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(54) **An improved belt transmission, particularly for laundry driers and washing machines**

(57) An improved belt transmission between a driving pulley and a driven pulley comprises a floating pulley (6) with a pair of identical circular winding surfaces (8,9) between which there is a third circular winding surface (7) which has a different diameter from that of the pair of surfaces and which is coaxial therewith, a pair of identical belts (10,11) coupling the floating pulley (6) kinematically to one of the driving and driven pulleys by being wound around the pair of identical surfaces (8,9) of the floating pulley (6) and around one of the driving and driven pulleys, and a third belt (5) coupling the floating pulley (6) kinematically to the other of the driving (12) and driven pulleys by being wound around the third surface of the floating pulley and around the other of the driving and driven pulleys.

The floating pulley or even one or other of the driving and driven pulleys may be of the type with a diameter which is variable according to the speed of rotation.

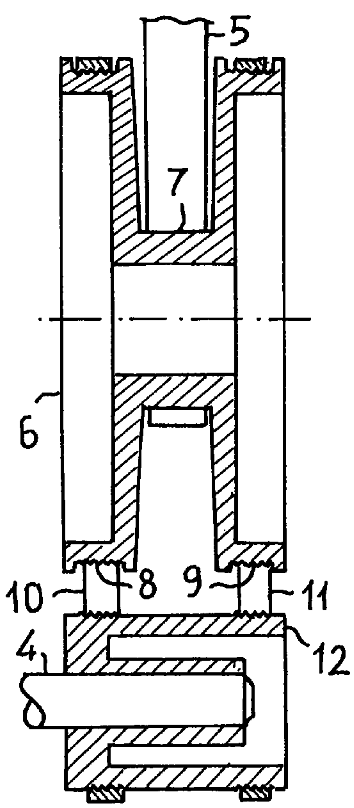

FIG. 3

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Description

[0001] The present invention relates to an improved belt transmission intended particularly for laundry driers and washing machines but also usable in any situation in which it is necessary to achieve a very high transmission ratio of the order of 50 or more with fairly large inert loads, with motors such as induction motors which have limited starting torque. In domestic laundry driers and washing machines, it is known to use induction motors (possibly with a switchable number of poles in washing machines) for driving the drying and washing drums, respectively, because, by virtue of their reliability, they are preferable to commutator motors which require periodic maintenance.

[0002] The drive is transmitted from the motor shaft to the drying or washing drum by means of a belt transmission.

[0003] In the case of laundry driers, the same motor preferably also drives directly the fan which produces a ventilation flow in the drum.

[0004] This achieves safer operation and ventilation at a lower cost than solutions which use an auxiliary fan motor or an auxiliary transmission.

[0005] Efficient ventilation requires a fast speed of rotation of the motor, which is typically an asynchronous motor with two poles, with a nominal rate of rotation of 2800 revolutions/min., whereas the drying drum typically has to rotate at a speed of 50-55 revolutions/min.

[0006] Consequently, the belt transmission has to have a very high transmission ratio (motor/load) of the order of 2800/50 = 56 which, within the dimensional limitations of the machine, is achieved by a belt which is wound directly around the motor shaft which is given a diameter of the order of 10 mm, and around a driven pulley with a diameter of the order of 550 mm, constituted by the drying drum.

[0007] This involves severe fatigue stresses on the belt which undergoes considerable periodic flexion as it is wound around the motor shaft.

[0008] Moreover, since the angle through which the belt is wound on the shaft is small, it is necessary to impart a considerable pull to the belt to ensure the necessary grip on the shaft without slippage. This also contributes to the fatigue stressing of the belt, only partially prevents slippage, and causes considerable wear of the belt.

[0009] In washing machines, it is possible to use a lower transmission ratio and therefore a larger-diameter driving pulley but there is nevertheless the problem which is also present to some extent in laundry driers, that the inertia of the rotating drum cannot easily be reconciled with the dynamic characteristics of induction motors which develop a relatively low driving torque upon starting or during reversal of the drive in comparison with that developed when the speed of rotation is close to the nominal speed.

[0010] As a result, changes in speed are quite lengthy because of the inertia of the system and involve considerable losses which are greater with greater "slip" of the motor, that is, greater difference between the rates of rotation of the rotating excitation magnetic field and of the rotor.

[0011] It is therefore necessary for the motor to be over-sized to a certain extent, at considerable cost, in order to reduce losses and to ensure a higher starting torque or, as occurs in some cases, to use commutator motors, variable-reluctance motors, variable-frequency motors, or even so-called "brushless" motors, all of which are much more expensive. The bearings supporting the motor shaft and the drive shaft are also over-sized in order to withstand the stresses imposed by the pull of the belt, with consequent increases in cost.

[0012] All of these problems are to a large extent eliminated by the belt transmission of the present invention, in which a very high transmission ratio is achieved by a driving pulley keyed to the motor shaft and having a diameter larger than that of the motor shaft, a driven pulley constituted, for example, by the drum of a laundry drier, and a floating pulley having a pair of identical circular winding surfaces and a third circular winding surface with a different diameter from that of the pair, a pair of transmission belts wound around the pair of identical circular surfaces and around one of the driving and driven pulleys, and a third transmission belt wound around the third winding surface and around the other of the driving and driven pulleys.

