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United States Patent	12385560
Kind Code	B2
Date of Patent	August 12, 2025
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Filtering pulley

Abstract

A filtering pulley for an accessory transmission of an internal combustion engine has a hub, a crown, a filtering unit for transmitting the torque that is interposed between the hub and the crown, a torsion spring, a carrier, and a torque limiting joint. The torque limiting joint has an open-loop strip spring and is configured to slide with respect to a surface of the crown when the torque transmitted between the crown and the hub reaches a predetermined level.

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Appl. No.: **18/699413**

Filed (or PCT Filed): **October 05, 2022**

PCT No.: **PCT/IB2022/059491**

PCT Pub. No.: **WO2023/057913**

PCT Pub. Date: April 13, 2023

Prior Publication Data

Document Identifier	Publication Date
US 20240410459 A1	Dec. 12, 2024

Foreign Application Priority Data

IT	102021000025901	Oct. 08, 2021

Publication Classification

Int. Cl.: **F16H55/36** (20060101); **F16F15/123** (20060101)

U.S. Cl.:

CPC **F16H55/36** (20130101); **F16F15/1232** (20130101); F16F2236/08 (20130101); F16H2055/366 (20130101)

Field of Classification Search

CPC: F16H (55/36); F16H (2055/366); F16H (2055/306); F16F (15/1232)

USPC: 474/70; 474/94

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) The present invention is filed under 35 U.S.C. § 371 as the U.S. National Phase of International Patent Application No. PCT/IB2022/059491, filed Oct. 10, 2022, which designated the United States and which claims the benefit of Italian Patent Application No. 102021000025901, filed on Oct. 8, 2021, the entire disclosure of which is incorporated herein by reference.

TECHNICAL SECTOR

(2) This invention relates to a filtering pulley, in particular for a belt transmission of an internal combustion engine of a motor vehicle.

(3) The preferred application of this invention, though not the exclusive one, is in the drive pulley of an alternator of an internal combustion engine. Reference will be made to this application below by way of example, it being, nonetheless, clear that the invention's pulley may be used as a driving pulley connected to the engine shaft or as a driven pulley for driving any other accessory of the engine itself, for example a reversible electric motor with the function of generator and motor.

PRIOR ART

(4) In motor vehicles the use of a filtering pulley is known for driving the alternator using the accessory transmission belt.

(5) This pulley comprises a hub designed to be connected to the rotor of the alternator, an annular crown provided with a profile designed to cooperate with the belt, and a filtering unit interposed between the hub and the crown of the pulley in order to avoid subjecting the belt to dynamic overloads when there are torsion vibrations of the engine shaft or quick changes in speed of the engine itself.

(6) The filtering unit generally comprises a spring, for example a helical or spiral spring, or multiple springs or other elastic elements arranged circumferentially between the hub and the crown.

(7) Since the alternator has a relatively high equivalent inertia and tends to drive the pulley when there are instantaneous speed reductions of the engine shaft, it is known to incorporate, in the filtering unit, a free wheel designed to transmit, in one direction, the motion of the crown to the hub (normal operating condition) but to decouple the hub from the crown if the torque is reversed.

(8) The introduction of start-stop systems in which a reversible electric motor that has the function of a drive motor or alternator, depending on the operating conditions, is used makes it impossible to use a filtering pulley with a free wheel since this would decouple the electric motor, when driving, from the belt transmission.

(9) To resolve this problem, solutions have been proposed in which the filtering unit comprises a spring attached at its ends to respective elements respectively coupled to the hub and to the pulley with relative freedom of rotation of a predetermined width.

(10) An example of a known solution to this problem is illustrated in WO 2015/198277 A1. In any case, this solution is not optimised enough to ensure the desired technical performance. Moreover, this solution is radially and axially bulky.

(11) There is, therefore, a need to provide a filtering pulley that can be used both in a start-stop system and in a conventional transmission system, which resolves the problems of the known filtering pulleys described above.

