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(54) **Title**: A CORD DRUM FOR A STARTER APPARATUS

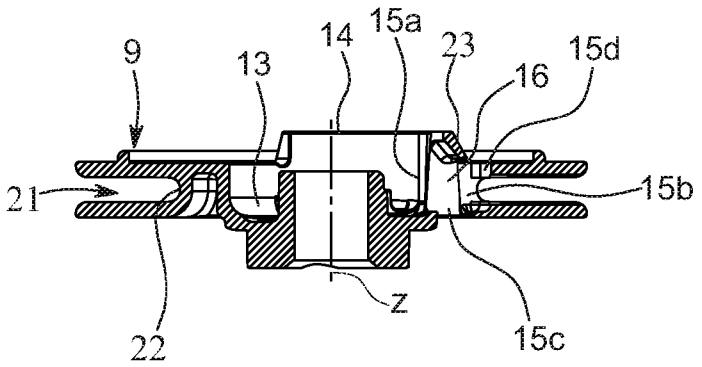

Fig. 10

(57) **Abstract**: A starter apparatus with reduced dimensions for small-sized internal combustion engines mounted on various manual work machines comprises a rotary starting cord drum (9), a rotary driver (3) adapted to operatively engage one end of the crankshaft (30) of the engine for transmitting torque thereto, and a helical torsion spring (6) connecting the cord drum (9) to the driver (3). The cord drum (9), the torsion spring (6) and the driver (3) are designed to provide a predetermined pre-tension to the spring (6) on assembling and to limit the maximum torsion created by rotating the cord drum (9) in relation to the driver (3). The cord drum (9) comprises a recess (16) for accommodating a cord knot (10') of the starting cord, and the recess (16) being mainly located radially inside a cord spool portion (21) of the cord drum (9).

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A CORD DRUM FOR A STARTER APPARATUS

DESCRIPTION

TECHNICAL FIELD

The present invention relates to a cord drum of a starter apparatus, wherein the cord drum defines an axis of rotation and is adapted for having a starting cord wound in a cord spool portion of the cord drum and the cord spool portion having an inner cord spool wall.

It also relates to a starter apparatus for an internal combustion engine, said apparatus comprising the cord drum of the preceding paragraph.

In addition, the present invention relates to a handheld power tool having the above starter apparatus.

In this context, the term "coaxial" shall be interpreted to permit minor deviations from absolute coaxiality, where such minor deviations have no effect on the desired function of the apparatus. Further, the term "annular" shall be interpreted to include also shapes where the border of the annulus is e.g. a regular polygon having e.g. five sides.

The function of the spring is to damp shocks from engine compressions, which the operator senses on pulling the starting cord. Also to some extent, the spring when tensioned will give an extra energy input at start to overcome the engine torque.

BACKGROUND ART

Such a starter apparatus is disclosed in US 6,971,359 B2 but requires a comparatively large axial building height. Further, the protection of the pre-tensioning means and the tension limiting means against dirt, for example, could be better, and the design is such that the cord knot in the cord drum may come into contact with a stopper piece provided on the driver.

SUMMARY OF THE INVENTION

It is an object of the present invention to minimize the dimensions of the starter apparatus. Other objects of the invention are to make the assembly of the starter apparatus easier and to prevent the cord knot from touching the driver.

In accordance with the present invention, at least one of these objects is achieved in that the cord drum comprises a first recess for accommodating a cord knot of the starting cord, said first recess being mainly located radially inside the cord spool portion and being connected to the cord spool portion through a first opening in the inner cord spool wall, the cord drum further comprising a bridge portion at an axial distance from a bottom portion of the first recess. This makes it possible to reduce the outer dimensions of the starter apparatus and/or increase the size of the cord knot.

Preferably the cord drum has a second recess around the axis of rotation and being mainly located radially inside of the first recess, the second recess for accommodating a torsion spring.

Preferably, a second opening connects the first recess to the second recess, and preferably at least a part of the second opening is located radially closer to the axis than the first opening. Preferably, the first and second openings at least partially face each other. This makes it easier to assemble the starter apparatus since the starting cord can easily be pushed or pulled straight through the openings without bending the cord in the area of the first recess.

Preferably, the bridge portion forms a part of an axially extending projection on a first side of the cord drum. Thus, the first recess is located under the bridge portion and also in the projection provided on said first side of the cord drum, so that the bridge portion of the projection forms a limit for the cord knot. Thereby, the cord knot is prevented from touching the driver. Such a detrimental contact may cause the cord drum and the driver to jam.

Preferably, the projection also forms a part of a pre-tensioning means and a tension limiting means. This, to optimize function, size and weight of the cord drum.

To reduce the axial dimensions down, it is preferred that the internal axial width of the cord spool portion is such, that consecutive full turns of the cord are located only radially outside one another.

In accordance with the present invention, another of these objects is achieved in that a starter apparatus for an internal combustion engine comprises in addition to the above cord drum:

a) a casing adapted to be attached to a housing enclosing the engine, said casing having a stationary shaft that is coaxial with a rotary axis of a crankshaft of the engine;

b) a rotary driver mounted on the shaft and adapted to operatively engage one end of the crankshaft for transmitting torque thereto, said driver having one side adapted to engage the crankshaft and an opposite side, the opposite side having a recess that is coaxial with the shaft;

c) said cord drum being mounted to be rotary on the shaft and coaxial with the second recess, said starting cord having a free end extending out of the casing;

d) a torsion spring made of a helically wound spring wire, said torsion spring having a first end received in the second recess of the cord drum and a first end of the spring wire attached to the cord drum and a second end received in the recess of the driver and a second end of the spring wire attached to the driver, and

e) a pre-tensioning means providing a desired pre-tension of the torsion spring and a tension limiting means limiting a tensioning of the torsion spring upon rotation of the cord drum in relation to the driver.

This makes it possible to reduce the outer dimensions of the starter apparatus and/or increase the size of the cord knot.

It is also preferred that a bottom bore is provided in the second recess of the cord drum for receiving the first end of the spring wire, said first end having an orientation so as to be retained in the bore upon tensioning of the spring.

Preferably a bore is provided also in the driver for receiving the second end of the spring wire, said second spring wire end having an orientation so as to be retained in the bore upon tensioning of the spring.

Preferably the pre-tensioning means and the tension limiting means are provided by a protrusion on said opposite side of the rotary driver and said projection of the first side of said cord drum. Each of said projection and protrusion has a front surface and a rear surface with respect to a direction of rotation, the front surface of the projection and the rear surface of the protrusion provides the desired pre-tension of the torsion spring, and the rear surface of the projection and the front surface of the protrusion limits the tensioning of the torsion spring upon rotation of the cord drum in relation to the driver. The driver preferably has an exterior wall from which the protrusion extends radially inward.

Then, the relative angular locations, relative to an axis of rotation defined by the cord drum, of the first and second ends of the helical torsion spring, the bores therefore, and the projection and the protrusion of the cord drum and the driver, respectively, are such that a complete axial assembling thereof requires a relative rotation between the cord drum and the driver, which results in a predetermined pre-tensioning of the helical torsion spring.