[0013] By an appropriate selection of the ratio between the diameters of the pair of identical circular surfaces and of the third circular surface of the floating pulley which, for example, may be of the order of 3:1, it is possible to use a driving pulley with a diameter larger than that of the motor shaft, for example, of 30 mm and to achieve the desired overall transmission ratio of 50 or more.

[0014] The floating pulley does not require a support axle and is therefore defined as floating since it is kept in position by the opposed pulls of the pair of belts and of the third belt.

[0015] In rest conditions and in the absence of driving torque, the position of the floating pulley is defined by the symmetrical pulling conditions of the transmission belts and its axis is aligned with the axes of the driving pulley and of the driven pulley and parallel thereto.

[0016] In working conditions, owing to the relative resilience of the transmission belts and to the asymmetry of the pull caused by the driving torque and by the resisting torque, the floating pulley is shifted from its rest position.

[0017] The changes in the position of the floating pulley in variable dynamic conditions (acceleration/ deceleration) disconnect the driving pulley from the driven pulley to a certain extent, reducing the resisting torque and facilitating starting and drive reversal.

[0018] As a further improvement, the use of a floating pulley in the belt transmission of the invention in combination with a pulley with a diameter which is variable according to the speed of rotation, which may be the floating pulley itself or one or other of the driving and driven pulleys, renders starting and drive reversal even easier by variation of the transmission ratio in dependence on the speed.

[0019] In this case, the transmission belts have to have sufficient resilience to compensate for changes in the length of the path of the belt due to the variable diameter of one of the pulleys or, in equivalent manner, the floating pulley may be biased by resilient restraints to a position in which it is not aligned with the axes of the driving and driven pulleys.

[0020] Moreover, for washing machines with induction motors having a variable number of poles, in which the relative speeds of rotation during washing and during spinning are conditional upon the limited selection of the number of poles, which is necessarily even, it is possible to optimize the two speeds.

[0021] Finally, even in the case of washing machines with fast spinning speeds which use commutator motors or equivalent motors, the use of an intermediate floating pulley with a variable diameter enables the maximum speed of rotation of the motor to be reduced to within limits of reliability.

[0022] As a further advantage, the use of an intermediate floating transmission pulley permits the use of belts of two different types of specifically suitable length, thickness and bending capacity, for example, a trapezoidal-sectioned belt for the coupling between the washing/drying drum and the floating pulley and a pair of relatively thin, flat or multi-channelled belts for the coupling between the floating pulley and the motor shaft.

[0023] The characteristics and advantages of the invention will become clearer from the following description of a preferred embodiment and variants thereof, provided by way of non-limiting example with reference to the appended drawings, in which:

Figure 1 is a schematic section showing a known laundry drier provided with a conventional belt transmission,
Figure 2 is a schematic section showing a laundry drier provided with an improved transmission according to a first embodiment of the present invention,
Figure 3 is a section showing a detail of the embodiment of the transmission shown in Figure 2, taken on the line I-I of Figure 2,
Figure 4 is a schematic view of the transmission of Figure 3 taken in a plane perpendicular to the axis of the transmission pulley,
Figure 5 is a schematic section showing a laundry drier provided with an improved transmission according to a second embodiment of the present invention,
Figure 6 is a section showing a detail of the embodiment of the transmission shown in Figure 5, taken on the line II-II of Figure 5,
Figure 7 is a variant of the transmission of Figure 6,
Figure 8 is a schematic section showing a washing machine provided with an improved transmission according to the second embodiment of the present invention.

[0024] With reference to Figure 1, this shows, in frontal section, a known laundry drier constituted by a casing 1 housing a drying drum 2 and a drive motor 3 with a shaft 4 parallel to the axis 2A of the drum and perpendicular to the plane of the drawing.

[0025] The motor 3, which is preferably of the two-pole induction type, drives directly a fan, not shown, and, by means of a belt transmission 5, the drum 2.

[0026] Since the motor rotates at a nominal speed of 2800 revolutions/minute when it is supplied with a voltage alternating at a frequency of 50Hz, in order to achieve the desired speed of rotation of the drum of 50/55 revolutions/minute, it is necessary for the belt 5 to be wound directly around the periphery of the drum 2 which has a diameter of the order of 55 cm and around the shaft of the motor which has a diameter of the order of 10 mm.

[0027] As result, the angle through which the belt is wound on the shaft 4 is very small, of the order of 90° or a little more, and the belt is subject to considerable bending stress with a radius or curvature of the order of 5 mm.

[0028] This involves the problems already mentioned of slippage, wear, ageing and premature breakage owing to fatigue.

[0029] To prevent these problems, according to the invention, as shown in Figure 2 and in the details of Figures 3 and 4, the coupling between the drum 2 and the motor 3 is formed by a belt transmission constituted by three belts and by a floating pulley 6.

[0030] By "floating pulley" is meant a pulley which is not engaged on a support axle in a fixed and predetermined position but which is free to move according to the pull exerted by the belts which are wound around the pulley.

