

Description

The present invention relates to an intermittent drive mechanism for use in an intermittently operative apparatus, such as an apparatus for intermittently feeding a tape-like flexible elongate material by and between a cooperative pair of feed and presser rollers.

There are known various intermittent feed mechanisms of the type described. One such known mechanism is shown in Figure 10, which mechanism comprises a gear ratchet including a drive pawl 101 pivoted to one end of a lever 102 and meshing with a toothed ratchet wheel 103 fixed on a driven shaft 106, the other end of the lever 102 being slidably fitted over an eccentric cam 105 connected with a drive shaft 104. Upon rotation of the drive shaft 104, the drive pawl 101 moves back and forth in the directions of the arrowheads A to thereby turn the ratchet wheel 103 and hence the driven shaft 106 stepwise in the counterclockwise direction. The drive mechanism further includes a friction brake unit composed of a brake drum 107 secured to the drive shaft 106, a pair of brake shoes 108, 109 secured to confronting inner edges of a pair of brake levers 110, 111 disposed on opposite sides of the brake drum 107, and a spring 112 acting between the brake shoes 108, 109 to urge them toward each other into frictional engagement with the brake drum 107.

The known intermittent drive mechanism thus constructed is disadvantageous in that it cannot precisely control the stepwise angular motion of the driven shaft 106 because the stopping timing of the stepwise motion solely depends on a friction or braking force exerted by the friction brake unit. The ratchet wheel 103 is likely to overrun while it is driven at a high speed. Furthermore, the contacting components, particularly the brake shoes 108, 109 and the drive pawl 101 are progressively worn out while in use, and hence a frequent adjustment or maintenance of such components is required. Another drawback is that the components in the drive mechanism themselves and other components driven by the drive mechanism are likely to be damaged due to undue shock forces applied thereto when the stepwise movement of the driven shaft 106 is started and stopped abruptly in such a manner that the angular speed of the drive shaft varies in a rectangular pulse-like fashion, as shown in Figure 11.

Another prior art intermittent drive mechanism is known from reference US-A 3 435 790 which avoids a part of said drawbacks.

This reference discloses an intermittent drive mechanism for converting a constant velocity of an input shaft into an intermittent drive of an output shaft, by use of a speed reducer acting as adding-reducing device and having a non reduced input member driven from said input shaft in a reciprocal movement of zero mean speed, and a reduced input member driven from said input shaft in a continuous movement of not zero mean speed, the amplitude of said reciprocal movement being so chosen as to periodically annul the speed of said output shaft.

Said speed reducer includes an externally toothed flexible spline slidably fitted over an elliptical cam or a pair of rollers and firmly connected with said output shaft, an internally toothed rigid circular spline rotatable relatively to an intermediate shaft fixedly connected with said elliptical cam and parallel to said input shaft, said flexible spline having teeth thereon at least two less in number than teeth on said rigid circular spline and meshing with said rigid circular spline at two diametrically opposite regions extending along a major axis of said elliptical cam.

Said reciprocal movement is obtained by an eccentric cam firmly connected with said input shaft for corotation therewith and a crank lever operatively connecting said eccentric cam with said rigid circular spline.

Still another prior art intermittent drive mechanism is known from reference US-A 4 012 964, also using an adding-reducing mechanism having a direct multiplied input member, a reverse multiplied input member, one or both input members being driven with a sinusoidal angular speed pattern of not zero mean speed by use of not circular gears.

However both of said reference produces a sinusoidal speed, the representative curve of which has a small curvature radius at its peaks and bottoms.

The present invention is starting from the first one of said both reference but distinguishes over them by the following added features:

- said continuous movement in which said reduced input member is driven has a sinusoidal angular speed pattern, the frequency of which is twice the frequency of said reciprocal movement, said sinusoidal angular speed pattern movement being obtained by a couple of non-circular drive and driven gears having an elliptical shape, and firmly connected respectively with said input shaft and intermediate shaft, and

- the phase relation between both movements is such that, when said reciprocal movement reaches its maximal direct and reverse speed, said sinusoidal angular speed pattern movement reaches its maximal speed.

As a result, said amplitude of reciprocal movement needed to periodically annul the output speed is lowered, and the output shaft speed curve has flat bottoms and flat tops. This is especially important for use in a sewing machine, in which the almost zero speed periods must be large enough to operate each stitch.