(12) Another purpose of this invention is to produce a filtering pulley, which is both compact and

inexpensive to manufacture.

SUMMARY OF THE INVENTION

(13) The above-mentioned purpose is achieved with a pulley for an accessory transmission of an internal combustion engine that has a hub, an annular crown provided with a profile configured to cooperate with a transmission belt, which is externally coaxial around an axis to the hub and is supported in free rotational motion on the hub itself, a filtering unit for transmitting the torque interposed between the hub and the crown, a torsion spring, a carrier, and a torque limiting joint. The carrier cooperates by sliding with respect to a portion integral with one of the hub and the crown. The carrier defines a spring holder and a projection extending along the axis that is configured to cooperate with the torque limiting joint. The torsion spring is operatively interposed between the carrier and one of the hub and crown and is provided with two ends cooperating in contact with respective spring holders integral with the carrier and one of the hub and crown. The torque limiting joint is coupled by interference on one surface of the other of the hub and crown. The torque limiting joint is an open loop strip spring that is configured to slide with respect to the surface when the torque transmitted between the crown and the hub reaches a predetermined level. The strip spring defines a pair of axial projections configured to cooperate selectively circumferentially in contact with, respectively, at least one axial projection integral with the hub and at least one projection axial integral with the carrier.

(14) Additional, preferred embodiments of the invention are constructed according to the following:

(15) The axial projection carried by the hub defines a seat within which the axial projection can move circumferentially. The seat extends angularly by an angle (B) included between 130° and 150° or defines a seat within which the axial projection can move circumferentially. More preferably, the seat extends angularly by an angle (a) included between 35° and 45°.

(16) The limiting joint has an actuator element housed in a space circumferentially delimited between two ends of the strip spring. The actuator element can be axially dimensioned to cooperate in contact, on the one hand, with the projection of the carrier and, on the other, the projection of the hub. The actuator element is a metal lever able to expand the spring under the thrust of the projection of the carrier. One of the two ends of the strip spring defines a circumferential protuberance extending into the space and configured to cooperate in contact with the actuator element, the protuberance extending in proximity of the axial projection cooperating with the projection integral with the hub. The actuator element has a trapezoidal section, where the plan of the section is circumferential, and the thickness of the actuator element is radial. The trapezoidal section defines a pair of equal inclined lateral portions. The inclination of the inclined side portions is between 20° and 40°.

(17) In all embodiment, the portion integral with the hub can have an annular head on which a bearing is mounted to support the crown.

(18) In all embodiments, the projections can be made on a flanged portion integral with the hub. The flanged portion being sized to wrap, in part, externally the torsion spring. The pulley comprises a sliding bearing operatively interposed between the flanged portion and the crown.

(19) In all embodiments, the carrier can define a radial projection defining a spring holder for one of the two ends of the torsion spring.

(20) The pulley comprises a damping ring operatively interposed between the carrier and the portion integral with the hub, and the damping can be configured to allow the sliding of the carrier with respect to the portion. The damping ring comprises a portion radially interposed between the crown and the carrier and a portion interposed between the carrier and the portion integral with the hub.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) To better understand this invention a preferred embodiment is described below, by way of non-limiting example and with reference to the attached drawings, in which:

(2) FIG. **1** is a longitudinal cross-section view of a pulley according to the invention;

(3) FIG. **2** is an exploded perspective view of the pulley in FIG. **1**;

(4) FIGS. **3** and **4** are perspective views, respectively from different angles, of the pulley in FIG. **1** with parts removed for clarity; and

(5) FIGS. **5** and **6** are perspective views of respective elements that are part of the pulley according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

(6) With reference to FIGS. **1** and **2**, a pulley **1** is illustrated that basically comprises a tubular hub **2**, a tubular crown **3** externally coaxial to the hub **2** and supported so that it is rotationally free on the latter, and a filtering unit **4** for transmitting torque operationally interposed between the hub **2** and the crown **3**. The hub **2** and the crown **3** are coaxial around a longitudinal axis A.