[0031] The pulley 6 has a first circular surface 7 for the winding of a first belt 5, flanked axially on opposite sides by two circular surfaces 8, 9 for the winding of two identical belts 10 and 11.

[0032] In the preferred embodiment shown in Figures 2-4, the first surface 7 has a diameter of the order of 30 mm and the pair of circular surfaces 8, 9 has a diameter of the order of 90 mm.

[0033] The generally circular winding surfaces 7, 8, 9 may be either cylindrical or grooved, or may even have a recessed trapezoidal shape, according to the type of belt to be used.

[0034] They may possibly also be toothed for coupling with toothed belts and thus forming a positive transmission. As shown, the larger-diameter surfaces 8, 9 may have restraining shoulders for preventing axial displacement of the belts relative to the pulley.

[0035] The first belt 5 is wound around the periphery of the drum 2 and around the first surface 7 of the pulley 6.

[0036] The other two belts 10, 11 are wound, respectively, around the other circular surfaces 8, 9 of the pulley 6 and around a hub 12 keyed to the motor shaft 4.

[0037] Since the difference in diameter between the first winding surface 7 of the pulley 6 and the pair of identical winding surfaces 8, 9 of the pulley 6 achieves an increase in the transmission ratio which, in the embodiment shown and in the preferred embodiment, is equal to 3, it is possible to keep the overall transmission ratio unchanged with the use of a hub 12 with a diameter of the order of 30 mm.

[0038] The bending stress on the belts is thus considerably reduced, the smallest radius of curvature for all of the belts being brought to 15 mm and thus being three times larger without any substantial reduction in the angle of winding on the winding surfaces which, in the case of the belts 10, 11 which are wound on the hub 12 is in fact larger than in the solution commonly used in the art.

[0039] This simple measure reduces slippage, wear and ageing of the belts to a considerable extent.

[0040] It should be noted that, even with the use of a hub 12 or even a motor shaft with an only slightly increased diameter, for example of 12-14 mm (in which case the floating pulley may have winding surfaces with diameters of the order of 28 and 38 mm, respectively) it is possible to achieve substantial benefits, particularly if multi-channelled belts (known as POLY-V belts) are used for the coupling between the motor shaft and the floating pulley.

[0041] The correct position of the pulley 6 between the motor shaft 4 and the drying drum 2 is ensured by the pull of the belts without the need for supports for the pulley.

[0042] In rest conditions, that is, in the absence of transmitted torque, the axis of the pulley 6 is parallel to and aligned with the axis of the motor shaft 4 and the axis of the drum, that is, in the plane defined thereby, by virtue of the symmetrical pull of the belts.

[0043] Figure 4 shows the pulley 6 in continuous outline in the rest position.

[0044] In the presence of transmitted torque, the asymmetry of the pull of the belts brings about a displacement of the pulley, which is floating, from the rest position, the displacement being greater the greater the torque transmitted.

[0045] In Figure 4, a generic working position of the pulley 6 is shown by the broken outline 13.

[0046] The changes in the position of the pulley have the effect of introducing into the transmission a resilient component which temporarily disconnects the motor shaft from the driven member to a certain extent.

[0047] This is particularly advantageous since it limits the amplitude of the angular accelerations transmitted and the consequent "snatching" effects due to the inertia of the rotating masses.

[0048] In particular, it makes it easier to start the rotation of the motor which, as is known, if it is of the induction type, has a very low starting torque; during the initial driving stage, the transmission yields and transfers a small torque to the load allowing the motor to adopt a speed of rotation at which the driving torque developed is higher.

[0049] The same advantageous effect is achieved when the sense of rotation is reversed.

[0050] This type of transmission with a floating pulley can therefore advantageously be used not only for laundry dryers but also for washing machines in which, as is known, the washing is carried out with periodic reversal of the sense of rotation of a washing drum.

[0051] As a further improvement, the transmission system described is suitable for the development of a transmission with a ratio which is variable in dependence on speed, making it even easier to start and reverse the movement of a drive system with an induction motor.

[0052] A transmission of this type fitted in a laundry drier is shown in the overall view of Figure 5 and in the detail of Figure 6.

[0053] In Figures 5 and 6, the floating pulley 14 has a first winding surface 15 for a trapezoidal-sectioned belt, the diameter of this surface being variable in dependence on speed, flanked by two identical circular surfaces 16, 17 of larger diameter.

[0054] As in the embodiment of Figures 2, 3 and 4, a first belt 18, in this embodiment of trapezoidal section, is wound around the first surface 15 and around the periphery of the drum 2, coupling them kinematically.

[0055] A pair of belts 19, 20 is wound around the two circular surfaces 16, 17 and around a hub 21 keyed to the shaft 4 of the motor 3.

[0056] A belt transmission with a variable transmission ratio is thus formed. The floating pulley 14 is advantageously supported by a

[0057] floating axle 22 biased resiliently by a spring 23 towards a position removed from the plane defined by the axis of the motor shaft and by the axis of the drum.

[0058] For inextensible belts, this provides the belts with a path the length of which is independent of the variable diameter of the fist winding surface 15.

