United States Patent

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[45] **Sept. 19, 1972**

[54] **SLIP-CLUTCH**

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[30] **Foreign Application Priority Data**

Sept. 10, 1969 Japan 44/73089
Jan. 27, 1970 Japan 45/7928

[52] **U.S. Cl.** ....**64/30 E**
[51] **Int. Cl.** **F16d 7/02**
[58] **Field of Search** ....64/30 R, 30 C, 30 E

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Primary Examiner—Allan D. Hermann
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[57] **ABSTRACT**

A slip-clutch for use with a tape winding-up mechanism of a tape recording and reproducing apparatus. A cylindrical drum is provided on a pulley for receiving input force of the clutch and a length of rope is wound around the drum in frictional torque transmitting sliding engagement therewith. The rope has opposite ends connected to a disc rigidly secured to an output shaft of the clutch whereby substantially constant torque is transmitted from the drum to the disc regardless of variation in coefficient of friction between the driving and driven members.

2 Claims, 10 Drawing Figures

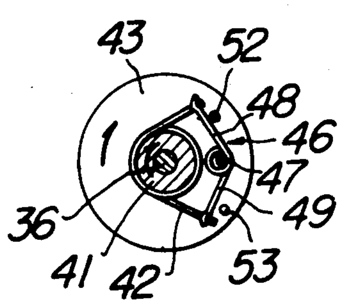

FIG. 1 PRIOR ART

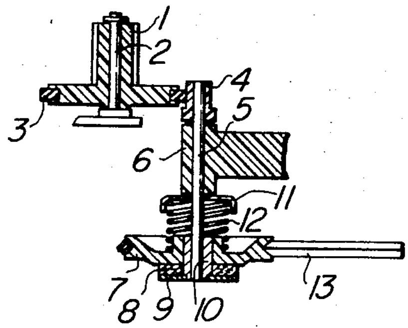

FIG. 3

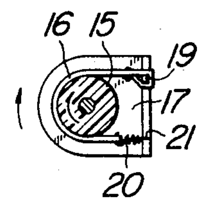

FIG. 2

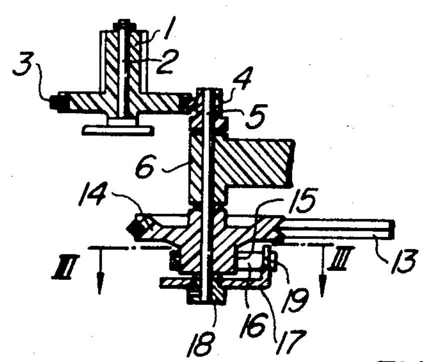

FIG. 4

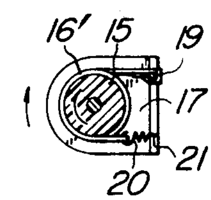

FIG. 5

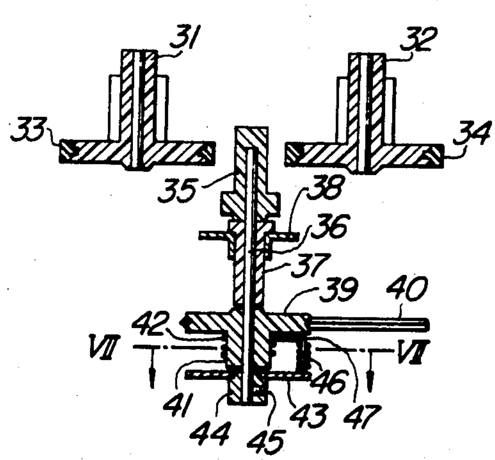

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FIG. 6

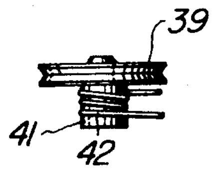


FIG. 7

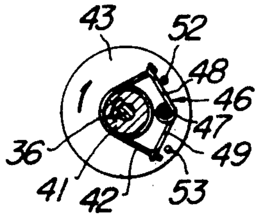


FIG. 8

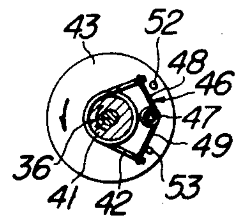


FIG. 9

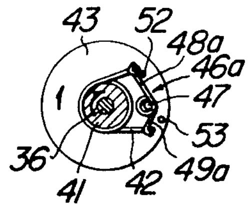
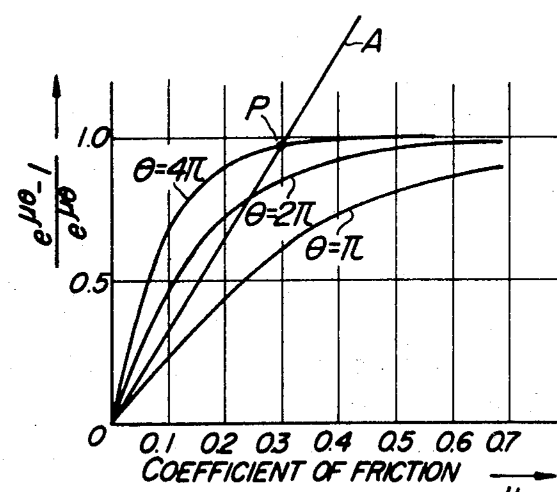


FIG. 10



SLIP-CLUTCH

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a slip-clutch used as a frictional torque transmission in a tope take up mechanism of a tape recording and reproducing apparatus and the like.

A conventional frictional torque transmission of this kind employs a pair of rotatable member or tape urged against each other by spring means for the transmission of torque from one of the discs to the other. In general, the coefficient of friction between the frictionally sliding surfaces of the opposite driving and driven members tends to increase with the variation in the surface condition due to wear of the surfaces, stain and blot on the surfaces and with the rise of the temperature at the surfaces. In some remarkable cases, the increase in the friction coefficient amounts to two to three times as compared with that in normal or initial operation. The torque transmitted by the conventional clutch, therefore, varies in proportion to the variation in the friction coefficient in prolonged operation of the device. This adversely affects the tape winding-up force of the reel supporting and driving wheels so that, when the friction coefficient is increased, the tape is subjected to excessive tension with a result that the tape becomes to have permanent strain and deformation and, in a remarkable case, the tape is broken. On the other hand, in case where the friction coefficient is decreased, the tape take-up mechanism becomes inoperative to wind up the tape.