Many other advantages and features of the present invention will become manifest to those versed in the art upon making reference to the detailed description and the accompanying sheets of drawings in which a preferred structural embodiment incorporating the principles of the present invention is shown by way of illustrative example.

Figure 1 is a fragmentary perspective view of an intermittent drive mechanism embodying the present invention;

Figure 2 is a schematic plan view of the mechanism shown in Figure 1;

Figure 3 is a cross-sectional view taken along line III-III of Figure 2, showing non-circular drive and driven gears of the mechanism;

Figure 4 is an enlarged longitudinal cross-sectional view of a speed reducer of the mechanism;

Figure 5 is an enlarged cross-sectional view taken along line V-V of Figure 4;

Figure 6 is a cross-sectional view taken along line VI-VI of Figure 2, showing a connection between an eccentric cam and an annular bracket of the mechanism;

Figure 7 is a graph showing a pattern of the angular speed of an intermediate shaft obtained by the non-circular drive and driven gears of the mechanism;

Figure 8 is a graph illustrative of the speed reduction property of the speed reducer shown in Figures 4 and 5;

Figure 9 is a graph showing a pattern of the angular speed of an output shaft of the mechanism shown in Figure 1;

Figure 10 is a schematic plan view of a prior intermittent drive mechanism; and

Figure 11 is a graph showing a pattern of the intermittent motion produced by the mechanism of Figure 10.

As shown in Figure 1, an intermittent drive mechanism embodying the present invention is particularly useful when incorporated in a sewing unit in a slide fastener manufacturing apparatus. In this figure, a frame, bearing members and a drive motor of the intermittent drive mechanism are omitted for clarity.

The intermittent drive mechanism comprises an input shaft 12 driven by the drive motor to rotate at a constant velocity and supporting thereon a non-circular drive gear 13 for corotation therewith. The drive gear 13 is held in driving mesh with a non-circular driven gear 14 fixedly connected with an intermediate shaft 15 extending parallel to the input shaft 12. The non-circular drive and driven gears 13, 14 have an elliptical shape and they serve to translate a constant velocity rotary motion of the input shaft 12 into a non-uniform velocity rotary motion of the intermediate shaft 15. The rotary motion of the intermediate shaft 15 has an angular velocity varying in a sinusoidal pattern, as shown in Figure 7.

The intermediate shaft 15 is operatively connected with an output shaft 16 through a speed reducer 17. The output shaft 16 carries thereon a toothed drive pulley 18 connected by a synchronous belt 19 with a toothed driven pulley 20. The driven pulley 20 is fixedly mounted on a drive shaft 21 of a feed unit 22. The feed unit 22 includes a feed roller 23 secured to the drive shaft 21, and a presser roller 24 associated with the feed roller 23 for urging a continuous slide fastener chain 25 against the feed roller 23. The feed unit 22 is driven by the present intermittent drive mechanism to feed the slide fastener chain 25 stepwise in a longitudinal direction, in synchronism with the operation of a sewing machine 26.

As shown in Figures 4 and 5, the speed reducer 17 includes an elliptical cam 27, an externally toothed flexible spline 28 slidably mounted around the elliptical cam 27 via a ball bearing 29, and an internally toothed rigid circular spline 30 held in mesh with the flexible spline 28 at two diametrically opposite regions extending along a major axis of the elliptical cam 27. The flexible spline 28 is formed of a toothed steel belt and has external teeth at least two less in number than the internal teeth on the rigid circular spline 30. In the illustrated embodiment, the flexible spline 28 has 46 external teeth while the rigid circular spline 30 has 52 internal teeth. The elliptical cam 27 is fixedly mounted on the intermediate shaft 15 for corotation therewith. The flexible spline 28 is fixedly connected with the output shaft 16 (Figure 4) while the rigid circular spline 30 is secured to a hollow cylindrical casing 31 rotatably mounted on the intermediate shaft 15 and the output shaft 16 by means of sets of ball bearings, not designated.

As shown in Figures 1 and 6, the input shaft 12 has fixed thereon an eccentric cam 32 on which a crank lever 33 is mounted via a roller bearing 34. The free end of the crank lever 33 is pivotably connected by a pin 35 with an arm 36 projecting radially outwardly from an annular bracket 37 concentrically secured to the casing 31 by a plurality of screws 38. The eccentric cam 32 has a cam profile designed such that when the input shaft 12 and hence the cam 32 rotates one turn, the casing 30 and therefore the rigid circular spline 30 angularly moves back and forth through an angle ω_1 which is half the angle defined jointly by the number of teeth of difference between the rigid circular spline 30 and the flexible spline 28.

