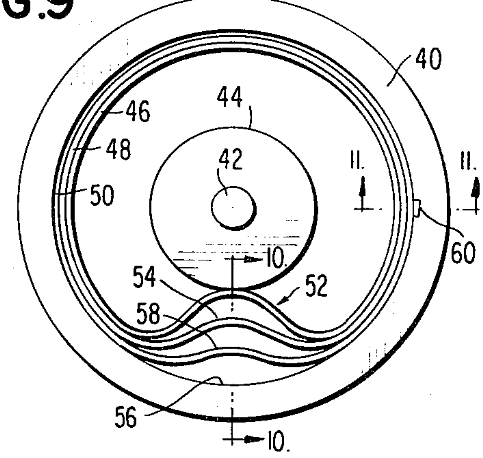


FIG. 10

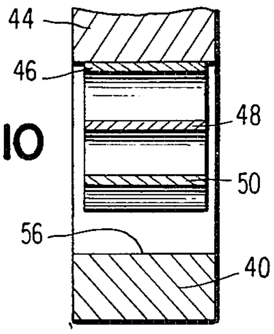


FIG. 12

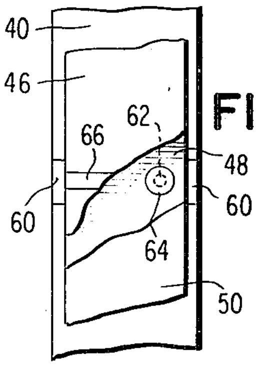


FIG. 11

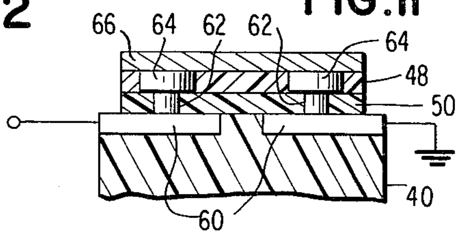


FIG. 13

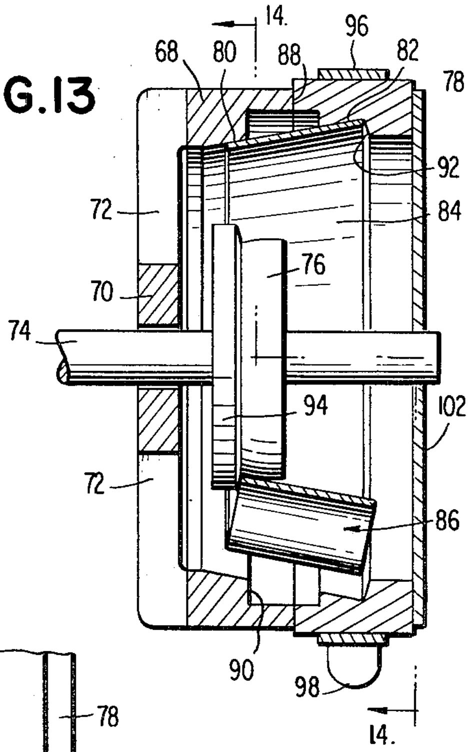


FIG. 14

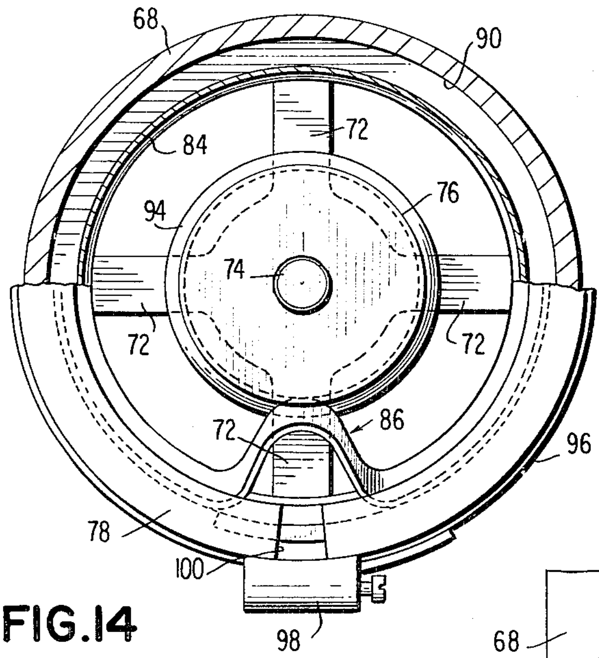


FIG. 15

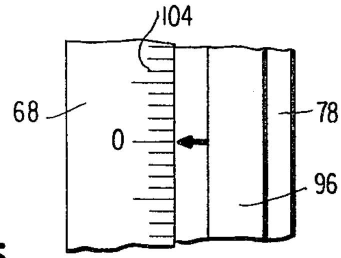
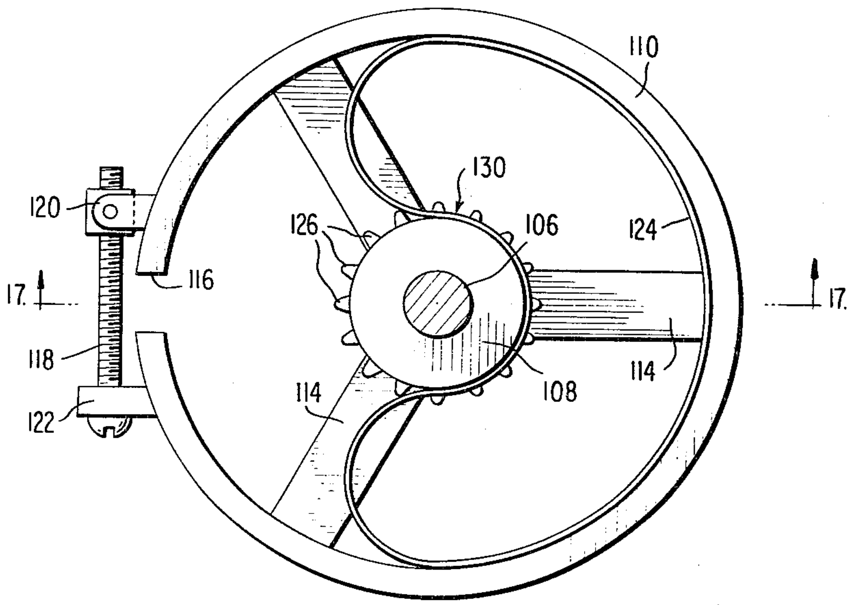


FIG. 16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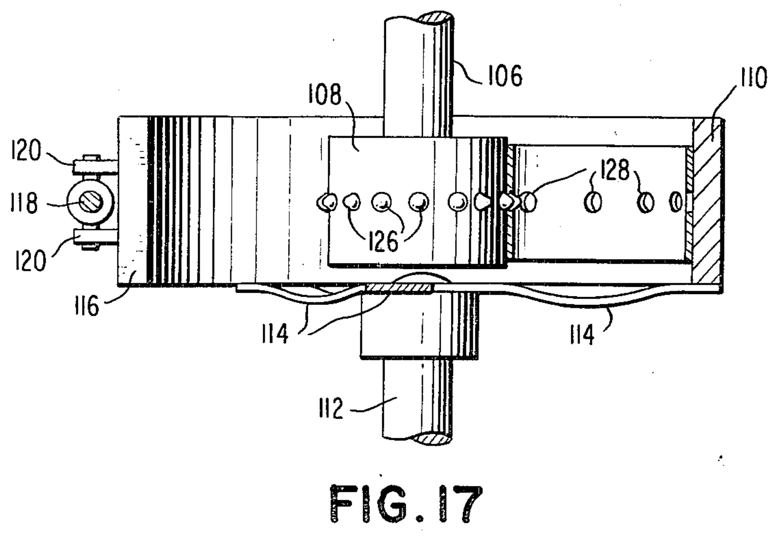
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FIG. 17

CYCLIC APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

Two related applications of Donald F. Wilkes entitled respectively "Mechanical Apparatus", Ser. No. 32,886 and "-Snap Action Apparatus", Ser. No. 32,885 are being filed concurrently herewith.

BACKGROUND OF THE INVENTION

This invention relates to cyclic apparatus, and more particularly to means for effecting relative cyclic motion between elements.

Conventional means for producing relative cyclic motion between elements include gears and belts. Gear transmissions, for example, typically have one gear mounted on an input shaft by which torque is applied to a gear on another shaft. The speed change between the input and output shaft is the ratio of the diameters of the gears. Pairs of gears may be connected together in series in order to increase the speed change between the input shaft and the output shaft. An extremely high degree of amplification cannot be achieved by gearing because of the friction between the teeth of mating gears. Also, the backlash due to dimensional tolerances in the gear teeth introduces error in the rotational position of the output element relative to the input element. Other disadvantages of gearing in transmitting motion are the space requirements and the costs in manufacturing the gears and providing bearings for supporting the gears.