It is, therefore, a principal object of the present invention to provide a slip-clutch which is able to provide a stable torque transmission characteristic which is scarecely influenced by the variation in the coefficient of friction between the frictionally sliding surfaces of the clutch.

The conventional friction clutch has an additional disadvantage that the frictionally sliding surfaces have therebetween a coefficient of friction which is largely varied with the difference in the direction in which the friction members are rotated. This variation gives rise to various troubles during practical operation of the clutch for prolonged period of time.

Accordingly, it is another object of the present invention to provide a bi-directional slip-clutch which can provide a torque-transmission characteristic which is remarkably stable and is hardly varied with the variation in the friction coefficient between the sliding surfaces due to the change of the direction of rotation of the friction members.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided a slip-clutch including a torque-transmission means comprising a cylindrical body and a length of frictional slider extending around the outer surface of said cylindrical body in frictional sliding engagement therewith, said slider being mounted on a support in such a manner that the leading end of said slider as viewed in the rotation of said cylindrical body in one direction is connected to said support through a spring means while the trailing end is directly secured to said support.

According to another aspect of the invention, there is provided a bi-directional slip-clutch including a torque-transmission means comprising a cylindrical drum member and a length of a rope having spiral turns extending around said drum in frictional sliding engagement therewith, spring means for resiliently connecting the opposite free ends of said rope to a support therefor, the leading end of said rope as viewed in the rotation of said drum in one direction causing the corresponding portion of said spring means to be operative, and stop means on said support for being abutted upon by the portion of said spring means cooperating with the trailing end of said rope as viewed in the rotation of said drum in the same direction to thereby cause the last said spring portion to be inoperative, the change-over of the direction of rotation of said drum serving to automatically render one of said spring portions operative and render the other spring portion inoperative.