[0059] In Figure 5, the position of the floating pulley when the first winding surface has the minimum diameter provided for is shown in continuous outline and the position of the floating pulley when the diameter of the first winding surface is at a maximum is shown in broken outline.

[0060] In the second case, the axis of the floating pulley may be aligned with the axes of the motor shaft and of the drying drum.

[0061] Alternatively, with the use of resilient belts which take up the difference in the length of the path imposed by the variable diameter, resilient biasing of the floating pulley may be unnecessary.

[0062] Figure 6 shows an embodiment of a floating pulley with a variable diameter in a detailed diametral section.

[0063] The pulley is constituted by a hub 24 having a conical flange 25 terminating at its periphery in a cylindrical winding surface for the belt 20.

[0064] A conical flange 26 is mounted for sliding axially on the hub 24, facing the flange 25.

[0065] The belt 18 is fitted between the two flanges 25, 26 and, as a result of the pull imparted, tends to keep the two flanges spaced apart.

[0066] A third conical flange 27 is fixed firmly to the hub 24 and terminates at its periphery in a cylindrical winding surface for the belt 19.

[0067] The two flanges 26 and 27 form an annular housing for a plurality of balls 28, 29.

[0068] The width of the housing in the axial direction decreases towards the periphery of the pulley.

[0069] If the pulley is set in rotation, the balls 28, 29 tend to move away from the axis of rotation as a result of the centrifugal effect and tend to move the flange 26 towards the flange 25, overcoming the axial thrust exerted by the belt 18 on the flange 26.

[0070] As a result of this movement, the trapezoidal-sectioned belt 18 is forced to be wedged between the flanges along a winding surface of larger diameter and hence with a higher transmission ratio.

[0071] The ratio varies with variations in the speed of rotation and increases therewith, although not proportionally.

[0072] By a suitable lenticular design of the chamber housing the balls and possibly by the dimensions of the biasing spring 23 which imparts a predetermined pull to the belts, it is possible to achieve a transmission ratio of the pulley which is variable in inverse proportion to speed and which decreases, for example, from a ratio of 6-9 to a ratio of 3.

[0073] The transmission system thus has an overall transmission ratio of 100-150 upon starting, permitting easy starting, decreasing to a value of 50 in running conditions.

[0074] Since the axial displacement of the flange 26 relative to the flange 25 involves a sideways movement relative to the belt 18 of value $x = 1/2S$ (where S is the axial displacement relative to the flange 26) the cylindrical surfaces 16, 17 for the winding of the belts 19, 20 advantageously extend axially to permit an equal relative axial displacement of the belts.

[0075] Naturally, moreover, the spring 23 acts on the axle 22 of the floating pulley by means of a stirrup or fork, not shown, to keep the axle 22 parallel to the axle of the motor shaft and of the drying drum.

[0076] The lateral displacement of the winding surface for the belt 18 can be eliminated by the formation of an axially symmetrical floating pulley of variable diameter as shown in Figure 7 which, by virtue of its similarity to Figure 6, can readily be understood and does not require further explanation.

[0077] The foregoing description relates merely to a preferred embodiment and to a variant thereof, but clearly many other variations may be applied.

[0078] For example, it is possible to use two identical transmission belts for coupling the floating pulley to the drying drum and one transmission belt for coupling the floating pulley to the motor shaft.

[0079] In this case, instead of being shaped like a reel with a central channel, the floating pulley adopts the shape of a cylindrical element extended axially at its opposite ends by two cylindrical elements of smaller diameter.

[0080] Moreover, to achieve a variable transmission ratio, it is possible to use a floating pulley with a fixed transmission ratio and a pulley with a variable diameter instead of the hub keyed to the motor shaft.

[0081] For washing machines, the use of a belt transmission such as that described with an intermediate pulley of variable diameter achieves further substantial advantages which will be explained with reference to Figure 8.

[0082] In Figure 8, the washing drum 2 has a driving pulley 30 with a diameter typically of 278 mm.

[0083] A motor 3 is coupled to the pulley 30 by means of a first transmission belt which is wound around a first circular surface 33 with a diameter variable between approximately 45 mm at low speeds of rotation and approximately 70 mm at high speeds of rotation, of a variable-ratio floating pulley 34.

[0084] The belt 31, which is trapezoidal, may be extensible. The floating pulley 34 of the type already described, has a pair of circular surfaces 35 with diameters of about 45 mm.

[0085] A pair of belts 36, preferably of the POLY-V type, is wound around the circular surfaces 35 and around a shaft or hub 37 rotated by the motor 31.

[0086] In the case of an induction motor of the type generally used, with a number of poles switchable from 2 to 12, it can readily be seen that it is possible to achieve a spinning speed of 600 revolutions/minute (2 poles) and a washing speed (12 poles) of about 60 revolutions/minute which is considered optimal for agitating and mixing the laundry.

[0087] However, the solution commonly used provides for direct coupling of the pulley 30 to the motor 31 by means of a trapezoidal-sectioned belt and a hub with a variable diameter keyed to the motor shaft.