Belt drives similarly have limitations on their use in transmitting motion between elements in apparatus. Since torque is transmitted from one pulley to the other by tension in the belt, the belt tends to slip relative to the surface of the pulleys, if the torque is too high. Belt slippage also makes belt drives unsuitable for applications where the rotational position of one pulley relative to the other must remain the same. It is also impractical to attempt to provide a high degree of amplification between two pulleys even at low torque because slippage of the belt is more likely to occur as the ratio of diameters of the pulleys increases. Furthermore, the space requirements for belt drives are even greater than those for gear transmissions.

Both belt drives and gearing are subject to wear, and the rate of wear usually increases as the degree of amplification increases. Also, internal friction in belt or gear transmissions makes them unsuitable where small actuating forces or torque is available.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide cyclic apparatus that is capable of effecting relative motion between elements efficiently and with a minimum of slippage between cooperating surfaces.

It is a further object of this invention to provide cyclic apparatus that is capable of providing a high ratio between motion of an input element and an output element in a minimum of space.

Another object of this invention is to provide cyclic apparatus for providing a high ratio of motion between input and output elements that is operable in response to relatively low torque or input forces.

A still further object of this invention is to provide cyclic apparatus that is capable of effecting a high ratio of motion between input and output elements in which there is a minimum of wear and frictional drag between components of the apparatus.

These objects are accomplished in accordance with a preferred embodiment of the invention by apparatus that includes a guide surface that extends along a continuous cyclic path and an endless thin, resiliently flexible band superimposed on the surface. Spaced portions of the band engage the surface and an intermediate portion is arched away from the surface in a lobe. The lobe is capable of progressing along the band to displace the lobe relative to the guide surface along the cyclic path. Each cycle of the lobe around the path advances the band relative to the surface a predetermined distance in the direction of movement of the lobe. In one embodiment, the guide surface is circular and a wheel is mounted concentrically with the guide surface. The band lobe extends between the guide surface and the peripheral surface of the wheel, with the apex of the lobe engaging the wheel surface. In another embodiment, the lobe is looped around the wheel.

DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a side elevational view of one embodiment of the apparatus of this invention;

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

FIG. 3 is a schematic view of the guide means and band of the apparatus of this invention;

FIG. 4 is an enlarged schematic view of a portion of the guide means in element of FIG. 3;

FIG. 5 is a side elevational view of a recording device incorporating the apparatus of this invention;

FIG. 6 is a cross-sectional view of the device along the line 6—6 in FIG. 5;

FIG. 7 is a detail view of the guide means and band in FIG. 5;

FIG. 8 is a side elevational view of a modified form of the apparatus shown in FIG. 5;

FIG. 9 is a side elevational view of an electrical switching device incorporating the apparatus of this invention;

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

FIG. 11 is a cross-sectional view of the device along the line 11—11 in FIG. 9;

FIG. 12 is an elevational view, partially in cross section of the device of FIG. 9;

FIG. 13 is a cross-sectional view of a device utilizing multiple guide rings in accordance with this invention;

FIG. 14 is a cross-sectional view of the device along the line 14—14 in FIG. 13;

FIG. 15 is a detail elevational view of the device in FIG. 13;

FIG. 16 is a side elevational view of a variable transmission in accordance with this invention; and

FIG. 17 is a cross-sectional view of the transmission along the line 17—17 in FIG. 16.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 1 to 4, a preferred embodiment of the invention is illustrated. The apparatus includes a guide 2 in the form of a ring having a cylindrical guide surface 4 on the interior of the ring 2. A thin, resiliently flexible elongated element is joined together at opposite ends to form a continuous band 6. The circumference of the band 6 is greater than the circumference of the surface 4, thereby causing the band to arched away from the surface in a lobe indicated at 8 in FIG. 1.

The action of the lobe relative to the band 6 and guide surface 4 are shown in detail in FIGS. 3 and 4. The curvature of the surface 4 imposes bending moments on the band tending to press the band outwardly against the surface 4 around the circumference of the guide 2. These bending moments also are applied to the band portion that is in the lobe 8 at opposite ends of the lobe, tending to shorten the length of the lobe. As shown in FIG. 3, the length L of the lobe 8 extends between the positions on the band beyond which the band is supported solely by the surface 4. The band should have sufficient resistance to plastic deformation to avoid becoming permanently set in the shape of the lobe 8. The band should also have sufficient stiffness to retain its cross-sectional shape and to support the bending moments, but it should not be so stiff that fracture or permanent set occurs at the lobe. It is also necessary for the band to be sufficiently resistant to longitudinal compression to avoid collapsing the lobe. The height H of the band lobe **8** is indicated in FIG. **3** as the distance between the surface **4** and the opposite face of the band **6**.