In a preferred embodiment of the present invention, each of the cylindrical body and drum is a part of a pulley which receives the input force of the clutch while the support for each of the frictional slider and the rope is drivingly connected to the output shaft of the clutch. The frictional slider of the clutch according to the first aspect of the invention may preferably be made of a material having a remarkably small stiffness and large taff and wear-resistant properties, such as rope of fibrous material, thread and belt. The rope of the clutch according to the second aspect of the present invention may preferably have similar properties. In addition, the spring means in the clutch according to the second aspect of the invention may preferably be a twisted spring because a spring of this type can have its free ends or arms each of which is positioned substantially in the same radial plane as the corresponding free end of the rope extending from the spirally wound turns around the cylindrical drum.

The torque-transmission characteristic of the slip-clutch according to any of the afore-stated aspects of the invention depends solely upon the coefficient of friction between the sliding surfaces of the cylindrical body or drum and the frictional slider or rope and upon the angle over which the slider or the rope extends around the outer surface of the cylindrical body or drum. The coefficient of friction and the angle in question can easily be determined to be of appropriate values so as to obtain a desired torque-transmission characteristic of the clutch. Thus, the characteristic concerned is made stable and is not influenced with any kind of variation in friction coefficient between the sliding surfaces of the driving and driven members. In addition, the maximum torque transmitted by the clutch according to the present invention is determined by the resiliency of the spring means used to connect the slider or rope to the support therefor.

The above and other objects and features of the present invention may be made apparent from the following description of preferred embodiments of the invention with reference to the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial sectional side view of conventional slip-clutch mounted in a tape winding-up mechanism of a tape recording and reproducing apparatus;

FIG. 2 is a similar sectional view of an embodiment of the slip-clutch according to the present invention which is mounted in a similar tape winding-up mechanism of a tape recording and reproducing apparatus;

FIG. 3 is a cross-section taken along line III—III in FIG. 2 and illustrating a cylindrical driving body, a frictionally driven slider and a support therefor;

FIG. 4 is a view similar to FIG. 3 but illustrates a modification to the clutch shown in FIGS. 2 and 3;

FIG. 5 is an axial sectional side view of another embodiment of the slip-clutch according to the present invention which is mounted in a tape winding-up mechanism of a different tape recording and reproducing apparatus;

FIG. 6 is a side view of the clutch of the instant embodiment with a part removed;

FIG. 7 is a cross-section taken along line VII—VII in FIG. 5 and illustrating the relative position of a cylindrical drum, a rope, a spring, a support for the rope and a pair of stops on the support when the latter is rotated in one direction;

FIG. 8 is a view similar to FIG. 7 but illustrates the relative position of the elements when the support is rotated in the other direction;

FIG. 9 is a view similar to FIGS. 7 and 8 but illustrates a modification to the clutch shown in FIGS. 5 to 8; and

FIG. 10 is a graphical representation illustrating the stability of the torque-transmission characteristic of the clutch of the invention with respect to the variation in the coefficient of friction between two cooperating friction members of the clutch and a comparable characteristic of a prior art clutch with respect to similar variation in the friction coefficient.

DESCRIPTION OF PRIOR ART

Before the embodiments of the present invention are described, a conventional friction clutch will be described with reference to FIG. 1 of the drawings. The conventional clutch is illustrated as being mounted in a tape winding-up mechanism of a tape recording and reproducing apparatus having a reel supporting and driving wheel **1** mounted on a shaft **2** for free rotation. A tire of rubber **3** is secured to the peripheral surface of the wheel **1**. The wheel **1** is so disposed as to be driven by a wheel or roll **4** which is in frictional rolling contact with the tire **3**. The roll **4** is rigidly mounted on one end of a shaft **5** which is rotatably supported by a bearing **6** which also serves to support a slip-clutch which is described hereafter.