[0088] To achieve a spin speed of 600 revolutions/minute, the maximum diameter of the hub is about 60 mm and the minimum diameter which is imposed by the use of a trapezoidal belt, may be no less than 46 mm, which necessitates the use of a speed of rotation for washing of about 75 revolutions/minute with a consequent reduction in washing efficiency.

[0089] Substantial advantages are also achieved in washing machines providing for a fast spin speed of 1200 revolutions/minute.

[0090] In these washing machines, commutator motors are used, and are coupled to the pulley 30 by means of a multi-channelled belt which excludes the possibility of the use of a variable-diameter hub.

[0091] The result is that, in order to develop adequate torque at low speeds of rotation, as is required for washing operations, it is necessary, in order to achieve the spin speed, to set a very fast speed of rotation for the motor (14,000 revolutions/minute).

[0092] With the use of a transmission system such as that of Figure 8 with a floating intermediate pulley with a variable diameter, however, it is possible to reduce the speed of rotation of the motor necessary to achieve the spin speed of 1,200 revolutions/ minute by a good 20%, or even up to 40%, for a given driving torque and speed of rotation for washing.

Claims

1. A belt transmission comprising a driving pulley (12) keyed to a motor shaft (4) or constituted by the motor shaft (4), a driven pulley (2) keyed to a driven shaft (2A), and a transmission belt (5),
   characterized in that it comprises

   a floating pulley (6,14) with a first circular surface (7,15) for the winding of the belt (5,18), a pair of identical circular surfaces (8,9,16,17) for the winding of belts (10,11,19,20), coaxial with the first surface (7,15) and arranged axially one on each side of the first surface (7,15), and a pair of identical transmission belts (10,11,19,20) wound around the pair of identical circular surfaces (8,9,16,17) of the floating pulley (6,14) and around one of the driving (12) and driven pulleys (2), respectively, the transmission belt (5,18) coupling the floating pulley (6,14) to the other of the driving (12) and driven pulleys (2).

2. A belt transmission according to Claim 1, in which the floating pulley (6) is shaped like a reel, the first winding surface (7) being the channel of the reel and the pair of winding surfaces (8,9) being formed by the peripheral surfaces of lateral flanges of the reel.

3. A belt transmission according to Claim 1 or Claim 2, comprising means (23) for biasing the floating pulley resiliently to a rest position.

4. A belt transmission according to the preceding claims in which one of the driving pulley and the floating pulley is a pulley (14) with a diameter which is variable in dependence on the speed of rotation in order to vary the transmission ratio of the belt transmission (18).

5. A belt transmission according to Claim 4, in which the variable-diameter pulley is structurally axially symmetrical.

6. A laundry drier comprising an induction motor for driving a rotary drying drum and a fan, incorporating a belt transmission according to the preceding claims for coupling the rotary drum to the motor.

7. A washing machine comprising an induction motor for driving a washing drum and incorporating a belt transmission according to the preceding claims for coupling the motor to a washing drum.

8. A washing machine comprising a variable-speed commutator motor or an equivalent motor and incorporating a belt transmission according to the preceding claims for coupling the motor to a washing drum.

