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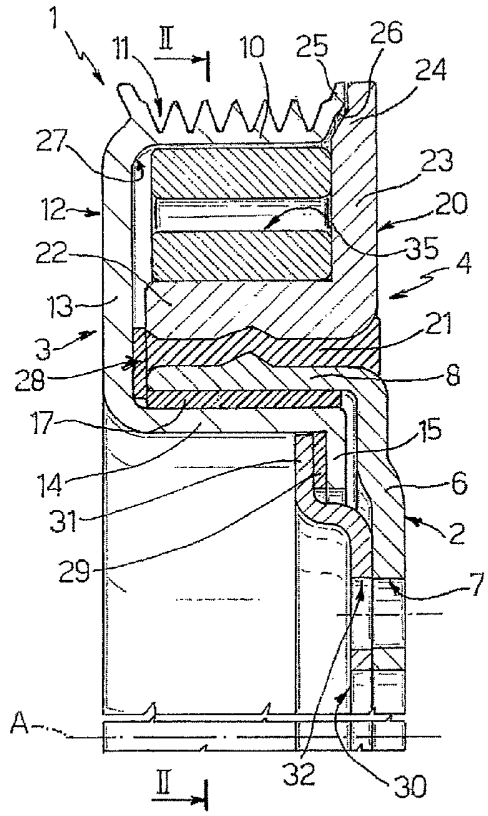
(54) Title: A PULLEY ASSEMBLY



(57) Abstract: Described herein is a pulley assembly (1) for a belt drive, particularly for an internal-combustion engine, comprising: a hub (2); a pulley (3) coaxial to the hub (2) and provided with a rim (10) designed to co-operate with a belt; a dynamic damper (4) comprising an inertial ring (20) fitted to the hub (2) via an elastic ring (21); and a spiral spring (35) having an external end portion (36) co-operating by friction with the rim (10) and an internal end portion (36) rigidly fixed to the inertial ring (20).

WO 2006/070422 A1

"A PULLEY ASSEMBLY"

TECHNICAL FIELD

The present invention relates to a pulley assembly, particularly for a drive belt designed to connect a plurality of accessory members to an engine shaft of an internal-combustion engine.

BACKGROUND ART

There are known pulley assemblies that comprise: a hub designed to be rigidly connected to a driving member, for example the engine shaft of an internal-combustion engine; a pulley coaxial to the hub and designed to co-operate with a drive belt; and a first elastically deformable connection element, interposed between the hub and the pulley, with the function of elastic coupling for the purpose of filtering the transmission of the torsional oscillations between the hub and the pulley.

Pulley assemblies of the type described briefly above are used in the automotive field for belt driving of auxiliary members of motor-vehicle engines, such as for example the alternator, the pump for the cooling water or for a hydraulic-steering system, or the compressor of a conditioning system.

Said known assemblies moreover generally comprise an integrated torsional damper, which is constituted by an annular inertial element coaxial to the hub, or inertial ring, and by a second elastic connection element interposed between the hub and the inertial ring. The moment of inertia of the inertial ring and the elastic characteristic of the second elastic connection element are calibrated so as to create a "mass-spring" system designed to correct the natural dynamic behaviour of the engine shaft, and in particular to attenuate the peak of oscillations at the first natural frequency of torsional vibration, thus enabling operation without critical conditions of resonance being reached.

The elastic coupling between the hub and the pulley is necessary for filtering the transmission of the torsional oscillations of the engine shaft to the accessories, and for absorbing instantaneous differences of speed of rotation in particular operating conditions, such as, for example, starting and sharp decelerations of the engine, in which, on account of the high levels of inertia of the driven members, in particular of the alternator, the pulley tends to overshoot the hub.

According to a first known embodiment, the elastic coupling is constituted by a ring made of elastomeric material interposed radially or axially between the hub and the pulley and fixed to both, for example by vulcanizing. For the purpose of performing effectively the function of "filter" referred to above, the elastomeric material must have a low stiffness. The component is consequently critical both from the mechanical standpoint, in so far as the high deformability of the material is in contrast with the requisites of high mechanical resistance that must be respected for transmitting the required torques, and, and above all, from the thermal standpoint. From this point of view, in fact, it is impossible to bestow upon the material characteristics of resistance to high temperatures.

In an attempt to overcome the problems referred to above, there have been proposed solutions in which the elastic coupling is constituted by one or more springs as a substitute for the ring made of elastomeric material.

EP-A-1 279 807 illustrates a pulley assembly in which the hub is fitted to the pulley by means of at least one spiral spring constrained in such a way as to work in compression when the hub drives the pulley. In this way, the stiffness of the elastic coupling is maintained substantially constant in the range of values of torque necessary for driving the accessories, and for higher values of torque it increases until a substantially rigid behaviour is obtained when the coils of the spring come into contact outwards. When, instead, the pulley tends to rotate faster than the hub, the coupling uncouples the pulley from the hub.