(7) The hub **2** is designed to be rigidly fixed to a shaft, not illustrated, of an accessory component of an internal combustion engine, for example an alternator or a reversible electric motor with the function of alternator and drive motor in a start-stop system.

(8) In particular, the hub **2** comprises a tubular cylindrical portion **2***a* defining, within, a coupling portion **2***c* with the above-mentioned shaft between a first end **2***a*′ and a second end **2***a*″ of the cylindrical portion **2***a*. The hub **2** comprises, in addition, a flanged portion **2***b* extending radially from one **2***a*″ of the end portions towards the crown **3** and provided with a radial portion **2***b*′ extending perpendicularly to the axis A and a longitudinal portion **2***b*″ extending so that it overhangs the radial portion **2***b*′ parallel to the axis A towards the other end **2***a*′ of the hub **2**.

(9) The crown **3** basically comprises an annular portion **3***a*, which has a multiple-groove profile **3***b* designed to cooperate with a poly-V belt **5** (of which a cross-section is schematically represented in FIG. **1**). The profile **3***b* is obtained on an outer surface **3**′ of the crown **3** opposite to an inner surface **3**″ cooperating with the filtering unit **4**.

(10) The crown **3** is supported on the hub **2** using rolling/sliding support means. In particular, the pulley **1** comprises a rolling bearing **6**, for example a sphere bearing, radially interposed between the crown **3** and the first end **2***a*′ of the hub **2**. In particular, the rolling bearing **6** is supported on the hub **2** via a head element **7** attached to the first end **2***a*′, due to pulley **1** assembly needs.

(11) On the other hand, the pulley **1** comprises a sliding bearing **8**, for example a ring made of low friction material, radially interposed between the crown **3** and the second end **2***a*″ of the hub **2**, i.e., between the longitudinal portion **2***b*″ and the inner surface **3**″ of the crown **3**.

(12) Between the crown **3** and the hub **2** there is, thus, a space **9** that is radially delimited between the inner surface **3**″ of the crown **3** and by the outer surface of the cylindrical portion **2***a* of the hub **2** and axially delimited between the rolling/sliding support means described above.

(13) The pulley **1** may, in addition, comprise a lid **10** configured to axially delimit one of the ends of the pulley **1** and, advantageously, configured to be housed within the crown **3**, i.e., radially cooperating in contact with the latter.

(14) The filtering unit **4** is housed in the space **9** and basically comprises a torsion spring **11**, a spring holder element **12**, said carrier below, cooperating with one end of the spring **11**, and a damping ring **13** axially interposed between the carrier and the head element **7**.

(15) The carrier **12** cooperates in contact by sliding, i.e., it axially slides in contact, with the head element **7**. Referring to FIGS. **1** and **5**, the carrier **12** is ring-shaped and defines an annular wall **12**′ coaxial to the axis A and a radial wall **12**″ extending radially towards the axis A beginning from an axial edge of the annular portion **12**′.

(16) This radial wall **12**″ is configured to cooperate by sliding with the head **7** on a first side, while on a second side opposite the previous one, it defines an inner radial protrusion **14** configured to