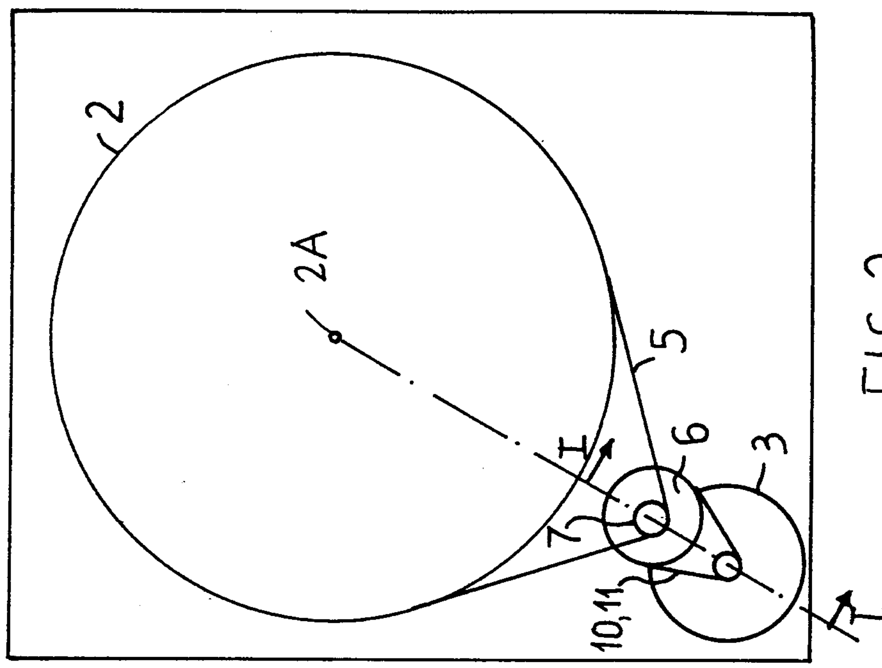

FIG.2

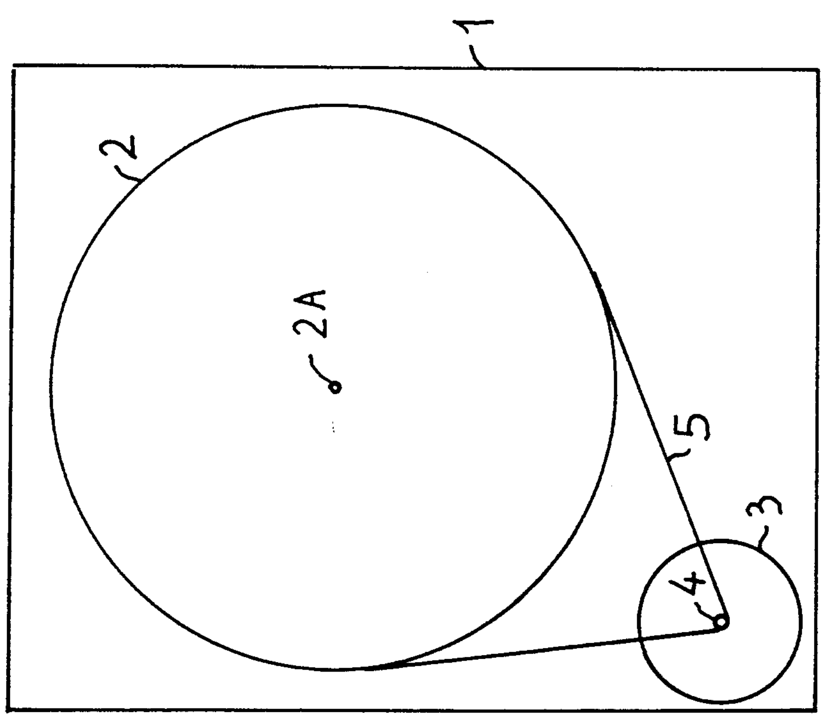

FIG.1

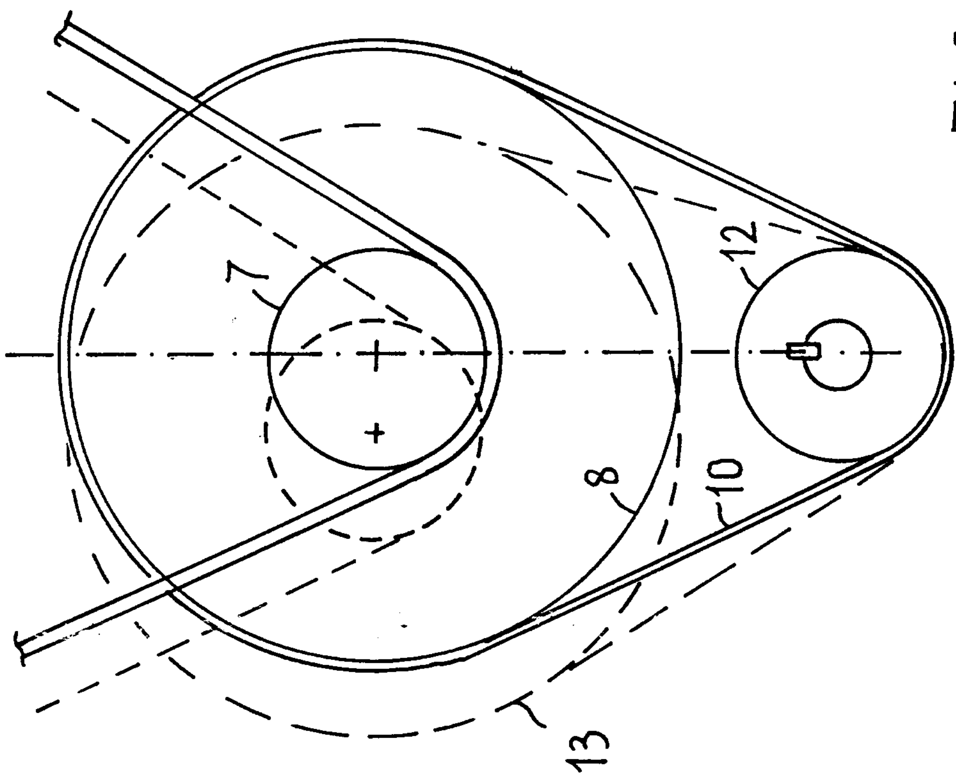