In Figure 5, as the intermediate shaft 15 and hence the elliptical cam 27 rotates in a direction indicated by the arrow B, the flexible spline 28, while being deformed by the elliptical cam 27 to follow the profile thereof, angularly moves along the rigid circular spline 30 in a direction indicated by the arrow C. Because the number of teeth on the flexible spline 28 is less than the number of teeth on the rigid circular spline 30, when the elliptical cam 27 rotates one turn, the flexible spline 28 will rotate 6/52 parts of a turn in a direction opposite that of the elliptical cam 27. The speed reduction is therefore 6 : 52 (or 1 : 8.66). That is to say, one of the teeth 38 on the flexible spline 28, which is meshing with one tooth 39 on the rigid circular spline 30, will mesh with a sixth succeeding tooth 40 on the rigid circular spline 30 when the elliptical cam 27 has rotated one turn.

As described above, the rigid circular spline 30 is reciprocated through the angle ω_1 which is three times as large as the tooth pitch of the rigid circular spline 30, as shown in Figure 5. The angular reciprocating movement of the rigid circular spline 30 is linked with the rotary motion of the intermediate shaft 15 in the manner as described below. As the intermediate shaft 15 turns to complete a first half of one turn, the rigid circular spline 30 is turned through the angle ω_1 in the same direction (clockwise in Figure 5) as the intermediate shaft 15 with the result that the flexible spline 28 remain immov-

able or non-rotatable relatively to the elliptical cam 27 and hence the intermediate shaft 15. In this instance, the tooth 31 on the flexible spline 28 is brought into meshing engagement with a tooth 41 on the rigid circular spline 30. During the next succeeding half-turn of the intermediate shaft 15, the rigid circular spline 30 is turned in the opposite direction (counterclockwise in Figure 5) through the same angle ω_1 . Consequently, the tooth 31 on the flexible spline 28 turns counterclockwise through an angle ω_2 , into meshing engagement with the tooth 40 on the rigid circular spline 30. Now, the flexible spline 28 has turned counterclockwise through an angle equal to the sum of ω_1 and ω_2 , relatively to the intermediate shaft 15 as the latter has rotated one turn.

Figure 8 shows a deceleration or speed-reduction property of the speed reducer 17. The flexible spline 28 remains immovable relatively to the intermediate shaft 15 as the latter turns through a first half of one turn, while it is active to effect speed reduction only when the intermediate shaft 15 is turning through the next succeeding half-turn. Due to rigid connection with the flexible spline 28, the output shaft 16 is also immovable during the first half-turn of the intermediate shaft 15 and is rotated during the second half-turn of the intermediate shaft 15. During the transmission of the rotary motion in the speed reducer 17, the flexible and rigid splines 28, 30 continuously mesh with each other with the result that the rotary motion can be transmitted gently without causing abrupt fluctuation in angular speed at the beginning and the end of the motion. The motion of the decelerated angular speed pattern shown in Figure 8 is combined with the motion of the sinusoidal angular speed pattern shown in Figure 7 when the rotary motion of the intermediate shaft 15 is transmitted to the output shaft 16 through the speed reducer 17. With this combination, the output shaft 16 is rotated stepwise in a pattern as shown in Figure 9. The rotary motion of the output shaft 16 thus obtained takes place gently without causing abrupt fluctuation in angular speed. In the illustrated embodiment, the eccentric cam 32 has a cam profile designed such that the intermittent motion is transmitted to the output shaft 16 when the angular speed of the intermediate shaft 15 becomes maximum. It is possible to modify the cam profile or the relative angular position of the cam 32 and the input shaft 12 to thereby vary the timing of the intermittent rotary motion of the output shaft 16.

As described above, the intermittent drive mechanism of the present invention includes a cooperative pair of non-circular drive and driven gears, and a speed reducer having an internally toothed rigid circular spline and an externally toothed flexible spline meshing with the rigid spline. With this construction, it is possible to accurately control the starting and stopping timing of the intermittent driving motion without causing overruning even when the mechanism is operating at a high speed. Furthermore, due to continuing meshing engagement of the gears and of the splines, the stepwise motion takes place without undesired shock. Consequently, the

structural components of the mechanism are free of damage. The gears and splines are relatively unsuceptible to abrasive wear and hence they are easy to maintain.

