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(54) STARTER APPARATUS FOR CRANKING OVER AN INTERNAL COMBUSTION ENGINE, AND STARTER SYSTEM FOR CRANKING OVER AN INTERNAL COMBUSTION ENGINE

(57) The present invention relates to a starter apparatus (1) for cranking over an internal combustion engine having a driveable drive shaft (3) which is coupled rotatably via a freewheel device (13) to a pinion shaft (7). It is essential for the invention that a sleeve (24) is arranged radially between the pinion shaft (7) and the freewheel device (13).

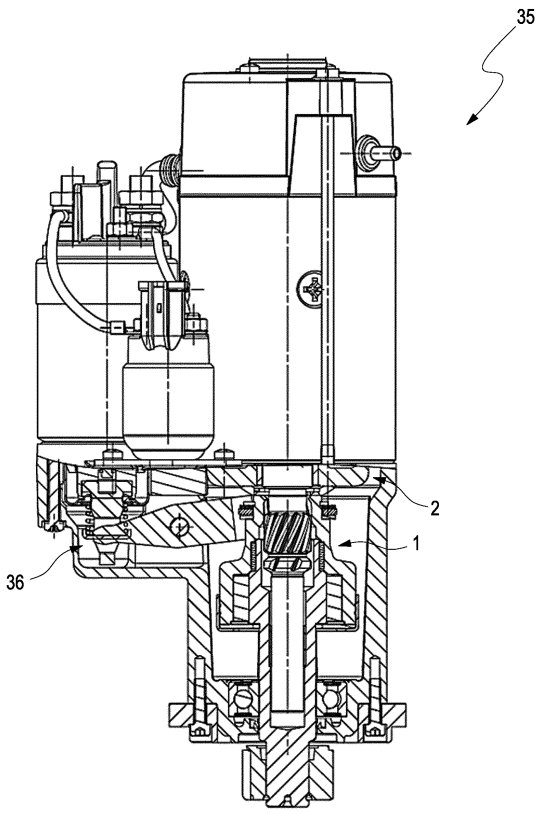

Fig. 1

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Description

[0001] The invention relates to a starter apparatus for cranking over an internal combustion engine in accordance with the preamble of Claim 1. Furthermore, the invention relates to a starter system for cranking over an internal combustion engine having a starter apparatus.

[0002] Electric starter apparatuses of this type are used in the case of internal combustion engines, in order to crank them over from a standstill, that is to say from a zero rotational speed, to a predefined or predefinable starting rotational speed.

[0003] Document US 8 371 259 B2 describes an electric starter apparatus of the generic type which is provided for cranking over an internal combustion engine. It has an electric starter motor which has a drive shaft which is provided with an external toothing system, a pinion shaft which carries a pinion, and a clutch part of a roller freewheel clutch which is arranged between the drive shaft and the pinion shaft. The clutch part has an internal toothing system which meshes with the external toothing system of the drive shaft, with the result that it can be displaced together with the pinion shaft away from the starter motor in the direction of the drive shaft into an engagement position. In order to load the roller raceways of the roller freewheel clutch to a less pronounced extent by way of the forces which are produced during cranking over of the internal combustion engine, a device is provided for the direct support of the pinion shaft on a section of the external toothing system of the drive shaft, which section faces away from the starter motor.

[0004] It is disadvantageous in the case of the known starter apparatuses that the pinion shaft and the drive shaft tend to tilt with respect to one another during operation of the starter apparatus. This can lead to undesired metallic contact between the pinion shaft and the drive shaft. As a result, material wear effects can occur, for example material abrasion or material melting loss, which decreases the service life to be expected of the starter apparatus, although relatively high cycle numbers and relatively long service lives are desired precisely in the automotive sector, in particular in the case of start-stop applications.

[0005] It is therefore the object of the invention to specify an improved embodiment or at least another embodiment of a starter apparatus, and a starter system which is equipped with said starter apparatus.

[0006] In the case of the present invention, this object is achieved, in particular, by way of the subjects of the independent claims. Advantageous embodiments are the subject matter of the dependent claims and the description.

[0007] The basic concept of the invention lies in optimizing a starter apparatus for disconnecting an electric starter motor from an internal combustion engine, by the bearing concept between a freewheel device and an internal combustion engine-side pinion shaft of the starter apparatus being improved by way of the addition of a further bearing part.