Since the surface **4** of the guide is cylindrical, the bending moments induced at opposite ends of the lobe **8** remain constant regardless of the position of the lobe along the surface **6**. The lobe therefore is stable at any position along the surface **6** and is free to progress along the band to displace the lobe along the surface in either circumferential direction.

The path of a point on the band as the lobe progresses relative to the band is shown schematically in FIG. **4**. As the lobe **8** progresses from the position shown in full lines to the position shown in dotted lines in FIG. **4**, a midpoint between the surfaces of the band **6**, indicated at **10** follows the path indicated by the arrows in FIG. **4**. As the front end of the lobe **8** passes over the point **10**, the band is lifted from the surface **4** in a direction that is initially almost radially of the surface **4**. The band is progressively displaced away from the surface **4** until it approaches the apex of the lobe **8**. It should be noted that the band portion that is momentarily at the apex is moving in the opposite direction from the movement of the lobe. On the rear side of the lobe **8**, the point **10** on the band progressively converges toward the surface **4** and after the rear end of the lobe has passed, the point **10** is positioned at the location indicated at **10'** in FIG. **4**. The height of th path h is equal to the height H in FIG. **3**, less the thickness of the band **2**. The distance *d* is equal to the difference between the arcuate length L as measured along the surface **4** and the length of the band that forms the lobe **8** between the opposite ends of the lobe. If the lobe **8** were progressed backward from the position shown in dotted lines to the position shown in full lines in FIG. **4**, each successive segment of the band would follow the path from the point **10'** to the point **10**, as shown in FIG. **4**. Thus, the apparatus of this invention is capable of advancing the band longitudinally in either direction relative to the surface **4** a predetermined distance without sliding.

As previously noted, the front end of the lobe advances as the band at the front end moves radially away from the surface **4**. Consequently, the lobe can be made to progress by pulling successive portions of the band away from the guide surface at the front end of the lobe. An implement for accomplishing this is illustrated in FIGS. **1** and **2**. The implement includes a thin roller **12** which has a knob **14** in one end. As the roller **12** is rolled along the surface **4** in a clockwise direction, as viewed in FIG. **1**, the roller advances counterclockwise around the circumference of the surface **4**. At the same time, movement of the roller urges successive segments of the band to peel away from the surface **4** at the front end of the lobe **8**. Of course, relative sliding occurs between the surface of the band **6** and the surface of the roller **12**, but the pressures normally encountered are very small, wear and frictional drag is negligible. As the roller **12** rolls in a counterclockwise path, the lobe **8** advances also in a counterclockwise direction relative to the surface **4**. The roller **12** may be mounted, for example, on a crank which rotates about the center of the surface **4** so that the roller **12** can make a complete revolution around the surface **4**. As explained with respect to FIG. **4**, each revolution of the lobe **8** advances the band **6** a distance *d*. By varying the circumference of the band **6**, the distance d may be adjusted, but the ratio of revolutions of the lobe **8** required to cause one complete revolution of a fixed point on the band **6** is greater than one.

Significant advantages can be achieved by utilizing a wheel mounted for rotation at the center of the guide with the peripheral surface of the wheel engaging the lobe of the band. A recording device incorporating the apparatus of this invention is shown in FIGS. **5** to **7**. The device includes a guide **16** which has a substantially cylindrical inner surface **18**. A thin, resiliently flexible endless band **20** is supported within the guide **16** and has a length which is greater than the circumference of the surface **18**, thereby forming a lobe indicated at **22**. The guide **16** has a plurality of spokes **24** which extend inwardly to support hubs **26** on opposite sides of the guide surface **18**. A shaft **28** is supported for rotation in bearings in the hubs **26** and a wheel **30** is fixed to the shaft **28** and turns with the shaft. Preferably, the difference between the radius of the wheel **30** and the radius of the guide surface **18** is less than the free height of the lobe **22**, so that the lobe is compressed between the peripheral surface of the wheel and the guide surface **18**.