Claims

An intermittent drive mechanism for converting a constant velocity of an input shaft (12) into an intermittent drive of an output shaft (16), by use of a speed reducer (17) acting as an adding-reducing device and having a nonreduced input member (37, 30) driven from said input shaft (12) in a reciprocal movement of zero mean speed, and a reduced input member (15, 27) driven from said input shaft (12) in a continuous movement of not zero mean speed, the amplitude of said reciprocal movement being so chosen as to periodically annul the speed of said output shaft (16), said speed reducer (17) including an externally toothed flexible spline (28) slidably fitted over an elliptical cam (27) and firmly connected with said output shaft (16), an internally toothed rigid circular spline (30) rotatable relatively to an intermediate shaft (15) fixedly connected with said elliptical cam (27) and parallel to said input shaft (12) said flexible spline having teeth thereon at least two less in number than teeth on said rigid circular spline (30) and meshing with said rigid circular spline at two diametrically opposite regions extending along a major axis of said elliptical cam (27), and said reciprocal movement being obtained by an eccentric cam (32) firmly connected with said input shaft (12) for corotation therewith and a crank lever (33) operatively connecting said eccentric cam (32) with said rigid circular spline, characterized in that

— said continuous movement in which said reduced input member (15, 27) is driven has a sinusoidal angular speed pattern, the frequency of which is twice the frequency of said reciprocal movement, said sinusoidal angular speed pattern movement being obtained by a couple of non-circular drive and driven gears (13, 14) having an elliptical shape, and firmly connected respectively with said input shaft (12) and intermediate shaft (15), and

— the phase relation between both movements is such that, when said reciprocal movement reaches its maximal direct and reverse speed, said sinusoidal angular speed pattern movement reaches its maximal speed, whereby said amplitude of reciprocal movement needed to periodically annul the output speed is lowered, and the output shaft speed curve has flat bottoms and flat tops.

Patentansprüche

1. Schrittschalt-Antriebsmechanismus zur Umwandlung einer gleichförmigen Geschwindigkeit einer Eingangswelle (12) in einen schrittweisen Antrieb einer Ausgangswelle (16) mit Hilfe eines Untersetzungsgetriebes (17), das als Überlagerungseinrichtung wirkt und aufweist: ein nicht untersetztes Eingangsteil (37, 30), das von der besagten Eingangswelle (12) mit Nullpunkt-Durchschnittsgeschwindigkeit zu einer hin- und

able or non-rotatable relatively to the elliptical cam 27 and hence the intermediate shaft 15. In this instance, the tooth 31 on the flexible spline 28 is brought into meshing engagement with a tooth 41 on the rigid circular spline 30. During the next succeeding half-turn of the intermediate shaft 15, the rigid circular spline 30 is turned in the opposite direction (counterclockwise in Figure 5) through the same angle ω_1 . Consequently, the tooth 31 on the flexible spline 28 turns counterclockwise through an angle ω_2 , into meshing engagement with the tooth 40 on the rigid circular spline 30. Now, the flexible spline 28 has turned counterclockwise through an angle equal to the sum of ω_1 and ω_2 , relatively to the intermediate shaft 15 as the latter has rotated one turn.

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hergehenden Bewegung angetrieben wird und ein untersetztes Eingangsteil (15, 27), das von der besagten Eingangswelle (12) mit einer Nicht-Nullpunkt-Durchschnittsgeschwindigkeit zu einer stetigen Bewegung angetrieben wird, wobei die Amplitude der hin- und hergehenden Bewegung so gewählt ist, damit die Geschwindigkeit der Ausgangswelle (16) periodisch null wird, wobei das Untersetzungsgetriebe (17) ein außenverzahntes flexibles Ritzel (28) enthält, das auf einen elliptischen Nocken (27) verschiebbar aufgesteckt und mit der Ausgangswelle (16) fest verbunden ist, ein innenverzahntes starres kreisrundes Zahnrad (30) enthält, das relativ zu einer Zwischenwelle (15) verdrehbar ist, die mit dem elliptischen Nocken (27) fest verbunden und zu der Eingangswelle (12) parallel ist, wobei das flexible Ritzel mindestens zwei Zähne weniger hat als das starre kreisrunde Zahnrad (30) und mit dem starren kreisrunden Zahnrad (30) an zwei diametral gegenüberliegenden Bereichen kämmt, die sich längs einer Hauptachse des elliptischen Nockens (27) erstrecken, und wobei die hin- und hergehende Bewegung durch einen mit der Eingangswelle (12) drehfest verbundenen exzentrischen Nocken (32) und durch einen Kurbelarm (33) erhalten wird, der den exzentrischen Nocken (32) mit dem starren kreisrunden Zahnrad verbindet, dadurch gekennzeichnet, daß