[0008] Therefore, it is provided for a starter apparatus (which is, in particular, self-engaging) for cranking over an internal combustion engine to a starting rotational speed to be equipped with a drive shaft which can be driven by an electric starter motor, in particular an electric motor. The drive shaft defines a drive shaft longitudinal axis along its main extent direction, and a radially outwardly oriented external toothing system with regard to the drive shaft longitudinal axis on an outer drive shaft surface which is oriented, in particular, radially to the outside with regard to the drive shaft longitudinal axis. Furthermore, the starter apparatus has a pinion shaft which defines a pinion shaft longitudinal axis, the pinion shaft having, at its free end, an internal combustion engine-side pinion for being brought into engagement with contact with (in particular a crown gear of) an internal combustion engine. Furthermore, the pinion shaft has a pot-like drive shaft receptacle for receiving the drive shaft, which drive shaft receptacle is arranged at a free end which lies opposite the one free end of the pinion shaft. Furthermore, the starter apparatus has a freewheel device for the transmission of a torque (which, in particular, is provided by the starter motor and is transmitted directly or indirectly to the drive shaft) in a manner which is independent of the rotational speed from the drive shaft to the pinion shaft. For this purpose, on a toothing section of an inner surface (which, in particular, is oriented towards the inside with regard to the pinion shaft longitudinal axis) of the freewheel device, the freewheel device has a toothing system which is in engagement or can be brought into engagement with contact with the external toothing system of the drive shaft. As a result, a torque can be transmitted in a positively locking and non-positive manner, starting from the starter motor, via the drive shaft to the freewheel device. Furthermore, the freewheel device has a clutch part which has a bearing arrangement which is arranged in a manner which makes contact on both sides between a torque transmission section of the inner surface of the freewheel device and a corresponding torque transmission section of the pinion shaft casing face of the pinion shaft. The bearing arrangement can have a plurality of bearing bodies, expediently namely a plurality of cylindrical anti-friction bearings. The latter can, during operation of the starter apparatus, run around the pinion shaft longitudinal axis between the torque transmission section and the corresponding torque transmission section, a transmission of torque which is independent of the rotational speed and is, in particular, non-positive being possible from the freewheel device to the pinion shaft by way of friction effects. Because no positively locking connection is configured between the torque transmission section and the corresponding torque transmission section or, the freewheel device and the pinion shaft, the pinion shaft and the driveshaft can "slip", allowing the pinion shaft to rotate faster than the drive shaft.. Furthermore, the pinion shaft receives the drive shaft in the drive shaft receptacle. Furthermore, it

is possible for the pinion shaft to be moved together with the freewheel device in the direction of the drive shaft longitudinal axis between an engagement position with an internal combustion engine and at least one engagement-free basic position which is spaced apart therefrom. The external toothing system of the drive shaft and the toothing system of the freewheel device are constantly in engagement during movement and in all positions. As a result, the pinion shaft can as it were be driven continuously by the drive shaft, and can be displaced together with the freewheel device axially with respect to the drive shaft, which is known as "capable of engaging" among experts, with the result that the starter apparatus can selectively be brought into engagement with an internal combustion engine or not.

[0009] It is essential for the innovative bearing concept that a sleeve is arranged radially between the pinion shaft and the freewheel device, in order to support the pinion shaft radially with regard to the freewheel device. This has the technical effect that the pinion shaft and the freewheel device are less inclined to tilt with respect to one another during operation of the starter apparatus, with the result that the bearing bodies axes remain parallel to pinion shaft axis. This has the advantage that the starter apparatus can run through significantly more starter cycles than starter apparatuses which are known from the prior art. As a result, the service life and the cost effectiveness of the starter apparatus are extended and improved, respectively.

[0010] The sleeve of the starter apparatus can be fixed on the freewheel device. This has the effect that the sleeve is fixed captively on the freewheel device, for example by way of caulking, pressing in, welding or adhesive bonding. This has the advantage that the sleeve does not slip axially during operation of the starter apparatus. This has the further advantage that the sleeve is not lost during operation of the starter apparatus.