FIG. 4

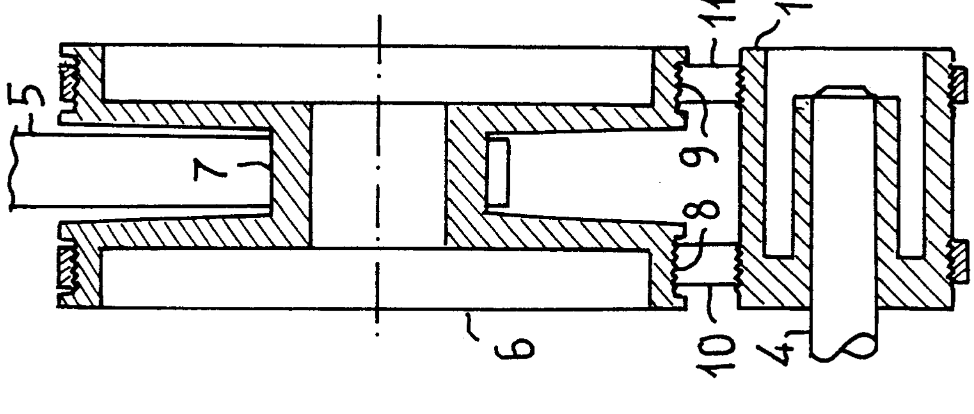

FIG. 3

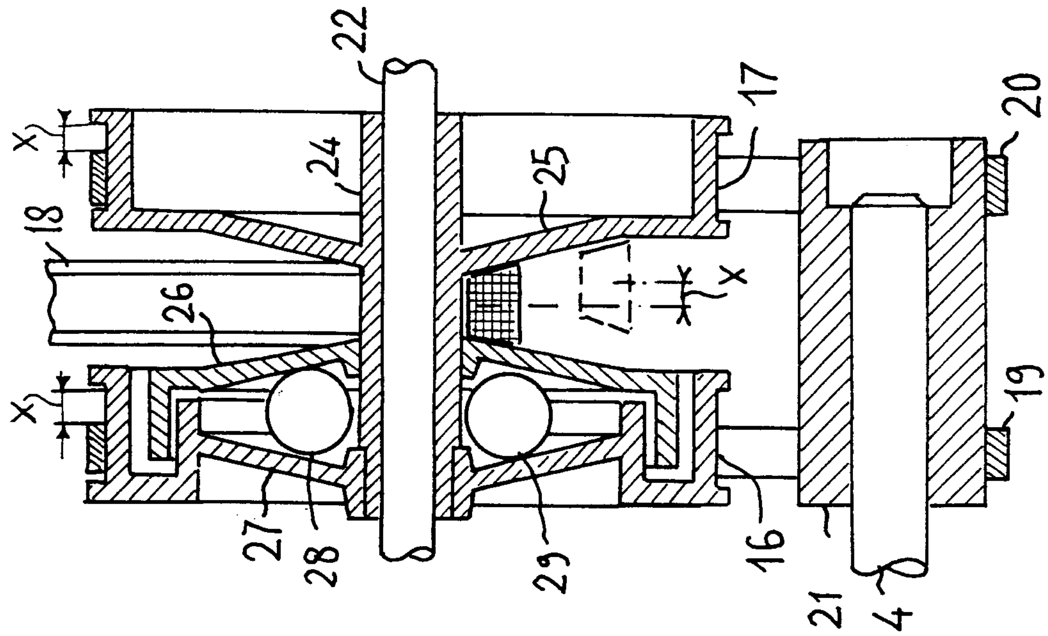

FIG. 6