A minimum length of the projection on the cord drum is set by strength considerations, and the projection suitably extends over an angle of 30–270°.

Then, the projection on the cord drum and the protrusion of the driver suitably are so dimensioned relative each other that a maximum relative rotation between them is in the range of 120–320° in order to limit the tension in the helical torsion spring to a predetermined maximum level.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in more detail with reference to preferred embodiments and the appended drawings.

Fig. 1 is a cross-sectional view of a preferred embodiment of a starter apparatus according to the present invention connected to a crankshaft of an internal combustion engine.

Fig. 2 is an exploded perspective view of the starter apparatus of Fig. 1.

Fig. 3 is an exploded perspective view similar to Fig. 2 but viewed from another angle.

Fig. 4 is an exploded perspective view of part of the starter apparatus of Fig. 1 and associated components for connection to the crankshaft.

Fig. 5 is a perspective view of a driver included in the starter apparatus of Figs. 1–4.

Fig. 6 is a perspective view of the driver of Fig. 5 viewed from an opposite direction.

Fig. 7 is a perspective view of a cord drum included in the starter apparatus of Figs. 1–4.

Fig. 8 is a perspective view of the cord drum of Fig. 7 viewed from an opposite direction.

Fig. 9 is a side view of the cord drum of Figs. 7 and 8.

Fig. 10 is a cross-sectional view taken along line A–A in Fig. 9.

Fig. 11 is an enlarged sketchy cross-sectional view similar to part of Fig. 10 showing the location of the cord knot in the cord drum.

Fig. 12 is a perspective view of the cord drum similar to Fig. 7 showing a stop surface preventing the cord knot from being pulled out of its cord knot recess.

MODE(S) FOR CARRYING OUT THE INVENTION

The starter apparatus of the present invention is intended to be used for starting a small internal combustion engine of a power tool or other manual work machine. The starter apparatus shown in the figures comprises a casing **1** that is adapted to be attached by screws (not shown) to an engine housing, such as to a crankcase or a cylinder portion of the engine. The casing **1** has a cantilevered stationary shaft **2** that is coaxial with a rotary axis of the engine crankshaft **30**. At the free end of the shaft **2** a rotary driver **3**, or hub, is

mounted. A countersunk central screw **24**, shown in Figs. 1–3, prevents the driver **3** from leaving the free end of the stationary shaft **2**. As is shown in Figs.1 and 4, the driver **3** is adapted to operatively engage one end of the crankshaft **30**, more precisely a combined flywheel and fan wheel **31** for cooling air on the crankshaft **30**, for transmitting torque thereto. The cooling air is drawn in through ventilation openings in the casing **1**. A nut **32** shown in Figs. 1 and 4 keeps the flywheel **30** fixed on the crankshaft **30**. The driver **3** has teeth, best shown in Figs. 2 and 5, that cooperate with spring-loaded pawls **33**, shown in Fig. 4, on the flywheel **31** so as to permit the driver **3** to rotate the flywheel **31** in one direction but not permitting the flywheel **31** to rotate the driver **3** in the same direction.

Further, a rotary cord drum **9** is mounted on the shaft **2** and having an axis of rotation **z** coaxial with the shaft **2**, as is shown in fig. 8 and 10. The cord drum **9** and the cord spool portion **21** having an inner cord spool wall **22**. In principle, a cord drum is a hub sandwiched between two coaxial discs. As shown in Figs. 1–3, the drum **9** is adapted to hold a starting cord **10** wound around the cord spool portion **21** of the drum **9** and having a free end extending out of the casing **1** and provided with a handle **11** for an operator. A cord retracting spring **12** is mounted to rotate the cord drum **9** to retract the starting cord **10** after it has been pulled out. As is best shown in Figs. 1–3, the cord retracting spring **12** suitably is mounted in a cassette **25**, which is attached to the casing **1** by screws **26**. One end of the cord retracting spring **12** is connected to the cassette **25**, and the other end is connected to the cord drum **9**.

A torsion spring **6** made of a helically wound spring wire interconnects the driver **3** and the cord drum **9**. The driver **3** has one side adapted to engage the crankshaft **30** and an opposite side, and the opposite side has a protrusion **5**, which extends radially inward from an exterior wall **3a** of the driver **3**, and a preferably annular recess **4** that is coaxial with the shaft **2**. Similarly, one side of said cord drum **9** has a projection **14** and a preferably annular recess **13** that is coaxial with the shaft **2**. Each of the projection **14** and protrusion **5** has a front surface **14a** and **5a**, respectively, and a rear surface **14b** and **5b**, respectively, with respect to a direction of rotation. The torsion spring **6** has a helical body having a first end **7** received in the annular recess **13** of the cord drum **9** and a first end **7'** of the spring wire attached to the cord drum **9**. A second end **8** of the spring body is received in the annular recess **4** of the driver **3** and has a second end **8'** of the spring wire attached to the driver **3**.

The helical torsion spring **6** makes the starting procedure easier and more user-friendly and ergonomic for the operator. The main function of the spring **6** is to damp shocks felt for overcoming the starting resistance when pulling the starter handle **11**, but to some extent, energy stored in the torsion spring **6** will assist in overcoming engine torque. The front surface **14a** of the projection **14** and the rear surface **5b** of the protrusion **5** cooperate to maintain a desired pre-tension of the torsion spring **6**, thereby providing a pre-tensioning means. The rear surface **14b** of the projection **14** and the front surface **5a** of the protrusion **5** cooperate to limit the maximum tension of the torsion spring **6** upon rotation of the cord drum **9** in relation to the driver **3**, thereby providing a tension limiting means.

As shown in the drawings, when assembled, the projection **14** on the cord drum **9** is located inside the driver **3** and as a consequence is covered and protected against external influences, such as dirt. This also means that the protrusion **5** will be covered and protected. There is no risk of the protrusion coming in conflict with the spring-loaded pawls **33** on the flywheel **31**. Further, since the projection **14** works as a motion limiter against the driver **3**, the cord knot **10'** (shown in Fig. 11) will lie protected and cannot come into contact with the driver **3**.

To minimize the dimensions of the starter apparatus in accordance with the present invention, the first spring wire end **7'** to be attached to the cord drum **9** is straight or slightly curved and extends parallel to or forms an angle of at most 15°, preferably about 7°, with a longitudinal axis of the helical torsion spring **6**, and a bottom bore **19** is provided in the annular recess **13** of the cord drum **9** for receiving the first end **7'** of the spring wire, said possible angle having an orientation so as to retain the first spring wire end **7'** in the bore **19** upon tensioning of the spring **6**. The location of the bottom bore **19** is such that the bore extends through a shoulder **17** provided for attachment of the cord retracting spring **12** to the second side of the cord drum **9**.