Even though this solution overcomes the drawbacks referred to previously, it is not without problems.

In the first place, the use of a spiral spring instead of a ring made of elastomeric material increases considerably the total weight of the pulley assembly; moreover, the weight and the cost of the pulley assembly are high because the use of the spring, which is already relatively costly in itself, leads to a more complex structure of the pulley assembly, with a larger number of components as compared to a traditional solution with the ring made of elastomeric material.

DISCLOSURE OF INVENTION

The purpose of the present invention is to provide a pulley assembly which is free from the drawbacks linked to the known assemblies and specified above.

The aforesaid purpose is achieved by the present invention in so far as it relates to a pulley assembly for a belt drive, particularly for an internal-combustion engine, which comprises: a hub designed to be constrained to a rotating member and to rotate therewith about its own axis; a pulley coaxial to the hub and provided with a rim designed to co-operate with a belt; at least one spiral spring interposed between said hub and said pulley for coupling rotationally said pulley to said hub; and a dynamic damper of torsional vibrations comprising an inertial ring coaxial to the hub and a ring made of elastomeric material interposed between said hub and said inertial ring, said pulley assembly being characterized in that said spiral spring has a first end portion constrained to said inertial ring and a second end portion constrained to said pulley.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention there are described in what follows three preferred embodiments, provided purely by way of non-limiting examples and with reference to the attached drawings, in which:

Figure 1 is a partial axial cross-sectional view of a pulley assembly according to a first embodiment of the present invention;

Figure 2 is a schematic cross-sectional view according to the line II-II;

Figure 3 is a graph that illustrates the characteristic torque/angle of relative rotation of an elastic coupling forming part of the pulley assembly of Figures 1 and 2;

Figure 4 is a partial axial cross-sectional view of a second embodiment of the present invention;

Figure 5 is an axial cross-sectional view of a third embodiment of a pulley assembly according to the invention; and

Figure 6 is a cross-sectional view according to the line VI-VI in Figure 5, with parts omitted for reasons of clarity.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference to Figure 1, designated as a whole by 1 is a pulley assembly according to the present invention.

The pulley assembly 1 basically comprises: a hub 2 of axis A, designed to be rigidly fixed on an engine shaft (not illustrated) of an internal-combustion engine; a pulley 3 coaxial to the hub 2; and a dynamic damper 4 carried by the hub itself.

The hub 2 is conveniently made of sheet metal and comprises integrally a flange 6, provided with holes 7 for fixing to the engine shaft, and an external cylindrical wall 8, which extends axially from the flange 6 on the opposite side of the side of the flange 6 designed to co-operate with the engine shaft.

The pulley 3, which is conveniently of the type with multiple races or poly-V type, is conveniently made of sheet metal by means of successive pressing and rolling or flowforming operations and integrally comprises: a substantially cylindrical rim 10, defining, on an external surface thereof, a plurality of races 11; and a disk 12, which extends integrally inwards from one axial end of the rim 10 facing the opposite side of the flange 6 of the hub.

More in particular, the disk 12 comprises: a plane external annular flange 13 integral with the rim 10; an intermediate cylindrical wall 14, internally coaxial to the cylindrical wall 8 of the hub 2; and an internal flange 15 facing the flange 6 of the hub 2.

The pulley 3 is supported radially with respect to the hub 2 via a bushing 17, conveniently made of anti-friction material, interposed radially between the wall 14 of the pulley 3 and the cylindrical wall 8 of the hub 2.

The dynamic damper 4 comprises an inertial ring 20 and an elastic ring 21 made of elastomeric material for connection of the inertial ring 20 to the hub 2. More in particular, the inertial ring 20 comprises a tubular wall 22 mounted on the cylindrical wall 8 of the hub 2 with interposition of the elastic ring 21, and a plane annular wall 23, which extends radially outwards from one axial end of the cylindrical wall 22 set on the side of the flange 6 of the hub 2. Conveniently, the elastic ring 21 is mounted between the cylindrical wall 8 of the hub 2 and the inertial ring 20 via radial force fitting.

The wall 23 extends radially outwards as far as in the proximity of a terminal edge 25 of the rim 10 of the pulley 3, and has an outer annular edge 24 shaped so as to reproduce the shape of said edge 25 and form therewith a passage 26 of minimum width substantially defining a labyrinth seal. The walls 22, 23 of the inertial ring 20, the rim 10, and the flange 13 of the pulley 3 delimit between them an annular cavity 27 substantially closed outwards thanks to the aforesaid labyrinth seal.