By rotating the shaft **28** in a clockwise direction, the wheel **30** causes the portion of the band that is at the apex of the lobe **22** to move toward the left, as viewed in FIG. **5**, while the lobe **22** progresses toward the right. Movement of the lobe **22** continues in a counterclockwise direction as long as the wheel **30** rotates. As explained with respect to FIG. **4**, as the lobe **22** peels away a portion of the band that is in engagement with the surface **18** at the front end of the lobe and converges that same portion onto the surface **18** at the rear end of the lobe after the portion has moved through the lobe, the band is displaced a distance corresponding to the difference in length between the arcuate length of the guide surface band by the lobe and the length of the band that is in the lobe. The device illustrated in FIG. **5** takes advantage of this step-wise travel of the band by means of indicia in the form of a series of numbers printed on the outer surface of the band **20**. A window **32** is provided in the guide **16** through which the numbers **34** may be viewed. During each revolution of the lobe **22** around the guide **16**, the lobe passes the window **32** once and displaces the band the distance between two consecutive numbers. After the lobe **22** passes, the next number appears at the window **32**. The ratio of the circumference of the band **20** to the circumference of the wheel **30** determines the number of revolutions of the shaft **28** that are required for each change in the indicia **34** at the window. In this way, a very accurate and yet relatively inexpensive revolution counter or recorder is provided.

Referring to FIG. **8**, a modified form of the revolution counter of FIGS. **5** to **7** is shown. The guide **16'** is shown schematically with the spokes and hubs omitted. The structure of the apparatus shown in FIG. **8** is that same as that shown in FIGS. **5** to **7**, except that the band has a greater circumference in FIG. **8**. The band **36** instead of being compressed between the peripheral surface of the wheel **30'** and the guide surface **18'**, has the lobe **22'** looped over the wheel **30'**. The frictional engagement between the band **36** and the wheel **30'** resists relative sliding movement between the wheel and the band. Since the lobe **38'** has a relatively large length of band, as compared to the corresponding arcuate length of the guide surface **18'**, the band makes a relatively large lengthwise displacement relative to the surface **18'** with each revolution of the lobe **38**. Since the circumference of the band **36** is necessarily greater than the circumference of the band **20**, the number of revolutions of the wheel **30'** to cause one revolution of the lobe **38** is greater than the corresponding ratio in the apparatus of FIG. **5**, assuming that the dimensions of the wheel and the guide surfaces are the same.

An electrical switch device incorporating the apparatus of this invention is shown in FIGS. **9** to **12**. The device includes a guide **40** and a rotary shaft **42** which rotates about a fixed axis with respect to the guide **40**. The shaft **42** is mounted in bearings supported in the same manner as the shaft **28** in FIGS. **5** and **6**. A wheel **44** is secured on the shaft **42**. An inner band **46**, an intermediate band **48**, and an outer band **50** are mounted within the guide **40**. The inner band **46** is longer than the circumference of the inner surface of the intermediate band **48** and a lobe **52** is formed in the inner band. Preferably, the lobe **52** is compressed between the peripheral surface of the wheel **44** and the inner surface of the band **48** to insure that friction between the bands prevents slippage of the bands relative to each other and relative to the wheel **44**. The intermediate band **48** has a length which is less than that of the inner band **46** but greater than the length of the outer band **196**, thereby forming a lobe **54**. Similarly, the outer band **50** is interposed between the intermediate band **48** and the cylindrical guide surface **56** and is of sufficient length to form a lobe **58**.

The inner lobe **52** is displaced relative to the guide **40** by the force transmitted from the wheel **44** to the band **46** at the apex of the lobe. As the lobe **52** is displaced counterclockwise, for example, relative to the intermediate band **48**, the intermediate lobe **54** is displaced outwardly at the forward end of the lobe **54** and is released progressively at the rear end of the lobe. This causes the intermediate lobe **54** to progress along the intermediate band **48** in a counterclockwise direction around the circumference of the guide **40** and to remain in substantially the same position relative to the lobe **52**, as shown in FIG. **9**. Similarly, the outer lobe **58** progresses in a counterclockwise direction along with the intermediate lobe **54**. All three of the lobes **52**, **54**, and **58**, therefore, progress together along their respective bands. Conversely, when the wheel **44** rotates in a counterclockwise direction, the lobes move together in a clockwise direction relative to the surface **56**.

Since the inner band **46** is supported on the intermediate band **48**, during each revolution of the lobe **52** around the guide **40**, the inner band **46** advances relative to the intermediate band a distance that corresponds to the difference in circumference between the bands **46** and **48**. The intermediate band **94** is similarly supported on the outer band **50** and during each revolution of the lobe **54**, the intermediate band advances relative to the outer band a distance corresponding to the difference in circumference between the intermediate and outer bands. Similarly, the outer band advances during each revolution of the lobe **58** a distance relative to the surface **56** that corresponds to the difference in length between the circumference of the band **50** and the guide surface **56**.