The clutch includes a pulley **7** mounted for free rotation on a hub **10** of a disc **9** which in turn is rigidly secured to the other end of the shaft **5**. A disc of felt **8** is disposed between the disc **9** and the pulley **7** and is secured to the disc **9** for rotation therewith. A spring retainer or washer **11** is mounted for free rotation on the shaft **5** adjacent the end of the bearing **6** remote from the roll **4**. A coil spring **12** is mounted around the shaft **5** and extends between the washer **11** and the pulley **7** so that the spring **12** resiliently urges the pulley **7** against the felt disc **8** with a substantially constant pressure force. The pulley **7** is driven by means of a belt **13**.

The torque transmitted by the clutch described is given by the following equation:

$$M = P \times \mu R$$

wherein P is the pressure force of the spring **12**, u is the coefficient of friction between the felt disc **8** and the pulley **7**, and R is the effective radius of the frictionally sliding surfaces. The value of the friction coefficient is varied as the clutch is operated for the reasons described before. Thus, the torque transmitted is also varied correspondingly.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring next to FIGS. 2 to 5 of the drawings which illustrate an embodiment of the present invention. The portions similar to those of the conventional device shown in FIG. 1 are indicated by similar numerals. The slip-clutch according to the instant embodiment of the invention includes a pulley **14** having a cylindrical outer surface **15**. The pulley **14** is mounted for free rotation on a shaft **5** for driving a reel supporting and driving wheel **1** in the same manner as that in the conventional device. A frictional slider **16** is mounted on a support **17** in such a manner that a part of the slider **16** extends around a part of the cylindrical outer surface **15** of the pulley **14** in frictional sliding engagement with the surface **15** as will be best seen in FIG. 3. The pulley **14** is rotated in clockwise direction, as indicated by the arrow draw within the circle of the outer surface **15** in FIG. 3. The leading end of the frictional slider **16** as viewed in the rotation of the pulley **14** is connected to a spring **20** which in turn is secured to the support **17** as at **21**. The trailing end of the slider **16** is directly secured to the support **17** as at **19**. The support **17** has thereon a hub **18** which is rigidly secured to the shaft **5**. The frictional slider **16** is preferably made of a material having a remarkably small stiffness and good tensile and wear-resistant properties, such as rope of fibrous material, thread and belt.

With the above arrangement, a part of the torque transmitted from a belt **13** to the pulley **14** is transmitted to the support **17** by virtue of the frictional sliding movement of the outer surface **15** of the pulley **14** with respect to the slider **16** so that the support **17** is also rotated in clockwise direction as indicated by another arrow drawn outwardly of the support **17** in FIG. 3.

FIG. 4 illustrates a modification to the slip-clutch shown in FIGS. 2 and 3. In this modified embodiment of the invention, a frictional slider **16'** has spiral turns wound around the outer surface **15** of the pulley **14** so that the slider extends around the surface **15** over an angle of more than 360°.

Referring to FIGS. 5 to 8 of the drawings, a description will be made with respect to a second embodiment of the present invention. The instant embodiment is directed to a bi-directional slip-clutch which is used as a torque transmission in a tape winding-up mechanism for a tape recording and reproducing apparatus. The tape winding-up mechanism includes a pair of laterally spaced reel supporting and driving wheels **31** and **32** having tires **33** and **34** mounted on the peripheral surfaces of the wheels, respectively. A pulley or roll **35** is mounted on one end of a shaft **36** and is positioned to extend between the wheels **31** and **32**. The shaft **36** rotatably extends through a bearing **37** mounted on a support **38** which is movably mounted so that the roll **35** can be selectively moved into frictional rolling contact with one of the tires **33** and **34** of the reel driving wheels **31** and **32** so as to drive the selected wheel for the take-up of the tape.