The pulley 3 is supported axially with respect to the hub 2 via a pair of rings 28, 29 conveniently made of plastic material. The ring 28 is axially interposed between the flange 13 of the pulley 3 and a front surface of the ensemble defined by the wall 8 of the hub 2 and by the elastic ring 21. The ring 29 is axially interposed between the internal flange 15 of the pulley 3 and an outer perimetral edge 31 of a disk 30 of arrest fixed to the flange 6 of the hub, for example via welding or riveting (not illustrated).

The disk 30 is provided with fixing holes 32 aligned axially to the holes 7 of the hub, for fixing to the engine shaft.

On the basis of the foregoing, the axial position of the pulley 3, and hence of the races 11, is uniquely defined in the two directions thanks to the resting of the flange 13 against the ring 28 and to the resting of the internal flange 15 against the ring 29.

According to the present invention, the pulley 3 is connected to the inertial ring 20 via a spiral spring 35. The spring 35 is housed in the cavity 27 and comprises an internal end portion 36 rigidly fixed to the tubular wall 22 of the inertial ring 20, and an external end portion 37 constrained to the rim 10 of the pulley 3 (see Figure 2). The direction of winding of the spring 35 is such that the spring itself is subject to a combined bending/compression stress in the normal torque transmission direction by the engine shaft to the accessories (in what follows defined as "positive torque"), and of bending/tension in the direction of transmission of the opposite torque, i.e., when the engine shaft tends to be driven by the accessories ("negative torque"). Basically (Figure 2), the spiral of the spring 35 has an increasing radius proceeding along the spring itself in the direction corresponding to the direction of rotation of the engine shaft (normally clockwise, if the engine shaft is viewed from the front end of the engine). The spring 35 has conveniently more than one turn.

The connection between the spring 35 and the inertial ring 20 is conveniently obtained by means of radial force fitting of the internal end portion 36 on the tubular wall 22 of the inertial ring 20. In order to reduce the level of interference necessary for transmitting the maximum torque in the positive direction, there is conveniently provided a unidirectional arrest between the spring 35 and the inertial ring 20, preferably defined by a contrast element 38 made on the tubular wall 22 of the inertial ring 20 and by an internal end

39 of the spring 35.

Preferably, as illustrated in the enlarged detail of Figure 2, the end 39 is bent inwards and engages a seat 40 made on the tubular wall 22 of the inertial ring 20. The end portion 39 has an end surface 41 and an internal surface 42 forming between them an acute angle, for example of approximately 75°. The seat 40 has a bottom surface 43 inclined accordingly with respect to the internal surface 42 of the end 39 of the spring 35, and a substantially radial side defining the contrast element 38 and forming with the bottom surface 43 an acute angle corresponding to that of the end 39 of the spring 35. The complementary shapes, with acute angle, of the end 39 of the spring and of the seat 40 eliminate the risks of disengagement when the internal end portion 36 of the spring 35 tends to unwind with respect to the wall 22.

The connection by friction between the spring 35 and the pulley 3 is conveniently obtained by means of radial force fitting between the external end portion 37 and an internal surface of the rim 10. Said force fitting is determined in such a way as to define a maximum value of transmissible torque when the pulley 3 tends to drive the inertial ring (negative torque).

Operation of the pulley assembly 1 is described in what follows.

The hub 2 of the pulley assembly 1 is in use fixed to the engine shaft of the engine and rotates fixedly therewith.

The pulley 3 is connected elastically via the spring 35 to the inertial ring 20, which is in turn connected to the hub 2 by means of the elastic ring 21. The torque between the inertial ring 20 and the pulley 3 is transmitted through the spring 35, which basically constitutes an elastic coupling. By appropriately choosing the stiffness (in a torsional sense) of the spring 35, it is possible to "filter" the torsional oscillations between the hub 2 and the pulley 3.

The behaviour of the elastic coupling is asymmetrical in the two directions of transmission of the torque. Figure 3 illustrates the characteristic: differential angle of rotation ($\Delta\theta$)/torque (C). For positive torques, the behaviour is substantially linear, with a tendency towards an increase of the stiffness for high torque values, without any sliding: in fact, as the torque increases, the arc of coupling between the external end portion 37 of the spring 35 and the rim 10 tends to increase; nor can there occur any sliding between the internal end portion 36 of the spring 35 and the inertial ring 20 on account of the positive constraint defined by the contrast element 38.

For negative torques, the behaviour of the coupling is linear until the maximum transmissible torque is reached, this being defined by the sliding of the external end portion 37 of the spring 35 with respect to the rim 10 of the pulley. The maximum transmissible torque can be substantially smaller, in absolute value, than the values of positive torque transmitted since, for negative torques, the spring 35 tends to contract radially, and consequently both the amplitude of the arc of engagement between the external end portion 37 and the rim 10 and the contact pressure are reduced.