house a spring-stop element **15**. In particular, the spring-stop element **15** comprises an axial projection **16** extending axially along the axis A from the inner radial protrusion **14** and configured to cooperate in contact with one end of the spring **11**.
(17) The annular wall **12**′ also defines an axial projection **17** extending axially along the axis A from the axial edge of the annular portion **12**′ opposite the radial wall **12**″, the function of which will be described below. In particular, the axial projection **17** extends circumferentially around the axis A, leaving a seat **17**′ free of an angle α ranging between 35° and 45°, preferably 40°.
(18) As can be seen in FIGS. **3** to **6**, the longitudinal portion **2***b*″ of the hub **2** defines a projection **18** extending axially along the axis A, in relation to the longitudinal portion **2***b*″ towards the carrier **11**. In particular, the axial projection **18** extends circumferentially around the axis A, leaving a seat **18**′ free of an angle β ranging between 130° and 150°, preferably 140°.
(19) The spring **11** is, preferably, a helical spring with wire of a rectangular cross-section and comprising multiple coils wrapping around the axis A between the carrier **12** and the flanged portion **2***b* of the hub **2**. As mentioned above, an end portion of the spring **11** cooperates in contact with the spring holder **15** while the opposite end cooperates in contact with a respective spring holder, not visible, made in the flanged portion **2***b*. As a result, the flanged portion **2***b* is configured to externally wrap, in part, the spring **11**.
(20) The damper **13** basically comprises the annular element **19** made of polymer that has an "L"-shaped cross section and, thus, is provided with a longitudinal portion **19**′ radially interposed between the carrier **12** and the inner surface **3**″ of the crown **3** and an axial portion **19**″ axially interposed between the carrier **12** and the head **7**. The annular element **19** is coupled, by friction or by coupling with the shape, to the carrier **12** and, thus, is not integral around the axis A.
(21) The pulley **1** also comprises a torque-limiting joint **20** basically comprising a strip spring **21** (FIGS. **3** to **6**) housed in the space **9** and configured to fulfil, at the same time, the function of free wheel in both relative rotation directions between crown **3** and hub **2**. Advantageously, this free wheel effect is provided at different levels of torque that can be transmitted between hub **2** and crown **3** in one direction compared to another.
(22) In particular, the torque-limiting joint **20** is sized in order to cooperate in contact with the hub **2** and the carrier **12** in order to decouple the crown **3**. In particular, the limiting joint **21** is housed in the space **9** in contact with the inner surface **3**″ of the crown **3**.
(23) In more detail, the strip spring **21** has a basically open-ring shape with two ends **21**′, **21**″ delimiting a space **22** between them. The strip spring **21** is mounted with radial interference inside the inner radial surface **3**″ of the crown **3**, in particular in a machined area **23**. In particular, the area **23** is machined in order to define a grooved/wavy surface, of the paracentric type, with dimensions designed to enable a predetermined friction between the strip spring **21** and crown **3**.
(24) The strip spring **21** has a basically constant axial dimension across the entire circumferential extension and preferably has a rectangular cross-section.
(25) In any case, one **21**′ of the two end portions **21**″ defines at least one projection **24**, **25**, **26**. In particular, according to the embodiment described, a first projection **24** extends in a circumferential direction beginning with the end portion **21**′ towards the end portion **21**″ opposite the inside of the space **22** a second projection **25** extends axially along the axis A from an axial edge of the strip spring **21** towards the carrier **12**; and a third projection **26** extends axially along the axis A from an axial edge of the strip spring **21** towards the flanged portion **2***b* of the hub **2**.
(26) In particular, the first projection **24** extends near the third projection **26**.
(27) The second projection **25** is axially sized to cooperate in contact in the circumferential direction with the projection **17** defined by the carrier **12** while the third projection **26** is axially sized to cooperate in contact in the circumferential direction with the projection **18** defined by the hub **2**.
(28) The torque-limiting joint **20** also comprises an actuator element **27** housed in the space **22** and configured to cooperate in contact with the projections **17**, **18** to increase or decrease the opening