The electrical switch shown in FIGS. **9** to **12** is designed to close a circuit after a predetermined number of revolutions of the wheel **44** has occured. As shown in FIGS. **11** and **12**, the guide **40** has a pair of transverse conductors **60** which are insulated from the guide **40**. The outer band **50** has a pair of conductive inserts **62** and the intermediate band **48** has a pair of conductive inserts **64**. The inner band has a transverse conductor **66**. The remainder of each of the bands if formed of a thin, resiliently flexible insulating material, such as Mylar. As shown in FIGS. **11** and **12**, when the conductors **60**, **62**, **64** and **66** are aligned, the circuit is completed. This arrangement may be used as a switch in a conventional signal circuit.

In operation, the conductors are initially in the position shown in FIGS. **11** and **12**. Clockwise rotation of the wheel **44** causes the lobes to progress in a counterclockwise direction and when the lobe **52** has passed over the conductors **60**, the conductor **66** in the inner band is advanced relative to the conductor **64** in the intermediate band a distance that is sufficient to open the circuit between the conductors **60**. At the same time, the conductors **64** advance relative to the outer band **50** and the conductors **62** advance relative to the stationary conductors **60**. Since the bands have different circumferences, a different number of revolutions of the respective lobes is required to return the conductors to a position in alignment with the stationary conductors **60**. Therefore, all of the lobes must complete a number of cycles that is sufficient to bring all of the conductive elements back into alignment. For example, this may require 10 revolutions of the inner band **46**, 15 revolutions of the intermediate band **48**, and 30 revolutions of the outer band **50**. However, to produce one revolution of each band may require a large number of revolutions of the lobes relative to the surface **56**. By selecting the appropriate sizes of bands, a guide surface and a wheel, the desired ratio of revolutions of the shaft **42** necessary to advance the bands one complete cycle can be obtained.

Although there are only three bands illustrated and described in the embodiments of FIGS. **8** to **12**, any convenient number of bands can be superimposed on each other, provided sufficient torque can be transmitted to the inner band to cause the lobe of each band to progress around the circumference of the surface **56** without slippage.

Apparatus having a pair of members connected by a single band in accordance with this invention is shown in FIGS. **13** to **15**. A guide in the form of a ring **68** is connected with a hub **70** at one side of the ring by a plurality of spokes **72**. The hub **70** journals a rotary shaft **74** for rotation relative to the ring **68**. A wheel **76** is fixed on the shaft **74**. A secondary guide ring **78** is positioned in abutting relation with the end of the ring **68**. The rings have conical guide surfaces **80** and **82**, respectively, with the minimum diameter of the guide surface **80** being less than the minimum diameter of the surface **82**.

A band **84** is positioned within the rings **68** and **78** and has a length that is greater than the circumference of either of the surfaces **80** and **82**, so that a lobe **86** is formed in the band. The band has sufficient width to extend laterally on both sides of the interface **88** between the rings **68** and **78** respectively. Preferably, a friction reducing material, such as polytetrafluoroethylene is coated on the ends of the rings at the interface to permit the surfaces to move freely relative to each other. A radial groove **90** extends around the circumference of the rings **68** and **78** between the surfaces **80** and **82**. Since the band **84** is thin and flexible, it bends to conform to the conical surfaces **80** and **82** and the major portion of the band lies flat against the respective surfaces **80** and **82**. Preferably, the wheel **76** cooperates with the surfaces **80** and **82** to compress the lobe **86**, thereby providing adequate frictional engagement with the large diameter surface **82** to avoid slippage between the band and the respective surfaces.

A strap **96** extends around the ring **78** and the ends of the strap **96** are connected together by a screw adjustment device **98**. The ring **78** has a radial slot **100** to allow the ring to expand and contract as the circumference of the band **96** is changed by the screw device **98**. This arrangement allows slight changes in the circumference of the guide surface **82** with respect to the guide surface **80**. A suitable retainer disc **102** is provided on the end of the shaft **74** to prevent separation of the ring **78** from the ring **68**. The ring **78** is centered with respect to the ring **68** by the band **84**. As the shaft **74** rotates, the lobe **86** progresses around the circumference of the surfaces **80** and **82**.