The slip-clutch of the instant embodiment of the invention is mounted on the other end of the shaft **36** and comprises a pulley **39** mounted for free rotation on the shaft **36**. The pulley **39** receives the input force of the clutch from a belt **40** which is in driving engagement with the pulley. The latter has a hub or cylindrical drum **41** on the side of the pulley **39** remote from the bearing **37**.

As will be best seen in FIG. **6**, a length of rope **42** is spirally wound around the drum portion **41** and extends therearound in frictional sliding engagement therewith. The material from which the rope **42** is made should be determined depending upon the material from which the drum **41** is made. The rope **42** is preferably made from a soft fibrous material in the case where the drum **41** is made from either a plastic material or a metal.

A disc **43** is rigidly connected to a hub **44** which in turn is fixed to the end extremity of the shaft **36** by means of a setscrew **45**. On the surface of the disc **43** facing the pulley **39**, the disc **43** has a pin **47** extending axially toward the pulley **39** in spaced relationship to the drum **41**. The pin **47** rotatably receives coiled turns of a spirally twisted spring **46** having opposite free ends or arms **48** and **49** each connected to one of the ends of the rope **42** extending from the spiral turns thereof, as shown in FIG. **7**, so that the twisted spring **46** is rotatably or swingably mounted on the disc **43**. The arms **48** and **49** have substantially the same length. Stop pins **52** and **53** are also mounted on the same side of the disc **43** as the pin **47** and adjacent the end extremities of the spring arms **48** and **49**, respectively, for the purpose which will become apparent later.

It is desired that the spring employed in the slip-clutch according to the present invention has as smaller spring constant as possible in that a spring having such property exhibits lesser variation in spring force as caused by the deformation of the spring. A twisted spring is satisfactory to this purpose. The use of a twisted spring in this invention provides an additional advantage that the axial spacing between the opposite ends or arms of a twisted spring can accommodate the axial spacing between the ends of the rope spirally wound around the drum, so that it is possible to simplify the arrangement for holding the spring. In fact, each of the spring arms **48** and **49** (**48***a* and **49***a* in case of FIG. **9** embodiment) is positioned to extend substantially in the same radial plane as the corresponding end of the rope **42**.

With the afore-described arrangement, when the pulley **39** is rotated in clockwise direction as shown in FIG. **7**, the rope **42** is frictionally driven by the outer surface of the drum **41** so that the leading end of the rope **42** as viewed in the rotation of the drum in this direction is pulled to render the corresponding spring arm **49** operative to serve as a spring while the trailing end of the rope **42** is loosened to allow the corresponding spring arm **48** to abut against and to be stopped by the stop pin **52**. Thus, the spring arm **48** is automatically made inoperative to serve as a spring. On the other hand, when the pulley **39** is rotated in counter-clockwise direction as shown in FIG. **8**, the spring arm **49** is allowed to abut against the stop pin **53** while the other spring arm **48** is caused to resiliently function.

For any of the directions of rotation, the same magnitude of torque is transmitted by the slip-clutch which employs spring arms **48** and **49** of the same length, as shown in FIGS. **7** and **8**.

FIG. **9** illustrates a modification to the embodiment shown in FIGS. **5** to **8**. In this modification, the clutch employs a spring **46***a* having arms **48***a* and **49***a* one (**48***a*) of which is longer than the other (**49***a*). The difference in the length of the spring arms causes the clutch to transmit a greater magnitude of torque in one direction of rotation of the clutch than in the other direction of rotation thereof.

In the afore-described embodiments of the present invention, the pulleys are disposed on input side of the clutch while the frictional slider and the rope are on the output side of the clutch. It is, however, to be noted that the same result can be obtained from the reversed relationship between the cooperating components of each clutch. Moreover, for the purpose of simplification of illustration, the ends of the rope **42** are shown as being directly connected to the spring arms **48** and **49** (**48***a* and **49***a* in the case of FIG. **9** embodiment). It is, however, to be understood that additional fittings or joints can of course be utilized to connect the rope ends to the spring arms.