The dynamic damper 4 alters, in a way in itself known, the vibrational behaviour of the engine shaft. In particular, by choosing the inertia of the inertial ring 20 so as to obtain a system that is resonant at a frequency close to the first natural frequency of torsional oscillation of the engine shaft, which is assumed as being without the damper 4, it is possible to attenuate the peak of amplitude of oscillation of the engine shaft at said frequency.

According to the present invention, since the internal end portion 36 of the spring 35 is forced on the inertial ring 20, it forms with the latter an "equivalent inertial ring" of mass equal to the sum of the mass of the inertial ring proper and of the aforesaid end portion 36 of the spring 35. Consequently, for the purposes of the dynamic behaviour of the damper 4, it is possible to obtain equivalent results using an inertial ring 20 of reduced mass, thus reducing the overall weight of the pulley assembly.

In addition to the reduction in weight that derives from the possibility of lightening the inertial ring 20, the present invention enables other advantages to be obtained. Since the internal end portion 36 of the spring 35 is constrained to the inertial ring 20, it is not necessary to provide a dedicated component for the purpose. Deriving therefrom is a reduction in the overall number of components of the pulley assembly 1 and hence in the cost and the weight of the assembly. Furthermore, since the external end 37 of the spring 35 is constrained to the rim 10 of the pulley 3, it is not necessary for the pulley 3 to be provided with an intermediate cylindrical wall dedicated for the purpose, and its structure can be simplified. The pulley 3 can consequently be easily produced with conventional operations of pressing and rolling or fluoride formation, with further reduction in the production costs.

Figure 4 illustrates a variant of the pulley assembly of Figure 1.

The pulley assembly of Figure 4, designated as a whole by 45, is altogether similar to the assembly 1 described and consequently is not described in detail. The only difference lies in the fact that the assembly constituted by the pulley 3, the spring 35, and the inertial ring 20 is mounted axially reversed on the hub 2, so that the wall 23 of the inertial ring 20 is located on the opposite side of the engine with respect to the pulley 3. With this arrangement it is possible to reduce the distance between the plane P of mounting of the assembly 45 on the engine shaft and the races 11, and thus limit to the minimum the encumbrance of the drive belt for driving the accessories on the front side of the engine.

To enable reversed mounting of the pulley 3, the hub 2 has a modified shape, and the arrest disk 30 is mounted on the opposite side of the hub 2, i.e., on the side of the engine shaft which it contacts in use.

Figures 5 and 6 illustrate a further embodiment of the present invention, designated as a whole by the number 50.

The pulley assembly 50 differs from the assembly 1 previously described substantially in that, instead of a single spring, three springs 35 are used in parallel to one another, each of which has an internal end 39, constrained in a built-in way to the inertial ring 20, and an external end portion 37, constrained to the rim 10 of the pulley 3 (see Figure 6). Each spring 35 is open, i.e., it extends for less than one complete turn.

More in particular, the internal end 39 of each spring 35 is conveniently bent inwards substantially at 45° with respect to the tangent. Said end 39 is drive-fitted in a corresponding cut 51 made on a respective radial projection 52 of the tubular wall 22 of the inertial ring 20. The radial projections 52 for anchoring of the three springs 35 are spaced at equal angular distances apart from one another of 120° on the tubular wall 22 of the inertial ring 20.

Conveniently, for manufacturing reasons, the cuts 51 extend also through the plane annular wall 23 of the inertial ring, i.e., they are axially through cuts.

The connection by friction between each of the springs 35 and the pulley 3 is obtained by means of radial force fitting between the external end portion 37 of each spring and the internal surface 44 of the rim 10 of the pulley 3. Said force fitting is determined so as to define a maximum value of transmissible torque when the pulley 3 tends to pull the inertial ring (negative torque).

As may be clearly seen from Figure 6, the internal surface 44 of the rim 10 of the pulley 3 is generally cylindrical with axis A but has three flats 53 parallel to the axis A of the pulley and spaced at equal angular distances apart from one another. Consequently, in cross section the surface 44 presents as a circumference interrupted by three equally spaced chords. Each chord forms with each of the tangents to the circumference at its end points respective angles α, of amplitude preferably greater than the angle of friction between the materials constituting the springs 35 and the pulley 3, for example approximately 15° or more.

Finally, said wall 44 has three areas 55 in slight relief located in the proximity of the respective cuts 51 and on which there rest axially respective portions 56 of the springs 35 immediately adjacent to the internal ends 39. For the rest of their length, the springs 35 are axially free.

The operation of the pulley assembly 50 is substantially the same as that of the pulley assembly 1 and consequently is not described in detail. Also in this case the characteristic differential angle of rotation ($\Delta\theta$)/torque (C) is asymmetrical, of the type of the one illustrated in Figure 3.