Preferably, also the second spring wire end **8'** to be attached to the driver **3** is straight or slightly curved and extends parallel to or forms an angle of at most 15°, preferably about 7°, with a longitudinal axis of the helical torsion spring **6**, and a bore **20** is provided in the driver **3** for receiving the second end **8'** of the spring wire, said possible angle having an orientation so as to retain the second spring wire end **8'** in the bore **20** upon tensioning of

the spring **6**. Thereby, the assembling is facilitated. Then, the angular location of the first and second ends **7'**, **8'** of the helical torsion spring **6**, the bores **19**, **20** therefore, and the projection **14** and the protrusion **5** of the cord drum **9** and the driver **3**, respectively, is such that a complete axial assembling thereof requires a relative rotation between the cord drum **9** and the driver **3** resulting in a predetermined pre-tensioning of the helical torsion spring **6**.

The projection **14** on the cord drum **9** suitably has the general shape of an arc of a circle that is coaxial with the shaft **2**. The cord knot **10'** is accommodated in a cord knot recess **16** of the cord drum **9** being mainly located radially inside the cord spool portion **21.** The recess **16** has an inner radial opening **15a** connecting to the annular recess **13** and an outer radial opening **15b** in the cord spool wall **22** connecting to the cord spool portion **21.** The inner radial opening **15a** and the outer radial opening **15b**, at least partially face each other. The inner radial opening **15a** is large enough to let the cord knot **10'** through, whereas the outer radial opening has a size preventing the knot **10'** to be pulled through. In part, the recess **16** is located under and also in the arcuate projection **14** on the cord drum **9**, so that a bridge portion **23** of the arcuate projection **14** forms a limit for the cord knot **10'** at an axial distance from a bottom portion of the recess. Advantageously, the recess **16** is so large that also two axial additional openings **15c** and **15d** from the recess **16** are formed. A minimum length of the projection **14** is set by strength considerations, and the projection **14** extends over an angle of 30–270°. Then, the arcuate projection **14** on the cord drum **9** and the protrusion **5** of the driver **3** suitably are so dimensioned relative to each other that a maximum relative rotation between them is in the range of 120–320°, typically about 190° in order to limit the tension in the helical torsion spring **6** to a predetermined maximum level. Thus, the arcuate projection **14** on the cord drum **9** functions both as a pre-tension limiter and a maximum angular deviation limiter for the helical torsion spring **6**, whereby it is possible to use a smaller and more optimized torsion spring with comparable characteristics to the ones used in energy storing starter devices of conventional design without limiters. However, although, the spring, when tensioned, to some extent will give an extra energy input at start to overcome the engine torque, the main function of the spring is to damp shocks from engine compressions, which the operator senses on pulling the starting cord. In addition, the arcuate projection **14** forms a limiter for the cord knot **10'**, preventing the cord from jamming against the driver **3**. The facing radial openings **15a, 15b** in the cord drum **9** facilitate the attaching of the cord **10** to the drum and the making of a

knot **10'**. The knot can be made before or after the cord being drawn through the radial openings **15a, 15b**. If the knot **10'** is made in advance, the free end of the cord is pushed or drawn in the direction from the inner radial opening **15a** out through the outer radial opening **15b**. After making the knot **10'** and pulling the cord **10** to place the knot in the recess **16**, the cord can be wound around the cord drum **9** as shown in Fig. 12. This figure also shows that the recess **16** has a stop wall **16'** (marked by hatching) for preventing the knot from leaving the recess **16** on pulling the cord **10** to start the engine. According to some embodiments of the invention, a first part of the first opening **15b** is arranged in the stop wall **16'**. The stop wall **16'** and said first part of the first opening **15b** are preferably configured such that the cord **10** extends essentially straight in the area of the first opening **15b** and through the first part of the first opening **15b** when the cord **10** is wound around the spool portion **21** of the cord drum **9**. Further, the stop wall **16'** preferably has an essentially radial orientation with respect to the axis **z**, and is essentially parallel with the axis **z**. Preferably, said wall **16'** deviates less than 30° from a radial orientation with respect to the axis **z**. Such arrangement has proved favorable also for configurations with no bridge portion **23**, and/or where the second opening **15a** is optional.

The openings **15a, 15b, 15c** and **15d** further create more space for the knot in the recess **16**. This space can *e.g.* be used for a bigger knot **10'**, or to provide more radial space for a wider torsion spring, or increase the capacity of the drum. For instance, a wider torsion spring can make it possible to reduce the axial extension of the spring while maintaining the same strength, thereby enabling a reduction of the width of the starting apparatus. Thus, the illustrated embodiment provides a maximum space for the cord knot **10'**, and without providing additional material the knot is locked in all directions. Radially inward it is the helical torsion spring **6** that forms a restricting wall member, radially outward it is the edge of the upper and lower circular disk of the cord drum **9**. Upward it is the projection **14** of the cord drum, and downward it is the border of the opening in the lower disk. Consequently, the position of the cord knot **10'** is locked, so that the knot cannot come into contact with the spring cassette **25** or the driver **3**.

To reduce the axial dimension of the starter apparatus still further, the internal axial width of the cord drum **9** preferably is such, that consecutive full turns of the cord **10** are located only radially outside one another.

Whereas the invention has been shown and described in connection with the preferred embodiments thereof it will be understood that many modifications, substitutions, and additions may be made which are within the intended broad scope of the following claims. From the foregoing, it can be seen that the present invention accomplishes the stated object of the invention.

INDUSTRIAL APPLICABILITY

The cord drum and the starter apparatus of the present invention are applicable to small-sized internal combustion engines mounted on various manual work machines such as portable brush cutters, clearing saws, chainsaws, mowers, backpack brush cutters, power-operated spraying machines, power cutters, engine blowers, dusters, and hedge trimmers. It is especially useful when reduced dimensions are an advantage. Reduced dimensions also give the advantage of reduced weight, which is appreciated by operators.

CLAIMS:

1. A cord drum (**9**) for a starter apparatus, wherein the cord drum (**9**) defines an axis of rotation (**z**) and is adapted for having a starting cord (**10**) wound in a cord spool portion (**21**) of the cord drum (**9**) and the cord spool portion (**21**) having an inner cord spool wall (**22**), the cord drum (**9**) comprising a first recess (**16**) for accommodating a cord knot (**10'**) of the starting cord (**10**), said first recess (**16**) being mainly located radially inside the cord spool portion (**21**) and being connected to the cord spool portion (**21**) through a first opening (**15b**) in the inner cord spool wall (**22**), the cord drum (**9**) further comprising a bridge portion (**23**) at an axial distance from a bottom portion of the recess (**16**).

2. A cord drum (**9**) as claimed in claim 1, wherein the first side of said cord drum (**9**) has a second recess (**13**) around the axis of rotation (**z**) and being mainly located radially inside of the first recess (**16**), the second recess (**13**) for accommodating a spring (**6**), preferably a torsion spring (**6**).

3. A cord drum (**9**) as claimed in claim 2, wherein a second opening (**15a**) connects the first recess (**16**) to the second recess (**13**), and the first opening (**15b**) at least partially radially facing the second opening (**15a**).