[0011] Furthermore, the sleeve can be supported radially, in particular with regard to the pinion shaft longitudinal axis, with contact on a plain bearing section of the pinion shaft. This has the effect that the forces and torques which occur during operation of the starter apparatus as a result of the pinion of the pinion shaft being brought into engagement with an internal combustion engine can be transmitted from the pinion shaft to the freewheel device and, from there, to the drive shaft. This has the advantage that the pinion shaft longitudinal axis is oriented practically in parallel with regard to the freewheel device longitudinal axis, and no angular offset occurs. As a result wear of the bearing bodies of the freewheel device can be minimized.

[0012] The pinion shaft can have a pot-shaped bearing projection which extends axially in the direction of the pinion shaft longitudinal axis and the outer radial surface of which forms or defines the bearing section. This has the effect that the bearing section is relatively great in terms of area. This has the advantage that the forces and torques which occur during operation of the starter apparatus can be supported on a greater area, as a result of which the surface pressure and, as a result, the loading of the bearing section are reduced.

[0013] The bearing projection can adjoin the pot-like drive shaft receptacle in an integrally joined manner in the direction of the pinion shaft longitudinal axis. This has the advantage that the forces and torques which occur during operation of the starter apparatus can be supported on an even greater area, as a result of which the surface pressure and, as a result, the loading of the bearing section can be reduced even further.

[0014] Furthermore, radial gaps which can be loaded with lubricant can be formed in a circumferential direction about the pinion shaft longitudinal axis at least in sections in the circumferential direction between a radially inwardly oriented inner surface of the sleeve and a radially outwardly oriented bearing section, in particular a pinion raceway, of the pinion shaft. This has the advantageous effect that lubricant can be arranged between the sleeve and the pinion shaft, in order to reduce the friction between the sleeve and the pinion shaft during operation of the starter apparatus. This has the advantage that the service life of the starter apparatus is improved or extended.

[0015] Furthermore, the sleeve can form an internally hollow ring body with a circular ring cross section, or a completely closed internally hollow ring body with a fully circular ring cross section. A design of this type is advantageously inexpensive to produce.

[0016] At least one completely circumferential lubricant channel can be arranged on an inner surface of the sleeve. This has the effect that lubricant can be arranged in a manner which is stored in the channel volume which is formed by the lubricant channel. This has the advantage that the lubrication between the sleeve and the pinion shaft can be designed, for example, for the entire service life of the starter apparatus.

[0017] Furthermore, the inner surface can be oriented radially towards the inside with regard to the pinion shaft longitudinal axis and can be configured as a plain bearing raceway. Plain bearing raceways can be identified by a ground and/or lapped and/or honed surface. Furthermore, two completely circumferential lubricant channels which are spaced apart from one another in the direction of the pinion shaft longitudinal axis can be provided on the inner surface. The lubricant channel cross section of said lubricant channels is expediently formed in each case by way of a circular segment area which is delimited by a circular arc and a chord. The pinion shaft can be supported on a stop projection of the freewheel device in at least one basic position. This has the effect that the pinion shaft is mounted on the freewheel device in the direction of the pinion shaft longitudinal axis in at least one basic position. For example, the stop projection has a stop projection end face which is oriented transversely with regard to the pinion shaft longitudinal axis and on which the pinion shaft can be supported with a pinion shaft end face.

[0018] The invention can comprise the alternative or additional further fundamental concept of specifying a starter system for cranking over an internal combustion engine. It is provided to this end that the starter system for cranking over an internal combustion engine has a starter apparatus in accordance with the preceding description and an electric starter motor for driving the drive shaft. In order that the pinion shaft can be displaced together with the freewheel device in the direction of the drive shaft longitudinal axis between an engagement position with an internal combustion engine and at least one engagement-free basic position which is spaced apart therefrom, the starter system has an actuating drive. It is realized in this way that the pinion shaft and the freewheel device can be driven at the same time by the drive shaft and can be displaced axially.

[0019] Furthermore, the said starter apparatus may have a freewheel bearing system consisting of several bearing bodies, wherein the said freewheel bearing system is, e.g. completely, arranged between the inner surface of the freewheel device and a corresponding torque transmission section of the pinion shaft.

[0020] Preferably the above-mentioned sleeve is arranged at a position radially, e.g. in relation to the drive shaft longitudinal axis, inwardly of the freewheel bearings of the said freewheel bearing system. Additionally or alternatively it is possible that the sleeve is arranged at a position axially, e.g. in relation to the drive shaft longitudinal axis, between the freewheel bearings of the said freewheel bearing system and the said starter motor.