The flats 53 of the internal surface 44 of the rim 10 of the pulley 3 basically have a safety function, in order to prevent any possible sliding between the springs 35 and the pulley 3 for positive values of the transmitted torque. In fact, any possible sliding between the springs 35 and the pulley 3 would bring the ends 37 of the springs themselves to co-operate with the respective plane stretches 54. If the angle α is greater than the angle of friction between the respective materials in contact, there is obtained a secure adhesion by friction of the ends 37 of the spring 35 to the pulley 3.

As compared to the embodiments that use a single spring as described previously, the same characteristics of resistance and flexibility of a single relatively long and thick spring are obtained with three shorter and thinner springs, each of which has a smaller mass and transmits one third of the load. This enables, given the same dynamic behaviour, the following further advantages to be obtained:

- anchoring of the springs 35 on the inertial ring 20 is facilitated, both because the built-in joint of each spring 35 is subjected to less stress and because the tolerances of fabrication of the springs are more precise, and there is hence a smaller dispersion of the values of interference as compared to that of design;
- the deformations of the springs 35 due to centrifugal force

are smaller thanks to the reduction in the mass of each spring;

- the load exerted by the three springs 35 on the pulley is balanced, which enables reduction of the length of the external end portion 37 of the springs 35 co-operating with the pulley 3; and
- the cost of the springs 35 is lower than that of a single thicker spring, both on account of the saving in material resulting from what has been described in the previous point and on account of the fact that a spring of large thickness requires thermal treatment after being formed, whereas thin springs can be obtained starting from raw material already treated.

Finally, it is clear that modifications and variations can be made to the assemblies 1, 45 and 50 built according to the present invention, without thereby departing from the sphere of protection defined in the annexed claims.

CLAIMS

1. A pulley assembly for a belt drive, particularly for an internal-combustion engine, comprising: a hub (2) designed to be constrained to a rotating member and to rotate therewith about its own axis; a pulley (3) coaxial to the hub (2) and provided with a rim (10) designed to co-operate with a belt; at least one spiral spring (35) interposed between said hub (2) and said pulley (3) for coupling rotationally said pulley (3) to said hub (2); and a dynamic damper (4) of torsional vibrations comprising an inertial ring (20) coaxial to the hub (2) and a ring (21) of elastomeric material interposed between said hub (2) and said inertial ring (20), the assembly being characterized in that said spiral spring (35) has a first end portion (36, 39) constrained to said inertial ring (20) and a second end portion (37) constrained to said pulley (3).

2. The assembly according to Claim 1, characterized in that said inertial ring (20) is at least partially housed within said rim (10) of said pulley (3), said first end portion (36) of said spring (35) being an internal end portion (36, 39) constrained to said inertial ring (20), said second end portion (37) of the spring (35) being an external end portion (37) constrained to said rim (10) of said pulley (3).

3. The assembly according to Claim 2, characterized in that said internal end portion (36) of said spring (35) is rigidly fixed to said inertial ring (20).

4. The assembly according to Claim 3, characterized in that said internal end portion (36) of said spring (35) is forced on said inertial ring (20).

5. The assembly according to Claim 3 or Claim 4, characterized by comprising stop means (38, 39) between said internal end portion (36) of said spring (35) and said inertial ring (20).

6. The assembly according to Claim 5, characterized in that said stop means (38, 39) are active in the torque transmission direction in which the inertial ring (20) drives

the pulley (3).

7. The assembly according to Claim 3, characterized in that said spring has an internal end (39) bent inwards and forced in a seat (38, 51) of said inertial ring (20).

8. The assembly according to Claim 7, characterized in that said seat is a cut (51), in which said internal end (39) of said spring (35) is drive-fitted.

9. The assembly according to any one of the preceding claims, characterized in that said spring (35) is subject to a bending/compression stress in the torque transmission direction in which the inertial ring (20) drives the pulley (3).

10. The assembly according to any one of Claims 2 to 9, characterized in that said external end portion (37) of said spring (35) is constrained to said rim (10) of said pulley (3) by means of a friction fit.

11. The assembly according to Claim 10, characterized in that said friction fit between said external end portion (37) of said spring (35) and said rim (10) of said pulley (3) defines a maximum value of transmissible torque in a torque transmission direction in which the pulley (3) tends to drive the inertial ring (20).

12. The assembly according to any one of Claims 2 to 11, characterized in that said inertial ring (20) comprises a plane wall (23), which extends radially from said tubular wall (22) of said inertial ring (20) as far as in the proximity of said rim (10) of said pulley (3), said pulley (3) and said inertial ring (20) delimiting a substantially closed annular cavity in which said spring (35) is housed.

13. The assembly according to Claim 12, characterized in that said plane wall (23) defines with said rim (10) a labyrinth seal.