4. A cord drum (**9**) as claimed in claim 3, wherein a part of the first opening (**15b**) is arranged in a stop wall (**16'**) of the cord drum (**9**), the stop wall (**16'**) being arranged for preventing the knot (**10'**) from leaving the first recess (**16**) on pulling the cord (**10**), wherein the stop wall (**16'**) has an essentially radial orientation relative to the axis (**z**).

5. A cord drum (**9**) as claimed in any one of claims 1-4, wherein the bridge portion (**23**) forms a part of an axially extending projection (**14**) on a first side of the cord drum (**9**).

6. A cord drum (**9**) as claimed in claim 5, wherein the projection (**14**) forms a part (**14a**) of a pre-tensioning means (**14a, 5b**) for applying a desired pre-tension to a spring (**6**) connecting the cord drum (**9**) with a rotary driver (**3**) of the starter apparatus.

7. A cord drum (**9**) as claimed in claim 5 or 6, wherein the projection (**14**) forms a part (**14b**) of tension limiting means (**14b, 5a**) for limiting tension applied to a spring (**6**) connecting the cord drum (**9**) with a rotary driver (**3**) of the starter apparatus upon rotation of the cord drum (**9**) in relation to the driver (**3**).

8. A starter apparatus as claimed in any one of claims 1-7, wherein the internal axial width of the cord spool portion (**21**) is configured such that consecutive full turns of the cord (**10**) are located only radially outside one another.

9. A starter apparatus for an internal combustion engine, said apparatus comprising in addition to a cord drum (**9**) as claimed in any one of claims 1–8:

a) a casing (**1**) adapted to be attached to a housing enclosing the engine, said casing (**1**) having a stationary shaft (**2**) that is coaxial with a rotary axis of a crankshaft (**30**) of the engine;

b) a rotary driver (**3**) mounted on the shaft (**2**) and adapted to operatively engage one end of the crankshaft (**30**) for transmitting torque thereto, said driver (**3**) having one side adapted to engage the crankshaft (**30**) and an opposite side, the opposite side having a recess (**4**) that is coaxial with the shaft (**2**);

c) said cord drum (**9**) being mounted to be rotary on the shaft (**2**) and coaxial with the second recess (**13**), said starting cord (**10**) having a free end extending out of the casing (**1**);

d) a torsion spring (**6**) made of a helically wound spring wire, said torsion spring (**6**) having a first end (**7**) received in the second recess (**13**) of the cord drum (**9**) and a first end (**7'**) of the spring wire attached to the cord drum (**9**) and a second end (**8**) of the torsion spring (**6**) received in the recess (**4**) of the driver (**3**) and a second end (**8'**) of the spring wire attached to the driver (**3**), and

e) a pre-tensioning means (**14a, 5b**) providing a desired pre-tension of the torsion spring (**6**) and a tension limiting means (**14b, 5a**) limiting a tensioning of the torsion spring (**6**) upon rotation of the cord drum (**9**) in relation to the driver (**3**).

10. A starter apparatus as claimed in claim 9, wherein a bottom bore (**19**) is provided in the second recess (**13**) of the cord drum (**9**) for receiving the first end (**7'**) of the spring wire,

said first end (**7'**) having an orientation so as to be retained in the bore (**19**) upon tensioning of the spring (**6**).

11. A starter apparatus as claimed in claim 10, wherein a bore (**20**) is provided in the driver (**3**) for receiving the second end (**8'**) of the spring wire, said second spring wire end (**8'**) having an orientation so as to be retained in the bore (**20**) upon tensioning of the spring (**6**).

12. A starter apparatus as claimed in claim 10 or 11, wherein the first spring wire end (**7'**) to be attached to the cord drum (**9**) is straight and extends parallel to or forms an angle of at most 15°, preferably 7°, with a longitudinal axis of the helical torsion spring (**6**), and preferably also the second spring wire end (**8'**) to be attached to the driver (**3**) is straight and extends parallel to or forms an angle of at most 15°, preferably 7°, with a longitudinal axis of the helical torsion spring (**6**).

13. A starter apparatus as claimed in any one of claims 9–12, wherein the pre-tensioning means (**14a, 5b**) and the tension limiting means (**14b, 5a**) are provided by a protrusion (**5**) on said opposite side of the rotary driver (**3**) and said projection (**14**) on the first side of said cord drum (**9**), and wherein each of said projection (**14**) and protrusion (**5**) has a front surface (**14a** and **5a**, respectively) and a rear surface (**14b** and **5b**, respectively) with respect to a direction of rotation, the front surface (**14a**) of the projection (**14**) and the rear surface (**5b**) of the protrusion (**5**) providing the desired pre-tension of the torsion spring (**6**), and the rear surface (**14b**) of the projection (**14**) and the front surface (**5a**) of the protrusion (**5**) limiting the tensioning of the torsion spring (**6**) upon rotation of the cord drum (**9**) in relation to the driver (**3**).

14. A starter apparatus as claimed in claim 13, wherein the driver (**3**) has an exterior wall (**3a**) from which the protrusion (**5**) extends radially inward.

15. A starter apparatus as claimed in claim 13 or 14, wherein the angular locations of the first and second ends (**7'**, **8'**) of the helical torsion spring (**6**), the bores (**19**, **20**) therefor, and the projection (**14**) and the protrusion (**5**) of the cord drum (**9**) and the driver (**3**), respectively, are such that a complete axial assembling thereof requires a relative

rotation between the cord drum (**9**) and the driver (**3**) resulting in a predetermined pre-tensioning of the helical torsion spring (**6**).

16. A starter apparatus as claimed in any one of claims 13–15, wherein the projection (**14**) on the cord drum (**9**) has the general shape of an arc of a circle that is coaxial with the shaft (**2**).

17. A starter apparatus as claimed in claim16, wherein a minimum length of the projection (**14**) is set by strength considerations, and the projection (**14**) extends over an angle of 30–270°.

18. A starter apparatus as claimed in claim 17, wherein the projection (**14**) on the cord drum (**9**) and the protrusion (**5**) of the driver (**3**) are so dimensioned relative to each other that a maximum relative rotation between them is in the range of 120–320° in order to limit the tension in the helical torsion spring (**6**) to a predetermined maximum level.

19. A starter apparatus as claimed in any one of claims 13–18, wherein the projection (**14**) on the cord drum (**9**) is located inside the driver (**3**) and covered and protected thereby.

20. A handheld power tool having a starter apparatus, characterized in that the starter apparatus is the one claimed in any one of claims 9–19.

21. A cord drum (**9**) for a starter apparatus, wherein the cord drum (**9**) defines an axis of rotation (**z**) and is adapted for having a starting cord (**10**) wound in a cord spool portion (**21**) of the cord drum (**9**) and the cord spool portion (**21**) having an inner cord spool wall (**22**), the cord drum (**9**) comprising:

-a first recess (**16**) for accommodating a cord knot (**10'**) of the starting cord (**10**), said first recess (**16**) being mainly located radially inside the cord spool portion (**21**) and being connected to the cord spool portion (**21**) through a first opening (**15b**) in the inner cord spool wall (**22**), and

-a second recess (**13**) arranged around the axis of rotation (**z**) and being mainly located radially inside of the first recess (**16**), the second recess (**13**) being configured for accommodating a torsion spring (**6**), wherein a second opening (**15a**) connects the first

recess (**16**) and the second recess (**13**), and the first opening (**15b**) at least partially radially facing the second opening (**15a**).