[0021] In summary, the following remains to be noted: the present invention preferably relates to a starter apparatus for cranking over an internal combustion engine having a driveable drive shaft which is coupled rotatably to a pinion shaft via a freewheel device. A sleeve can expediently be arranged radially between the pinion shaft and the freewheel device.

[0022] Further important features and advantages of the invention result from the subclaims, from the drawings and from the associated description of the figures on the basis of the drawings.

[0023] It goes without saying that the features which are mentioned in the above text and are still to be explained in the following text can be used not only in the respective specified combination, but rather also in other combinations or on their own, without departing from the scope of the present invention.

[0024] Preferred exemplary embodiments of the invention are shown in the drawings and will be described in greater detail in the following description, identical reference numerals relating to identical or similar or functionally identical components.

[0025] In the drawings, in each case diagrammatically,

Fig. 1 shows a view of one preferred exemplary embodiment of a starter system for cranking over an internal combustion engine (not illustrated) having a starter apparatus,

Fig. 2 shows a view of the starter apparatus from Fig. 1,

Fig. 3 shows a detail of the starter apparatus from Fig. 2 in a frame which is bordered by way of a solid line, and

Fig. 4 shows a perspective view of a sleeve of the starter apparatus.

[0026] Fig. 1 shows a starter system which is denoted overall by way of the reference numeral 35 and serves to crank over an internal combustion engine (not illustrated) from a zero rotational speed to a predefined or predefinable starting rotational speed. The starter system 35 has a starter apparatus 1 which is illustrated more precisely in Figs. 2 and 3 and is described in more detail in the following text, an electric starter motor 2 for driving the starter apparatus 1, and an actuating drive 36 for actuating the starter apparatus 1.

[0027] Fig. 2 shows a view of the starter apparatus 1 from Fig. 1. The starter apparatus 1 serves to disconnect the electric starter motor 2 from an internal combustion engine, for example in order to avoid damage to the starter motor 2 as a result of excessively high rotational speeds. For this purpose, the starter apparatus 1 has a drive shaft 3 which can be driven by the electric starter motor 2 and defines a drive shaft longitudinal axis 4 which is indicated using a dash-dottedline. Furthermore, the drive shaft 3 has an external toothing system 6 on an outer drive shaft surface 5. The teeth of the external toothing system 6 protrude radially away to the outside with regard to the drive shaft longitudinal axis 4. In addition, the starter apparatus 1 has a pinion shaft 7 which defines a pinion shaft longitudinal axis 8. At a free end, it has a pinion 10 which serves for being brought into engagement with an internal combustion engine. At a free end which lies opposite the former free end, the pinion shaft 7 has a pot-like drive shaft receptacle 12 for receiving the drive shaft 3. In order to couple the pinion shaft 7 to the drive shaft 3 in a manner which is independent of the rotational speed, furthermore, the starter apparatus 1 has a freewheel device which is denoted by way of the reference numeral 13 (see Fig. 2). In order to realize coupling which is independent of the rotational speed by means of the freewheel device 13, with the result that a transmission of torque in a manner which is independent of the rotational speed is possible from the drive shaft 3 to the pinion shaft 7, the freewheel device 13 has an inner surface 14 which is oriented radially to the inside with regard to the pinion shaft longitudinal axis 8. A toothing system 16 which is in engagement contact with the external toothing system 6 of the drive shaft 3 is arranged on a toothing section 15 of the inner surface 14. The teeth of the toothing system 16 protrude radially to the inside with regard to the pinion shaft longitudinal axis 8. Furthermore, the freewheel device 13 has a clutch part 17 consisting of a bearing arrangement 20 which is arranged

with contact between a torque transmission section 18 of the inner surface 14 and a corresponding torque transmission section 19 of the pinion shaft 7. The bearing arrangement 20 can have a freewheel bearing system 21' consisting of a plurality of bearing bodies 21, expediently cylindrical anti-friction bearings.