14. The assembly according to any one of the preceding claims, characterized by comprising a plurality of spiral springs (35) constrained in parallel to one another to said inertial ring (20) and to said pulley (3).

15. The assembly according to any one of the preceding claims, characterized in that said pulley (3) comprises a generally cylindrical internal surface (44) having a plurality of internal projections (54) designed to co-operate with respective external end portions (37) of the respective spiral springs (35) in the event of sliding under a torque of positive value.

16. The assembly according to Claim 15, characterized in that said projections are flats (44) parallel to the axis (A) of said pulley (3).

17. The assembly according to Claim 14 or Claim 15, characterized by comprising three springs (35) spaced at equal angular distances apart from one another.

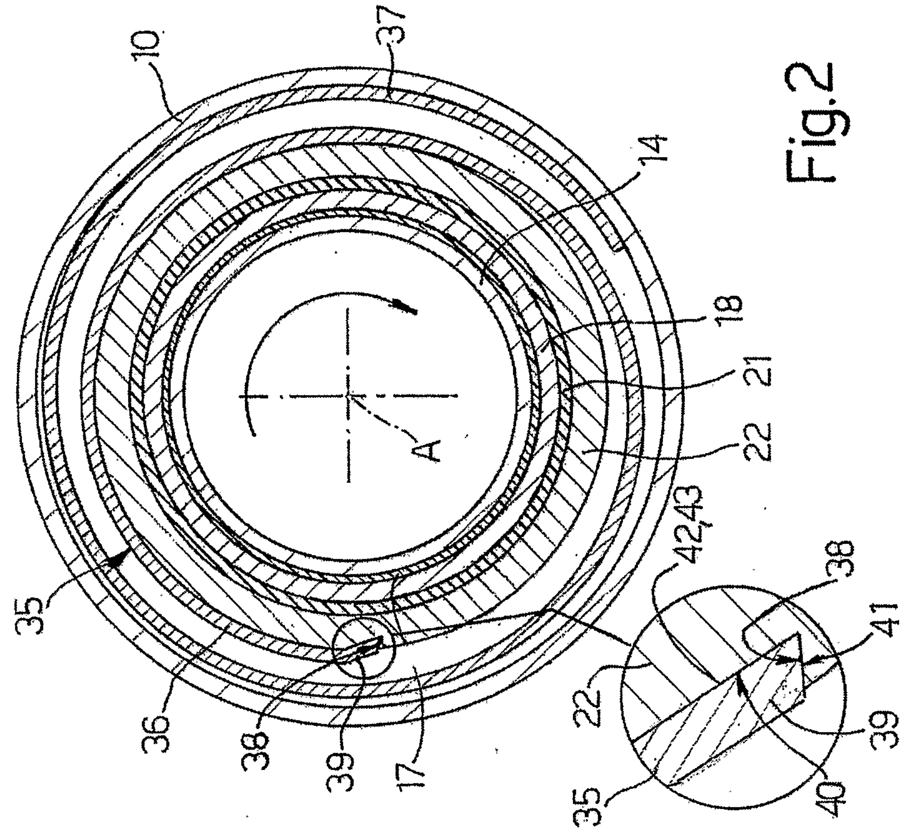

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Fig.2

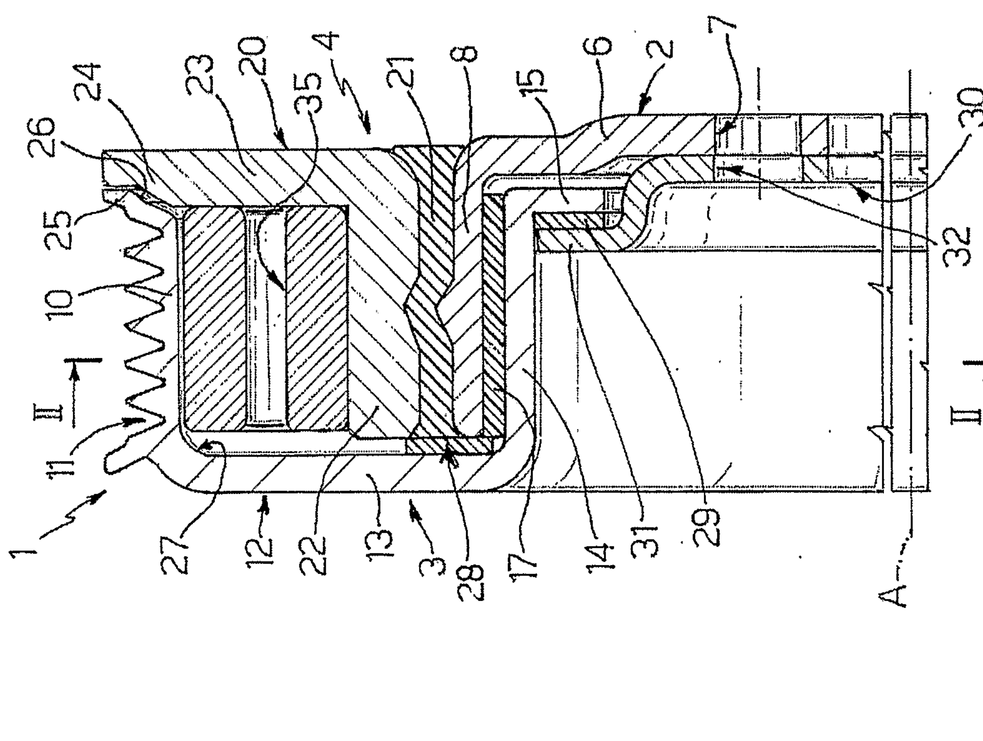
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Fig.1