— die stetige Bewegung, mit der das untersetzte Eingangsteil (15, 27) angetrieben wird, ein sinusförmiges Winkelgeschwindigkeitsprofil hat, dessen Frequenz doppelt so groß ist als die Frequenz der besagten hin- und hergehenden Bewegung, wobei dieses sinusförmige Winkelgeschwindigkeitsprofil durch zwei unrunde treibende und getriebene Zahnräder (13, 14) erhalten wird, die eine elliptische Form haben und die mit der Eingangswelle (12) bzw. mit der Zwischenwelle (15) fest verbunden sind, und

— die Phasenverschiebung zwischen den beiden Bewegungen derart ist, daß, wenn die hin- und hergehende Bewegung ihre maximale Vor- und Rücklaufgeschwindigkeit erreicht, das sinusförmige Winkelgeschwindigkeitsprofil der Ausgangswelle flache Wellentäler und flache Wellenberge hat.

Revendications

1. Mécanisme d'entraînement intermittent pour convertir une vitesse constante d'un arbre d'entrée (12) en un entraînement intermittent d'un arbre de sortie (16), grâce à l'utilisation d'un réducteur de vitesse (17) agissant comme dispositif d'addition et de réduction et ayant un élément d'entrée (37, 30) non réduit entraîné par ledit arbre d'entrée (12) dans un déplacement de va-et-vient de vitesse moyenne nulle, et un élément d'entrée (15, 27) réduit entraîné par ledit arbre d'entrée (12) en un déplacement continu de vitesse moyenne non nulle, l'amplitude dudit déplacement de va-et-vient étant choisie de façon à annuler périodiquement la vitesse dudit arbre de sortie (16), ledit réducteur de vitesse (17) comportant un arbre cannelé (28) flexible pourvu de dents extérieures fixé de façon à pouvoir glisser sur une

came elliptique (27) et connecté fermement audit arbre de sortie (16), un arbre cannelé (30) circulaire rigide muni de dents intérieures pouvant tourner par rapport à un arbre intermédiaire (15) connecté de façon fixe à ladite came elliptique (27) et parallèle audit arbre d'entrée (12), ledit arbre cannelé flexible ayant des dents sur celui-ci, dont le nombre est inférieur d'au moins deux à celui des dents sur ledit arbre cannelé (30) circulaire rigide et qui s'engrène avec ledit arbre cannelé circulaire rigide en deux régions diamétralement opposées s'étendant le long d'un axe principal de ladite came elliptique (27), et ledit déplacement de va-et-vient étant obtenu par une came excentrique (32) fermement connectée audit arbre d'entrée (12) pour la rotation simultanée avec celui-ci et un bras de levier (33) connectant de façon opérationnelle ladite came excentrique (32) audit arbre cannelé circulaire rigide, caractérisé en ce que

— ledit déplacement continu dans lequel ledit élément d'entrée (15, 27) réduit est entraîné à un motif de vitesse angulaire sinusoïdal, dont la fréquence est double de la fréquence dudit déplacement de va-et-vient, ledit déplacement à motif de vitesse angulaire sinusoïdal étant obtenu par un couple d'engrenages d'entraînement et entraîné non-circulaires (13, 14) ayant une forme elliptique, et fermement connectés respectivement audit arbre d'entrée (12) et audit arbre intermédiaire (15), et

— la relation de phase entre les deux déplacements est telle que, lorsque le déplacement de va-et-vient atteint sa vitesse directe et inverse maximale, ledit mouvement à motif de vitesse angulaire sinusoïdal atteint sa vitesse maximale, grâce à quoi ladite amplitude du déplacement de va-et-vient nécessaire pour annuler périodiquement la vitesse de sortie est diminuée, et la courbe de vitesse de l'arbre de sortie a des vallées plates et des crêtes plates.