The torque transmitted by the clutch according to the present invention is mathematically given by the following equations:

$$M = R\,(F_1 - F_2) \qquad (1)$$

wherein M represents the torque; R represents the radius of the cylindrical outer surface **15** or the cylindrical drum **41**; E_1 represents the tension in the leading end portion of the slider **16** or rope **42** which tension is equal to the spring force of the spring **20** or either one of the spring arms **48** and **49** (**48***a* and **49***a* in FIG. **9** embodiment); and E_2 represents the tension in the trailing end portion of the slider **16** or the rope **42**.

On the other hand, the tension E_1 is given by

$$F_1 = F_2 e^{\mu\theta} \qquad (2)$$

wherein e is the base of natural logarithm, μ is the coefficient of friction between the cylindrical outer surface **15** or drum **41** and the slider **16** or the rope **42**, and θ is the angle over which the slider **16** or the rope **42** extends around the cylindrical surface **15** or the drum **41**.

$$\text{Thus, } F_2 = \frac{F_1}{e^{\mu\theta}} \qquad (3)$$

The equation (3) is substituted for F_2 in equation (1) to give

$$M = R\left(F_1 - \frac{F_1}{e^{\mu\theta}}\right) = \left(\frac{e^{\mu\theta}-1}{e^{\mu\theta}}\right) F_1 \cdot R \qquad (4)$$

In equation (4), the angle θ, the tension E_1 and the radius R remain constant throughout the operation of the clutch. It is, therefore, understood that the torque M is determined by the variable represented by

$$\left(\frac{e^{\mu\theta}-1}{e^{\mu\theta}}\right)$$

which in turn is determined by the variable or the friction coefficient μ.

FIG. **10** graphically illustrates the relationship between the two variables. It will be appreciated from FIG. **10** that, when appropriate values are selected for the angle θ and the friction coefficient μ, a torque-transmission characteristic which is kept stable or substantially constant throughout prolonged operation is obtainable from the slip-clutch of the present invention even if the friction coefficient μ is varied during operation. It will further be understood that the slip-clutch of the invention provides remarkably improved stability in torque-transmission characteristic particularly with respect to the increase in the friction coefficient. For example, a curve indicated by 4πrepresents the torque-transmission characteristic of the clutch of the invention in the case where the slider **16** or rope **42** is wound around the cylindrical outer surface **15** or drum **41** over an angle (θ) of 4π, as in the embodiments shown in Fig. **4** and Figs. **6** to **9**. This curve represents a very stable or constant torque-transmission characteristic in the range rightward of a point P at which friction coefficient μ is equal to 0.3, that is, in the range wherein μ is increased and is more than 0.3. To the contrary, a conventional disc type slip-clutch which is designed to have its coefficient of friction μ on the point P provides a torque-transmission characteristic as represented by a curve A which extends substantially linearly in proportion to the value of μ.

From the foregoing description and illustration, it will be appreciated that the present invention provides a slip-clutch whose torque-transmission characteristic is scarcely influenced by the variation in the coefficient of friction between two cooperating driving and driven members but is kept substantially constant and stable throughout the operation for prolonged period of time.

What is claimed is:

1. A bi-directional slip-clutch including a torque-transmission means comprising a cylindrical drum member and a length of a rope having spiral turns extending around said drum in frictional sliding engagement therewith, spring means for resiliently connecting the opposite free ends of said rope to a support therefor, the leading end of said rope as viewed in the rotation of said drum in one direction causing the corresponding portion of said spring means to be operative, and stop means on said support for being abutted upon by the portion of said spring means cooperating with the trailing end of said rope as viewed in the rotation of said drum in the same direction to thereby cause the last said spring portion to be inoperative, the change-over of the direction of rotation of said drum serving to automatically render one of said spring portions operative and render the other spring portion inoperative.

2. A bi-directional slip-clutch as defined in claim **1**, wherein said spring means comprise a twisted spring number having spirally twisted turns operatively connected to said support and opposite free ends extending from said turns for being connected with the opposite ends of said rope, respectively, each of said spring ends being positioned substantially in the same plane as the corresponding end of said rope.

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