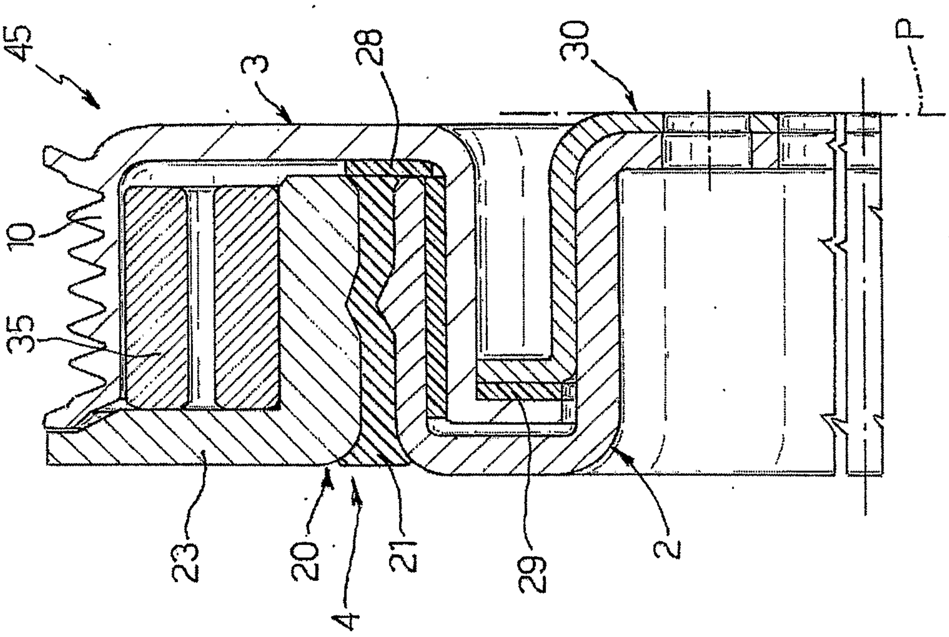

Fig.4

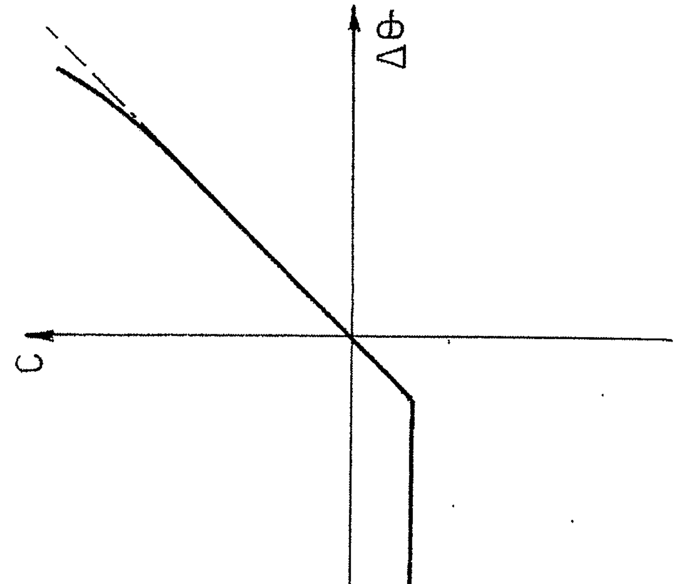

Fig.3

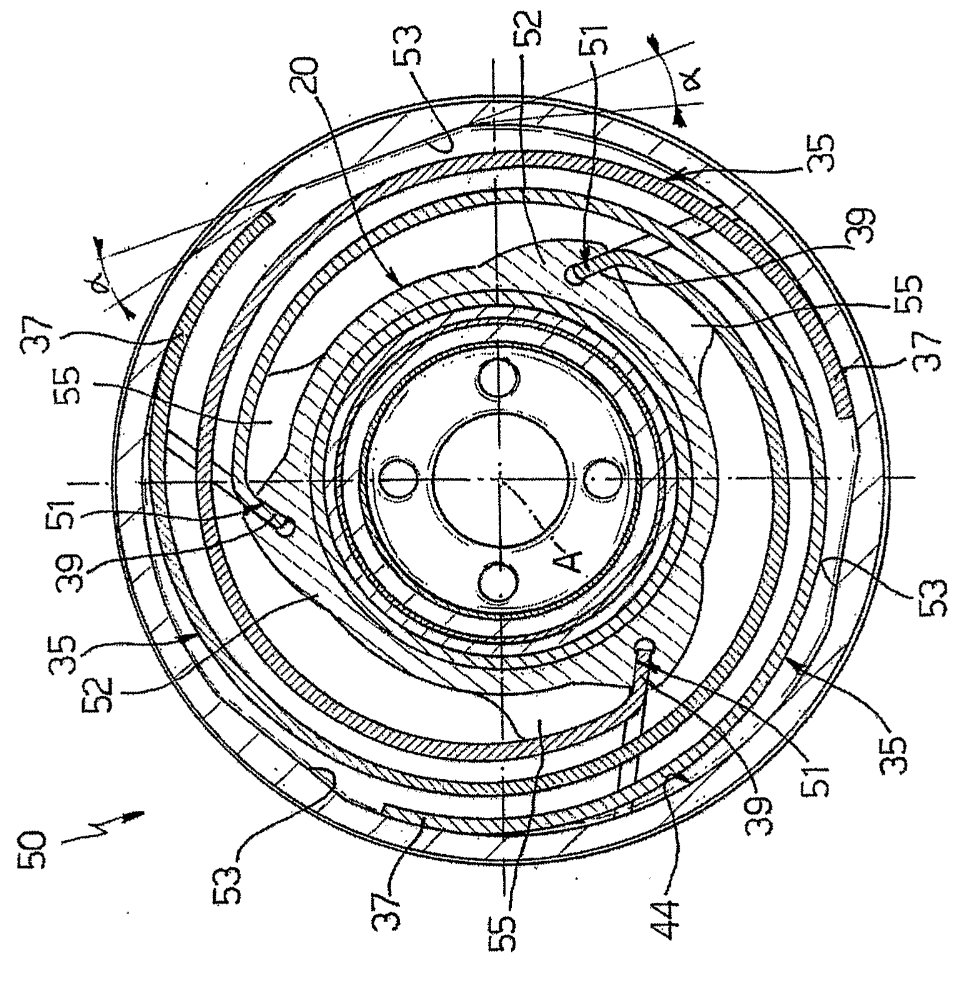
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Fig 6

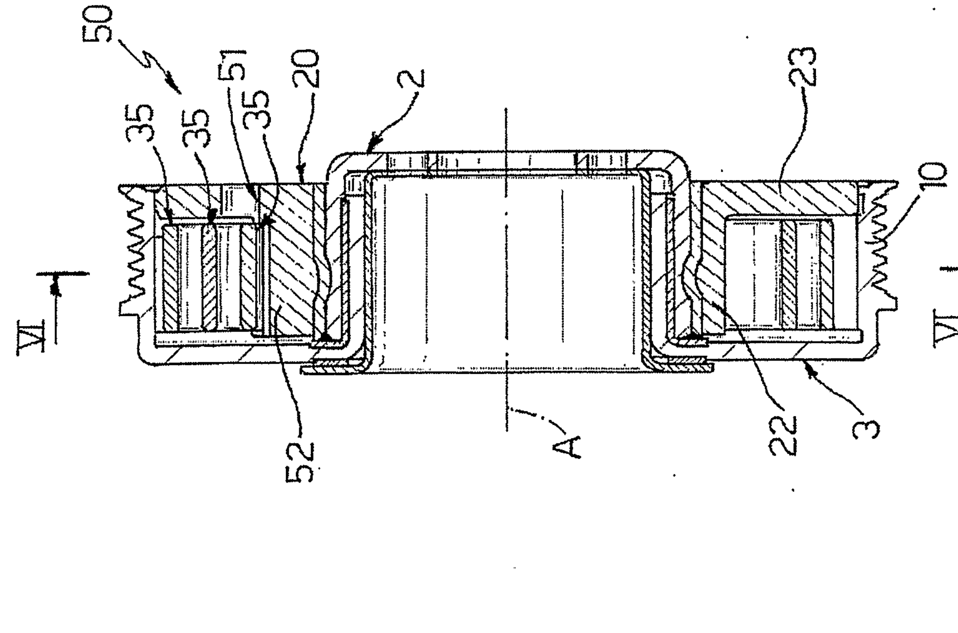
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Fig 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT2005/000152

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16F15/121 F16F15/126

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☐ Further documents are listed in the continuation of box C.

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3 August 2005	16/08/2005

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