22. A cord drum (**9**) as claimed in claim 21, wherein the second opening (**15a**) extends through an axially extending projection (**14**), which projection (**14**) forms a part (**14a**) of a pre-tensioning means (**14a, 5b**) for applying a desired pre-tension to the spring (**6**) connecting the cord drum (**9**) with a rotary driver (**3**) of the starter apparatus.

23. A starter apparatus for starting an internal combustion engine comprising the cord drum (**9**) according to any one of the claims 21 or 22.

24. A hand-held power tool comprising the starter apparatus according to claim 23.

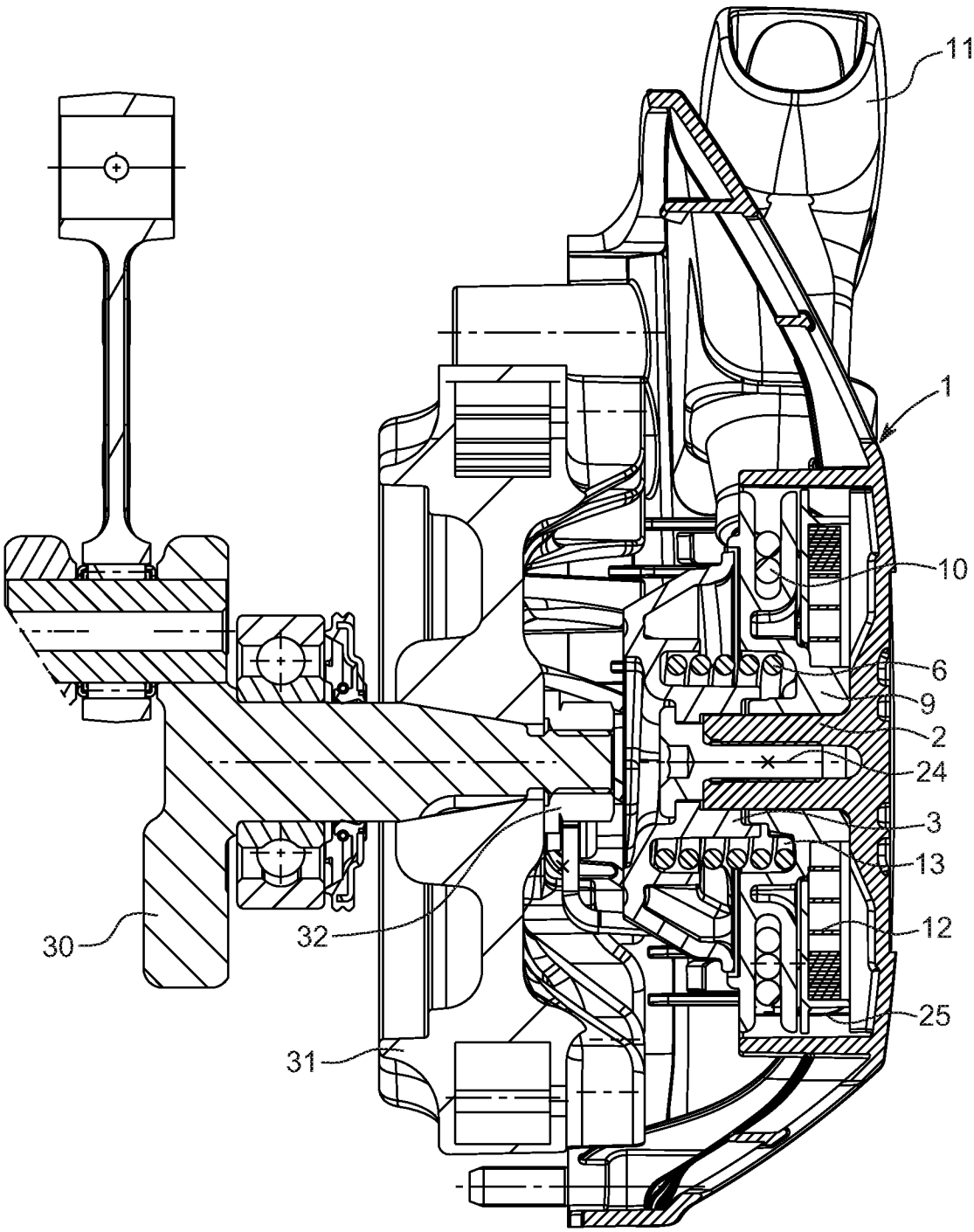

Fig. 1

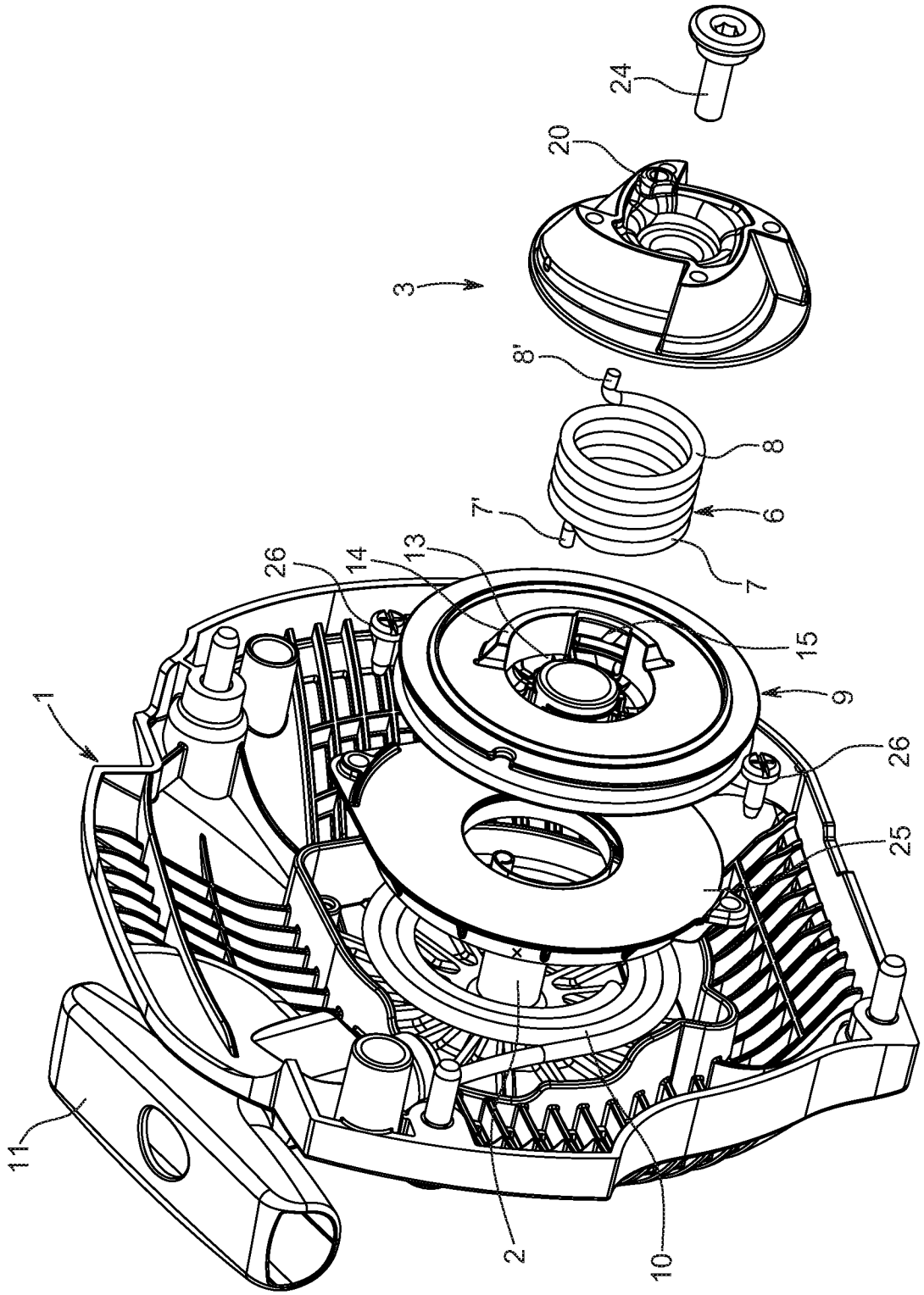