If it is assumed that the length of the band in the lobe **86** is the same at both edges, then the distance (FIG. 4) that the band would advance relative to the surfaces **80** and **82** for each cycle of the lobe would be the same if the arcuate length L (FIG. 4) were the same. The guide surfaces **80** and **82**, however, do not have the same circumference and therefore the distance d for each edge of the band is slightly different. Consequently, it is necessary for one of the surfaces to rotate a distance corresponding to the difference in circumference between the two surfaces. Torque causing this rotation is transmitted from the wheel **76** to the ring **78** through the band lobe **86**. The degree of movement may be measured, for example, on a scale **104** on the outer periphery of the ring **68**. By adjusting the screw device **98**, the diameter of the moveable ring **78** may be changed to vary the ratio between the circumference of the guide surface **80** to the circumference of the guide surface **82**.

Another embodiment of the invention is illustrated in FIGS. **16** and **17**. This embodiment includes a rotary shaft **106** with a wheel **108** secured on the end of the shaft. A guide ring **110** is mounted for rotation on a shaft **112**. A plurality of arms **114** connect the hub on the shaft **112** with the ring **110**. The ring has a radial slot **116** and a screw **118** is rotatably mounted on a bracket **120** at one side of the slot **116** and is threaded in a sleeve **112** on the opposite side of the slot **116**. The ring **110** has sufficient flexibility that by rotating the screw **118** the width of the slot **116** can be adjusted, thereby changing the circumference of the guide surface on the interior of the ring **110**. The arms **114** also have sufficient flexibility to accommodate changes in the shape of the ring.

A thin flexible band **124** is arranged within the ring **110** and extends over the peripheral surface of the wheel **108**. Preferably, sprockets **126** are provided on the surface of the wheel **108** to engage corresponding holes **128** in the band to provide positive traction between the wheel and the band. The length of the band is substantially the same as the circumference as the guide surface on the ring **110** when the screw **118** is adjusted approximately mid-way of its length. In this condition, the lobe **130** in the band progresses around the circumference of the ring as the wheel **108** rotates. Since the length of the band is the same as the length of the guide surface, the difference in length *d*, as seen in FIG. **4**, does not exist. Therefore, the position of the band does not change relative to the guide surface as the lobe **130** progresses around the circumference of the ring. In other words, a point on the band **124** always returns to the same location relative to the guide surface as the lobe progresses around the circumference of the guide surface.

A differential effect is achieved by changing the length of the guide surface relative to the length of the band. This is accomplished by turning the screw **118** to increase or decrease the diameter of the ring **110**. If the circumference of the guide surface is made larger than the length of the band **124**, then the ring **110** rotates through an angular sector corresponding to the difference between the circumference of the guide surface and the length of the band. Since the diameter of the ring **110** can be made either larger or smaller than the band **124**, the ring can be made to rotate either in the same direction or in the opposite direction to that of the wheel **108** and the differential can be adjusted by means of the screw **118**. The device of FIGS. **16** and **17** can be used as reversible, variable speed ratio transmission. Also, by the proper selection of sizes of the ring **110** and the wheel **108**, it is possible to drive the wheel by turning the ring **110** to provide an increased output speed at the shaft **106** relative to the rotation applied to the shaft **112**.

The cyclic advancement of the band relative to the guide surface in accordance with this invention provides a large ratio between the rotary input motion and the stepwise advancement of the band, and yet only a few operative elements are required. Furthermore, these elements, a band and a guide means, can be easily fabricated and, if necessary, can be calibrated to provide the desired speed reduction ratio within reasonable tolerances. Since the band frictionally engages the surface, there is virtually no relative sliding between these surfaces and there is a minimum of resistance to motion of the components and a minimum of wear. This is particularly important in applications in which the input shaft rotates at high speed.

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

I claim:

1. Apparatus comprising:

means having a guide surface,

a flexible elongated element extending along said guide surface, said guide surface providing a closed cyclic path along said surface, said element being arched away from said surface in a lobe between two surface engaging portions of said element, said lobe being maintained solely by the cooperation of said element with said guide surface and said lobe being capable of progressing along said element to displace said lobe along said path, each cycle of said lobe around said path advancing said element a predetermined distance relative to said surface.

2. The apparatus according to claim **1** wherein the length of said element is greater than the length of said cyclic path, and including means preventing sliding of said element longitudinally relative to said guide surface, and including means for selectively advancing said lobe at least one cycle around said path.