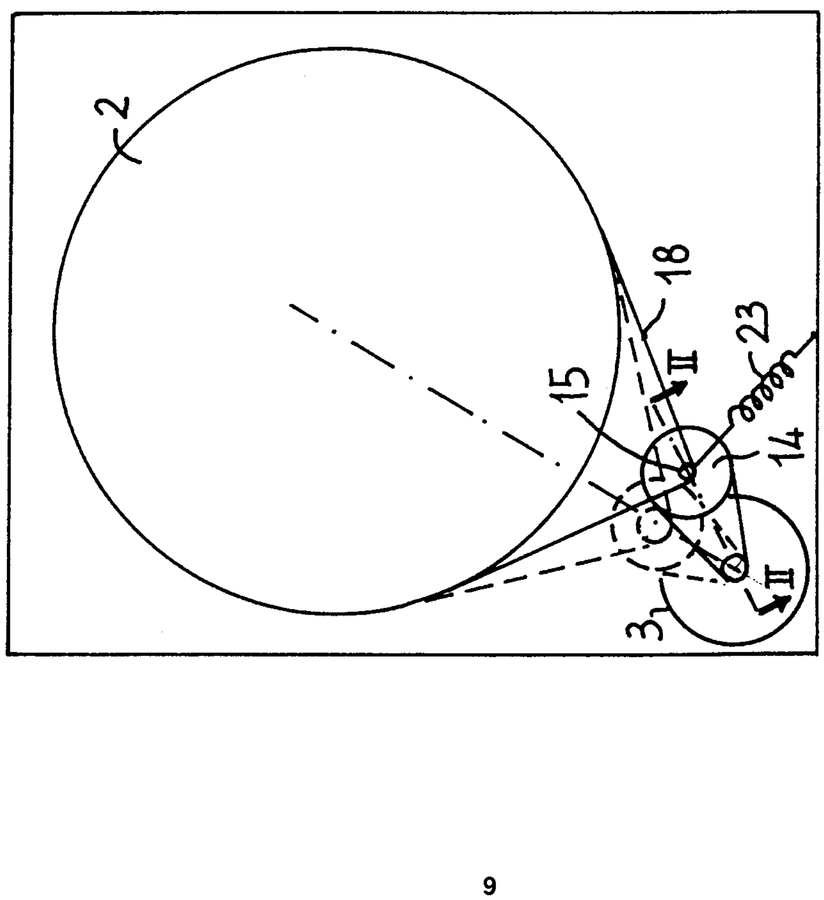

FIG. 5

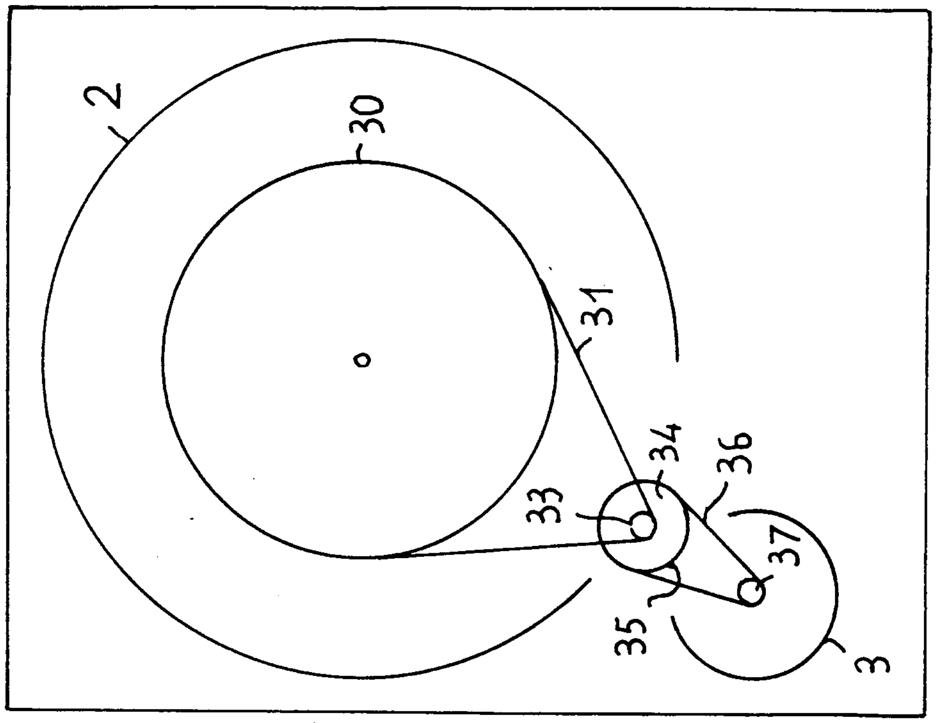

FIG. 8

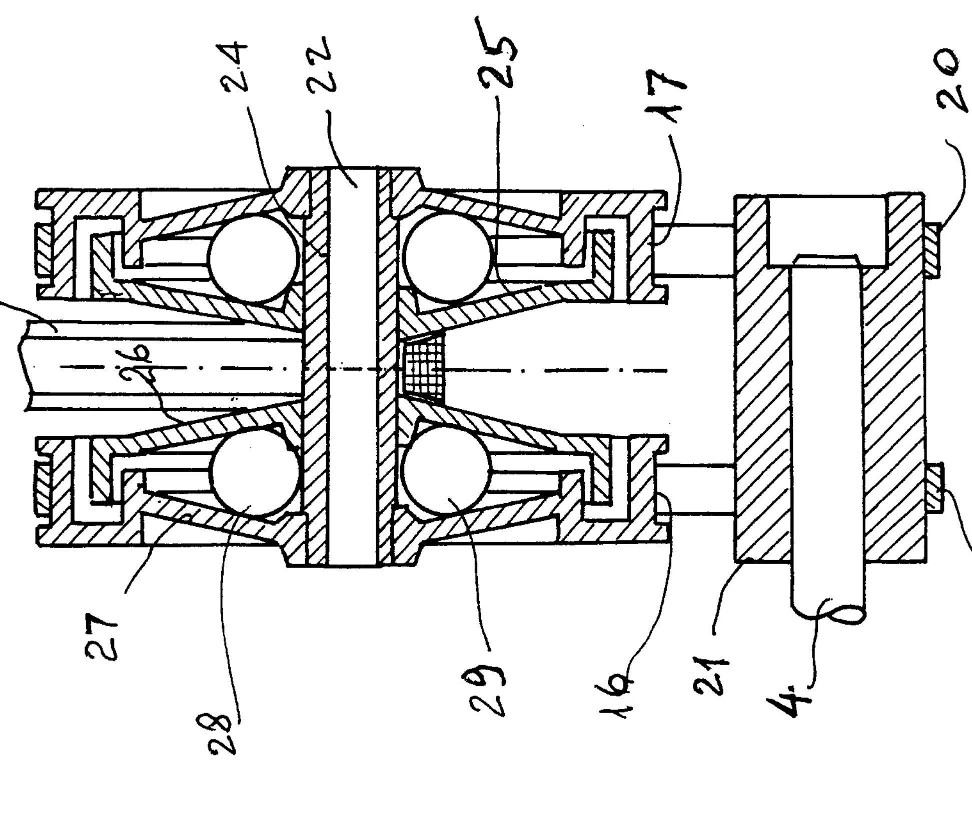

FIG. 7