Fig. 2

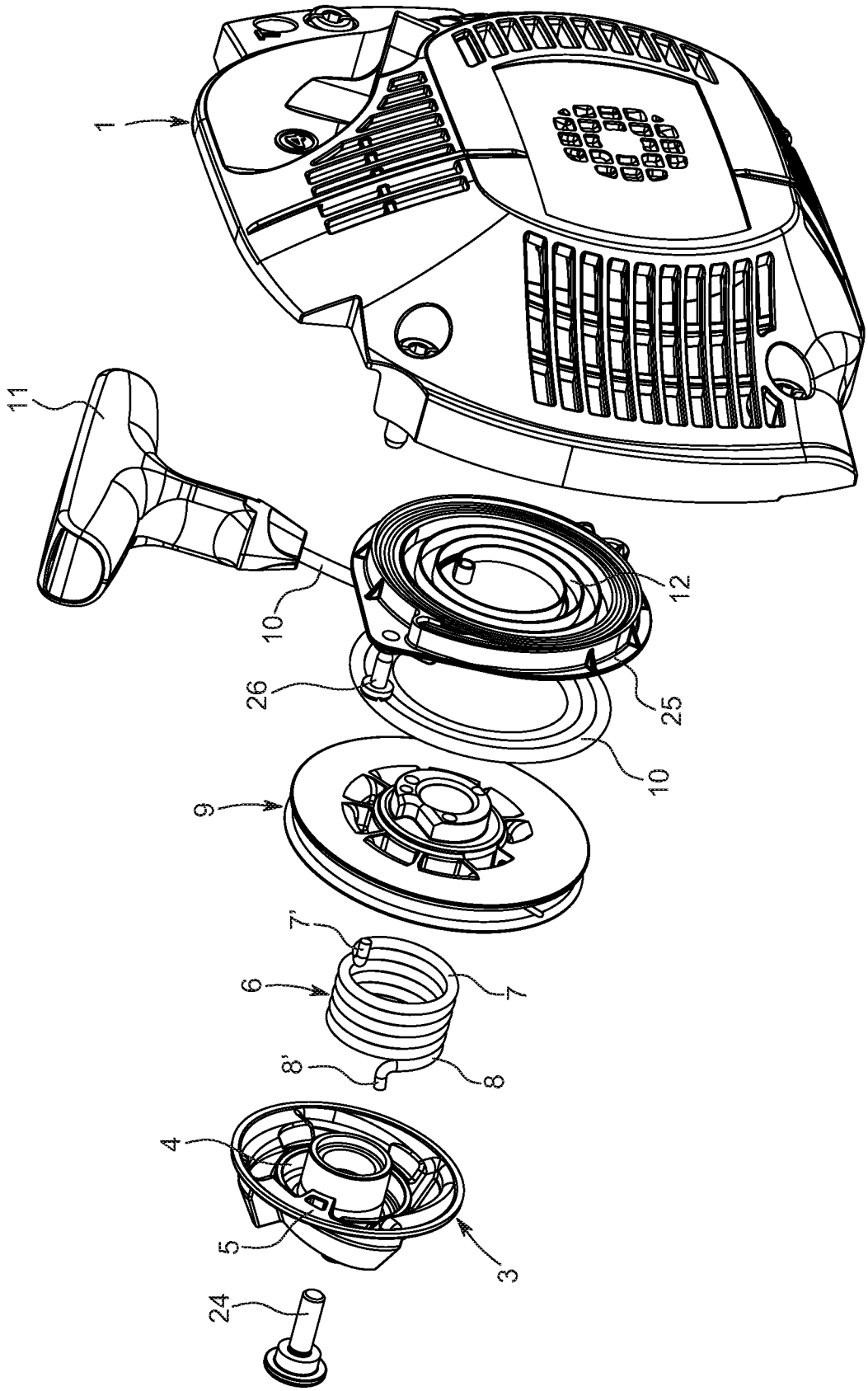

Fig. 3

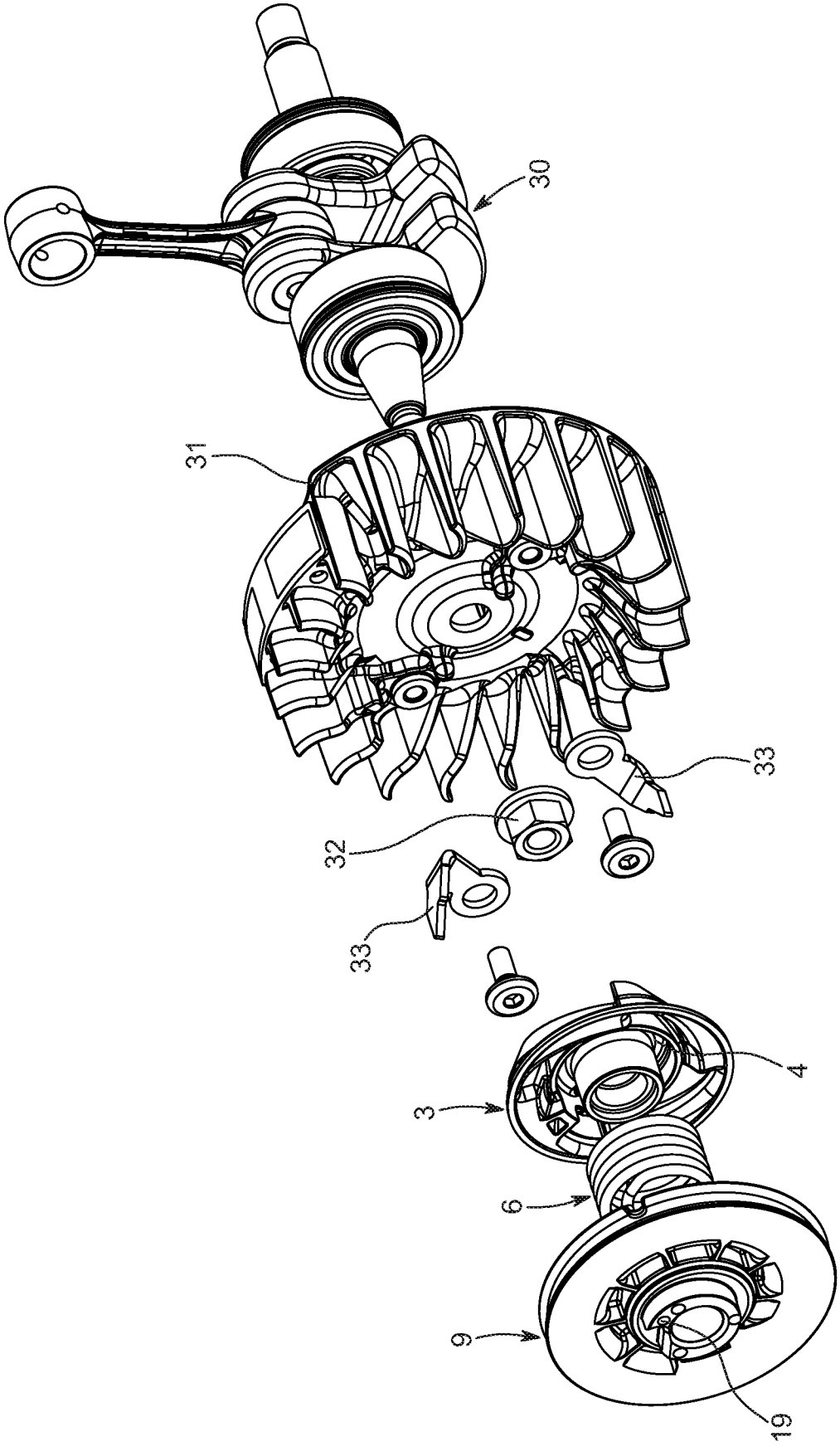

Fig. 4

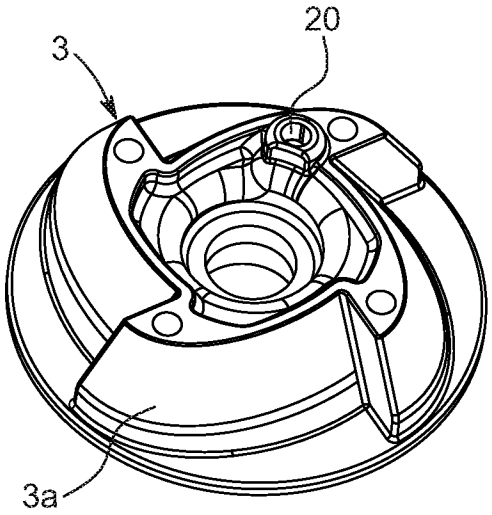

Fig. 5

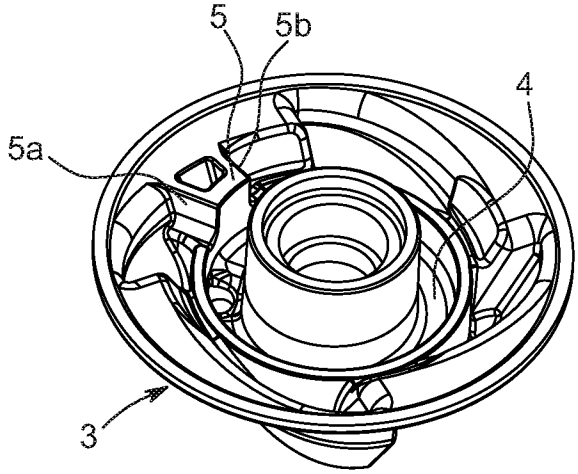

Fig. 6

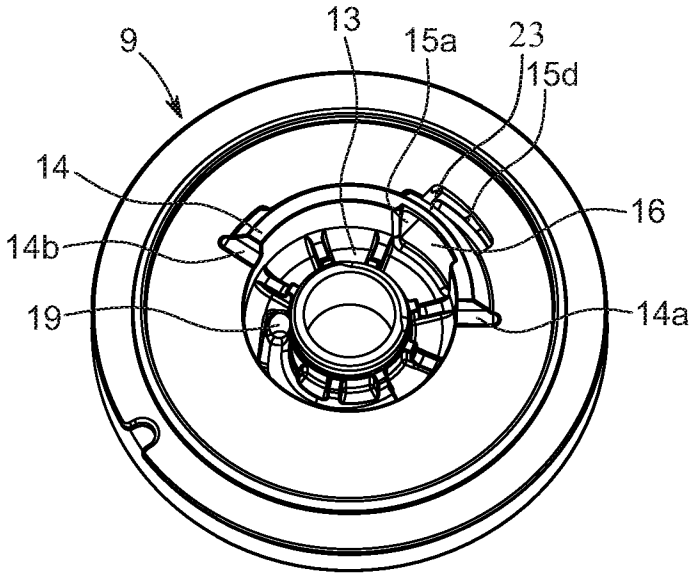

Fig. 7

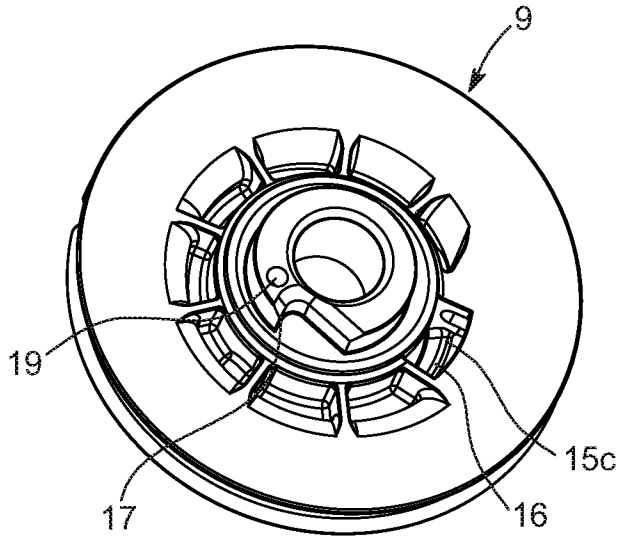

Fig. 8

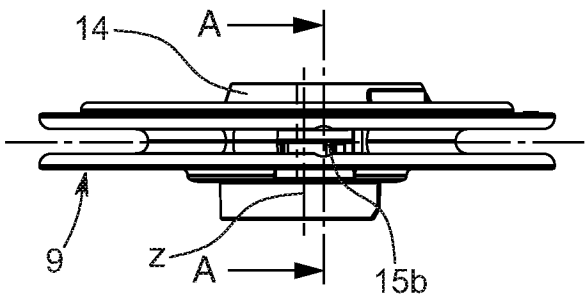

Fig. 9

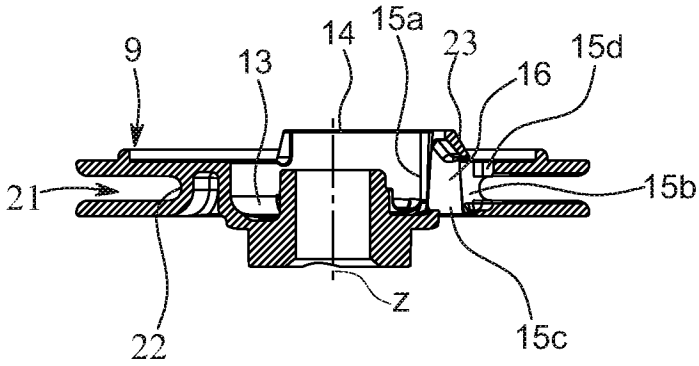

Fig. 10

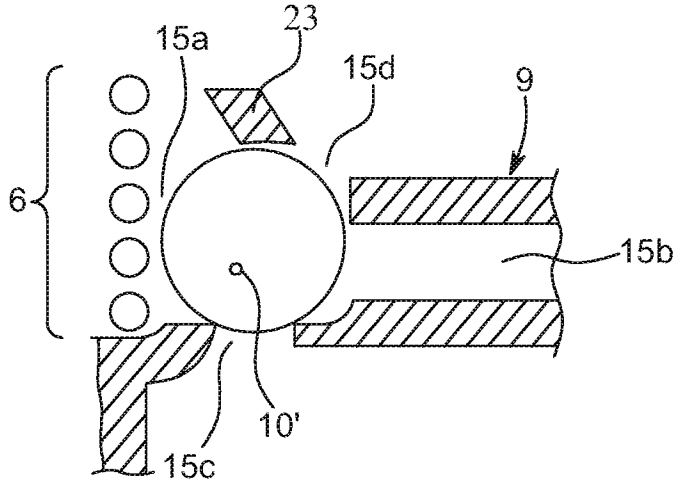

Fig. 11

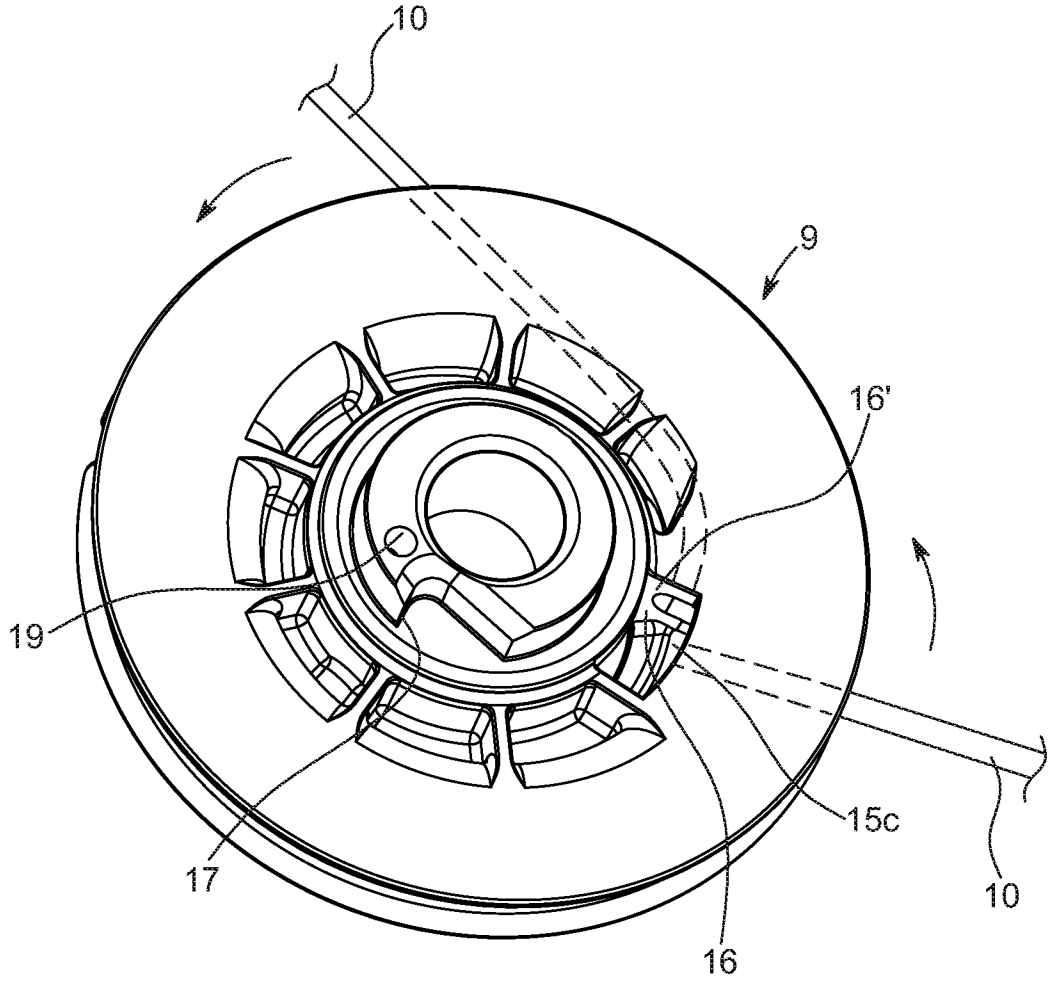

Fig. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/050271

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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: F02N

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20040250786 A1 (KRUSE OLAF ET AL), 16 December 2004 (2004-12-16); abstract; paragraphs [0019]-[0020], [0034], [0079], [0082], [0108]-[0111]; figures 1-5	1-24
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X	US 20060219204 A1 (HASHIBA HIDEKI), 5 October 2006 (2006-10-05); abstract; paragraph [0031]; figure 2	1-8, 21-24
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Date of the actual completion of the international search	Date of mailing of the international search report
07-11-2012	07-11-2012

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Marianne Dickman Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/050271

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20100170465 A1 (EAKINS JR CHARLES ARTHUR), 8 July 2010 (2010-07-08); abstract; figures --	1-24
A	US 20030213455 A1 (TOHYAMA ISAO), 20 November 2003 (2003-11-20); abstract; figures --	1-24
A	US 4658775 A (GREENWOOD LEON D ET AL), 21 April 1987 (1987-04-21); column 8, line 15 - line 23; figure 4 -- --------	1, 8

International application No.
PCT/SE2012/050271

Continuation of: second sheet

International Patent Classification (IPC)

F02N 3/02 (2006.01)

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Cited literature, if any, will be enclosed in paper form.

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