[0028] Furthermore, it can be seen in Fig. 2 that the pinion shaft 7 receives the drive shaft 3 completely in the driveshaft receptacle 12. It is possible by means of the actuating drive 36 to act on a circumferential ring projection 40 which is arranged on the freewheel device 13, in order therefore to move the freewheel device 13 and the pinion shaft 7 together in the direction of the drive shaft longitudinal axis 4, which is indicated in Fig. 2 by way of example by a double arrow. The freewheel device 13 and the pinion shaft 7 can expediently be moved together between an engagement position 22, in which the pinion 10 of the starter apparatus 1 is in engagement with a crown gear of an internal combustion engine and torque is transmitted from the starter motor 2 to said crown gear, and at least one engagement-free basic position 23 which is spaced apart therefrom. The pinion shaft 7 can be supported axially on a stop projection 34 of the freewheel device 13 (see Fig. 3).

[0029] Fig. 3 shows a detail of the starter apparatus 1 from Fig. 2 in a frame which is bordered by way of a continuous line; it can be seen that a sleeve 24 is arranged in a stationary manner on the freewheel device 13 radially between the pinion shaft 7 and the freewheel device 13. The sleeve 24 makes it possible for the pinion shaft 7 to be radially supported or to be mounted via the freewheel device 13 with regard to the drive shaft 3. This is necessary because during operation of the starter apparatus 1 a crown gear of the internal combustion engine is in engagement with the pinion 10. This causes radial forces, in particular, pressing on the pinion 10 in the radial direction, which results in a skew of the drive shaft 3 with regard to the pinion shaft 7 due to the radial gap (necessary due to tolerances) between the components. The skew of the drive shaft 3 and/or the pinion shaft 7 causes increased material wear which is to be ascribed, in particular, to a change of the contact type between the pinion shaft 7 and bearing bodies 21 from the linear to punctiform. The support or mounting by means of the sleeve 24 has the advantageous technical effect that the bearing bodies 21 axes remain parallel to pinion shaft axis 8.

[0030] Furthermore, it can be seen in Fig. 3 that the sleeve 24 is supported with contact on a bearing section 25 of the pinion shaft 7 radially with regard to the pinion shaft longitudinal axis 8. The bearing section 25 is formed by way of example by a pot-shaped bearing projection 26 which adjoins the pot-like driveshaft receptacle 12 in an integrally joined manner and extends in the direction of the pinion shaft longitudinal axis 8, in particular by an outer radial surface 27 of the bearing section 25. Furthermore, it is illustrated in Fig. 3 that radial gaps 31 which can be loaded with lubricant are formed in a circumferential direction 28 about the pinion shaft longitudinal axis 8 at least in sections in the circumferential direction 28 between a radially inwardly oriented inner surface 29 of the sleeve 24 (see also Fig. 4) and a radially outwardly oriented pinion raceway 30 of the pinion shaft 7.

[0031] Finally, Fig. 4 shows the sleeve 24 in a perspective view. It is formed by way of example by an internally hollow ring body 32 with a circular ring cross section. The perspective view shows the inner surface 29 of the sleeve 24, which inner surface 29 has already been mentioned above and is radially inwardly oriented by way of example with regard to the pinion shaft longitudinal axis 8. The sleeve 24 has by way of example two completely circumferential lubricant channels 33 which can be filled with a lubricant. The lubricant channels 33 are arranged spaced apart from one another in the direction of the pinion shaft longitudinal axis 8. Each lubricant channel 33 has a constant lubricant channel cross section which is formed in each case by way of a circular segment area which is delimited by a circular arc and a chord.

Claims

1. Starter apparatus for cranking over an internal combustion engine,

- having a drive shaft (3) which can be driven by an electric starter motor (2), wherein the drive shaft (3) has a drive shaft longitudinal axis (4) and an external toothing system (6) arranged on an outer drive shaft surface (5),
- having a pinion shaft (7) which has a pinion shaft longitudinal axis (8) and has, at a free end, a pinion (10) for being brought into engagement with an internal combustion engine and, at an opposite end, a pot-like drive shaft receptacle (12) for receiving the drive shaft (3),
- having a freewheel device (13) for the transmission of a torque in a manner which is independent of the rotational speed from the drive shaft (3) to the pinion shaft (7) which, on a toothing section (15) of an inner surface (14) of the freewheel device (13) has a toothing system (16) which is in engagement with the external toothing system (6), and has a clutch part (17) consisting of a bearing arrangement (20) which is arranged between a torque transmission section (18) of the inner surface (14) and a corresponding torque transmission section (19) of the pinion shaft (7),
- the pinion shaft (7) receiving the drive shaft (3) in the drive shaft receptacle (12), and it being possible for the pinion shaft (7) to be moved together with the freewheel device (13) in the direction of the drive shaft longitudinal axis (4) between an engagement position (22) with an internal combustion engine and at least one engagement-free basic position (23) which is