of the strip spring **21** when the actuator element acts with them.
(29) Advantageously, the actuator element **27** comprises a metallic lever **28** housed in the space **22** and circumferentially interposed between the end portions **21**′, **21**″ of the strip spring **21** and configured to cooperate in contact with the projection **24** and the end portion **21**″, circumferentially, and extending in the axial direction to cooperate in contact, circumferentially, with the projections **17** of the carrier **12** and **18** of the hub **2**.
(30) In particular, the lever **28** has a trapezoidal shape where the plan of the trapezoidal shape is circumferential and the thickness is radial in relation to the axis A. In particular, thus, the lever **28** comprises a central portion **28**′ with a basically rectangular shape and a pair of tapered lateral portions **28**″ that are, advantageously, equal to each other.
(31) The angle of inclination of the lateral portions **28**″ in relation to the central portion **28**′ preferably ranges between 20° and 40°, advantageously 30°.
(32) The operation of the embodiment of the pulley **1** according to the invention described above is the following.
(33) In normal conditions, i.e., when the crown **3** driven by the belt **4** drives the hub **2** and, thus, tends to overrun it (“drive mode”), the spring **21** rotates integrally with the crown **3** and the hub **2** is resistant.
(34) Imagining a starting condition wherein one of the lateral portions **28**″ of the actuator **28** is in contact with the projection **18**, the strip spring **21** will tend to move clockwise in relation to the axis A driven by the crown **3**. The actuator **28** moves inside the seat **18**′ (FIG. **5**) until (FIG. **6**) the projection **26** of the spring **21** enters into contact with the projection **18**. Starting from this condition, the lever **28** is arranged inclined since pushed tangentially between the portions **21**′, **21**″ by the thrust between the projection **17** and the opposite lateral portion **28**″. In this way, the opening thereof is increased, increasing the adherence between the latter and the inner surface of the crown **3**. During this movement, the projection **25** acts in contact with the projection **17** of the head element **7**. In this way, the spring **11** is charged with torsion and transmits torque to the hub **2** being attached to the opposite flanged portion **2***b*. If the torque transmitted by the crown **3** continues to increase, at a certain point, the strip spring **21** slides in relation to the inner surface **3**″ of the crown **3**, lacking the necessary adherence and, thus, decoupling the crown **3** and the hub **2**.
(35) If, instead, the hub **2** tends to overrun the crown **3** (“overrunning”), the spring **21** rotates integrally with the crown **3** and is resistant to the hub **2**.
(36) Imagining its being in the decoupling condition described earlier, the crown **3** will tend to rotate anticlockwise in relation to the hub **2** decoupling the lever **28** from the projection **18**. In this condition, the spring **11** will tend to discharge and the strip spring **21**, borne by the crown **3**, will continue to rotate anticlockwise driven by the projection **17** in contact with the projection **25** inside the seat **17**′. This condition continues until the lateral portion **28**″ of the lever **28** contacts the projection **17** on the other side of the seat **17** and tends to close the spring **21** that slides.
(37) If there is no lever **28**, the operation is similar and in the driving torque condition, the coupling occurs directly between the projections **17**, **18** and **25**, **26**.
(38) From the above, the advantages of a pulley **1** according to the invention are clear.
(39) In relation to the known solutions that involve the use of a free wheel, this invention equipped with a torque-limiting joint **20** makes it possible to obtain bi-directional coupling between hub and pulley, at least within a predetermined range of torques, making it possible to use the pulley in start-stop systems.
(40) In relation to the solutions described, the angular limitation function is directly performed by the appropriately sized torque-limiting joint **20**. In particular, thanks to the angular intervals a, B, which are different to each other, it is possible to optimise these values between driving torque and overrunning.
(41) In particular, the angle β is particularly reduced in order to ensure the sliding of the spring as soon as an overrun condition is detected, thus avoiding collisions that cause noise and reduce the

service life of the pulley **1**.
(42) In addition, the trapezoidal shape of the lever **28** is particularly optimised in order to ensure the opening of the spring **21** and, at the same time, enough structural resistance.
(43) In general, the filtering pulley illustrated here has small radial and axial dimensions and has a limited number of elements. Thus, it is inexpensive to manufacture and its assembly is easier.
(44) Finally, it is clear that changes may be made to the pulley **1**, and variations produced thereto, according to this invention that, in any case, do not depart from the scope of protection defined by the claims.
(45) In particular, the spring **21** could be coupled to the hub **2** instead of to the crown **3**.
(46) The lever **28**, as mentioned, may be omitted if the adherence between the spring **21** and the surface **3″** of the crown **3** (or of the hub **2**) in the “drive mode” is enough to transmit the torque required.
(47) Clearly, the angular values of the seats **17′** and **18′** may vary depending on the need of the vehicular transmission.
(48) The pulley may be used as a drive pulley on the engine shaft instead of on the alternator and may also be used on a conventional alternator or on any other accessory.