3. The apparatus according to claim **1** wherein said element is an endless band.

4. The apparatus according to claim **1** wherein said path is substantially circular and said lobe progresses along said path in the same direction as the advancement of said element, and wherein said element is resilient, and said two surface engaging portions of said element being spaced circumferentially along said path an arcuate distance that is substantially less than one half the circumference of said path, said element engaging said surface along a major portion of the circumference of said path and said lobe extending along a minor portion of the circumference of said path, whereby the length and resilience of said element maintains said lobe as it progresses along said path.

5. Cyclic apparatus comprising:

guide means having a cylindrical support surface,

rotary means having a cylindrical support surface, said rotary surface being substantially concentric with said guide surface,

a thin resiliently flexible elongated element interposed between said guide surface and said rotary surface, said element having outer and inner sides with respect to the center of said guide means surface, spaced portions of said element being in engagement with said guide surface along the outer side of said element and an intermediate portion of said element being arched away from said guide surface in the shape of a lobe, the inner side of said element at the apex of the lobe being in engagement with said rotary surface, whereby rotation of said rotary surface progresses said lobe along said element and advances said element relative to said guide surface.

6. The apparatus according to claim **5** wherein said element is an endless band, said band extends around the circumference of said guide surface, whereby the frictional engagement between said band and said guide surface resists sliding movement of said band relative to said guide surface.

7. The apparatus according to claim **5** wherein said element is an endless band, said band extending around the circumference of said guide surface, said band being in frictional engagement with said guide surface to resist longitudinal displacement relative to said guide surface, said lobe progressing by lifting successive portions of said band away from said guide surface at one end of said lobe while another portion of said band converges onto said guide surface at the opposite end of said lobe, thereby advancing said successive portions of said band a predetermined longitudinal distance relative to said guide surface during each passage of said lobe over said band portion.

8. Cyclic apparatus comprising:

guide means having a cylindrical support surface,

rotary means having a cylindrical support surface, said rotary surface being substantially concentric with said guide surface,

a plurality of thin, resiliently flexible elongated endless elements interposed between said guide surface and said rotary surface, said elements each having outer and inner sides with respect to the center of said guide surface,

a first one of said elements being in engagement along its outer side with said guide surface and a second one of said elements being in engagement along its inner side with said rotary surface, each of said elements being arched inwardly toward the axis of said rotary surface in a lobe, said second element engaging said rotary surface along its inner side at the apex of its lobe, whereby rotation of said rotary surface relative to said guide surface causes said second element lobe to progress along its element relative to said guide surface and relative to the adjacent element, whereby the respective lobes of each element progress together around said guide surface.

9. Cyclic apparatus comprising:

first and second guide means, said guide means each having a frusto-conical support surface converging toward a common apex, said first and second guide means being movable relative to each other about a central axis;

a thin resiliently flexible elongated element extending around and supported on said first and second guide surfaces, said element including a portion arched away from said guide surfaces in a lobe;

a wheel mounted concentrically of said support surfaces for rotation about said central axis said wheel being in engagement with said lobe, whereby rotation of said wheel causes said lobe to progress around the circumference of said first and second guide surfaces and thereby inducing rotation of one of said guide means relative to the other guide means.

10. Cyclic apparatus according to claim 9 wherein said first and second guide means includes a pair of rings, said frustoconical support surfaces being provided on the internal surface of each ring.

11. Cyclic apparatus according to claim 10 wherein said elongated element is an endless band having lateral edges, said wheel including a flange in position to engage one of said lateral edges in said lobe and one of said rings having a circular shoulder in opposition to said wheel flange, said wheel flange being spaced from said shoulder an axial distance less than the width of said band, whereby said lobe is distorted to produce substantially the same lobe length along both said guide surfaces.

12. Cyclic apparatus comprising:

a wheel mounted for rotation about an axis;

guide means having a circular support surface concentric with said wheel; and

a thin flexible element arranged in a continuous path, a portion of said element being supported on the peripheral surface of said wheel and another portion of said element being supported on said guide surface, the length of said element being substantially equal to the circumference of said guide surface, and

means for maintaining the position of a point on said flexible element with respect to said guide surface constant for each repeating cycle of said element around said guide surface.

13. Cyclic apparatus according to claim 12 including means for changing the circumference of said guide surface, said guide means being mounted for rotation about said central axis, whereby rotation of said wheel is transmitted through said element to said guide means.

14. Cyclic apparatus according to claim 12 wherein said flexible element includes a thin band, the portion of said band on said wheel surface being in opposed relation to another portion of said band on said guide surface, whereby flexure of said band maintains said band within said guide surface.

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