Claims

1. Filtering pulley for an accessory transmission of an internal combustion engine, comprising a hub, an annular crown provided with a profile configured to cooperate with a transmission belt, externally coaxial around an axis to said hub and supported in free rotational motion on the hub itself, and a filtering unit for transmitting the torque interposed between said hub and said crown and comprising a torsion spring, a carrier and a torque limiting joint, said carrier cooperating by sliding with respect to a portion integral with one of said hub and said crown, said carrier defining a spring holder and a projection extending along said axis and configured to cooperate with said torque limiting joint, said torsion spring being operatively interposed between said carrier and said one between said hub and said crown and being provided with two ends cooperating in contact with respective spring holders integral with said carrier and said one between said hub and said crown, said torque limiting joint being coupled by interference on one surface of the other between said crown and said hub said torque limiting joint comprising an open loop strip spring and being configured to slide with respect to said surface when the torque transmitted between said crown and said hub reaches a predetermined level, wherein said strip spring defines a pair of axial projections configured to cooperate selectively circumferentially in contact with, respectively, at least one axial projection integral with said hub and at least one projection axial integral with said carrier.
2. The pulley according to claim 1, wherein said axial projection carried by said hub defines a seat within which said axial projection can move circumferentially, said seat extending angularly by an angle included between 130° and 150°.
3. The pulley according to claim 1, wherein said axial projection carried by said carrier defines a seat within which said axial projection can move circumferentially, said seat extending angularly by an angle included between 35° and 45°.
4. The pulley according to one of claim 1, wherein said torque limiting joint comprises an actuator element housed in a space circumferentially delimited between two ends of said strip spring, said actuator element being axially dimensioned to cooperate in contact, on the one hand, with said projection of said carrier and, on the other, said projection of said hub.
5. The pulley according to claim 4, wherein said actuator element is a metal lever able to expand said spring under the thrust of said projection of said carrier.
6. The pulley according to claim 4, wherein one of said two ends of said strip spring defines a circumferential protuberance extending into said space and configured to cooperate in contact with

said actuator element, said protuberance extending in proximity of said axial projection cooperating with said projection integral with said hub.

7. The pulley according to claim 4, wherein said actuator element has a trapezoidal section, where the plan of said section is circumferential and the thickness of said actuator element is radial.

8. The pulley according to claim 7, wherein said trapezoidal section defines a pair of equal inclined lateral portions.

9. The pulley according to claim 8, wherein the inclination of said inclined side portions is between 20° and 40°.

10. The pulley according to claim 1, wherein said portion integral with said hub comprises an annular head on which a bearing is mounted to support said crown.

11. The pulley according to claim 1, wherein said projections are made on a flanged portion integral with said hub, said flanged portion being sized to wrap, in part, externally said torsion spring.

12. The pulley according to claim 11, wherein said pulley comprises a sliding bearing operatively interposed between said flanged portion and said crown.

13. The pulley according to claim 1, wherein said carrier defines a radial projection defining a spring holder for one of the two ends of said torsion spring.

14. The pulley according to claim 1, wherein said pulley comprises a damping ring operatively interposed between said carrier and said portion integral with said hub, said damping being configured to allow the sliding of said carrier with respect to said portion.

15. The pulley according to claim 14, wherein said damping ring comprises a portion radially interposed between said crown and said carrier and a portion interposed between said carrier and said portion integral with said hub.