spaced apart therefrom, with the result that the pinion shaft (7) and the freewheel device (13) can be driven by the drive shaft (3) and can be displaced together in the direction of the drive shaft longitudinal axis (4), **characterized**
- **in that** a sleeve (24) is arranged radially between the pinion shaft (7) and the freewheel device (13), in order to support the pinion shaft (7) radially with regard to the freewheel device (13).

2. Starter apparatus according to Claim 1, **characterized** **in that** the sleeve (24) is fixed on the freewheel device (13).

3. Starter apparatus according to Claim 1 or 2, **characterized** **in that** the sleeve (24) is supported radially with contact on a bearing section (25) of the pinion shaft (7).

4. Starter apparatus according to Claim 3, **characterized** **in that** the pinion shaft (7) has a pot-shaped bearing projection (26) which extends in the direction of the pinion shaft longitudinal axis (8) and the outer radial surface (27) of which forms the bearing section (25).

5. Starter apparatus according to Claim 4, **characterized** **in that** the bearing projection (26) adjoins the pot-like drive shaft receptacle (12) in an integrally joined manner in the direction of the pinion shaft longitudinal axis (8).

6. Starter apparatus according to one of the preceding claims, **characterized** **in that** radial gaps (31) which can be loaded with lubricant are formed in a circumferential direction (28) about the pinion shaft longitudinal axis (8) at least in sections in the circumferential direction (28) between a radially inwardly oriented inner surface (29) of the sleeve (24) and a radially outwardly oriented bearing section (25), in particular a pinion raceway (30), of the pinion shaft (7).

7. Starter apparatus according to one of the preceding claims, **characterized** **in that** the sleeve (24) is an internally hollow ring body (32) with a circular ring cross section.

8. Starter apparatus according to Claim 7, **characterized** **in that** the sleeve (24) is a completely closed internally hollow ring body (32) with a fully circular ring cross section.

9. Starter apparatus according to one of the preceding claims, **characterized** **in that** at least one completely circumferential lubricant channel (33) is arranged on an inner surface (29) of the sleeve (24).

10. Starter apparatus according to Claim 9, **characterized** **in that** two completely circumferential lubricant channels (33) which are spaced apart from one another in the axial direction of the pinion shaft longitudinal axis (8) are provided on the inner sleeve surface (29), the lubricant channel cross section of which lubricant channels (33) is formed in each case by way of a circular segment area which is delimited by a circular arc and a chord.

11. Starter apparatus according to one of the preceding claims, **characterized** **in that** the pinion shaft (7) is supported axially on a stop projection (34) of the freewheel device (13) in at least one basic position (23).

12. Starter apparatus according to one of the preceding claims, **characterized** **in that** a freewheel bearing system (21') consisting of bearing bodies (21) is arranged between the inner surface (14) of the freewheel device (13) and a corresponding torque transmission section (19) of the pinion shaft (7).

13. Starter apparatus according to one of the preceding claims, **characterized** **in that** the sleeve (24) is arranged at a position radially inwardly of the freewheel bearings (21) of the freewheel bearing system (21'), and/or that the sleeve (24) is arranged at a position axially between the freewheel bearings (21) of the freewheel bearing system (21') and the starter motor (2).

14. Starter system for cranking over an internal combustion engine

- having a starter apparatus (1) according to one or more of the preceding claims,
- having an electric starter motor (2) for driving the drive shaft (3),
- having an actuating drive (36) for the joint actuation of the pinion shaft (7) and the freewheel device (13) in the direction of the drive shaft longitudinal axis (4) between an engagement position (22) with an internal combustion engine and at least one engagement-free basic position (23) which is spaced apart therefrom, with the result

that the pinion shaft (7) and the freewheel device (13) can be driven by the drive shaft (3) and can be displaced in the direction of the drive shaft longitudinal axis (4).

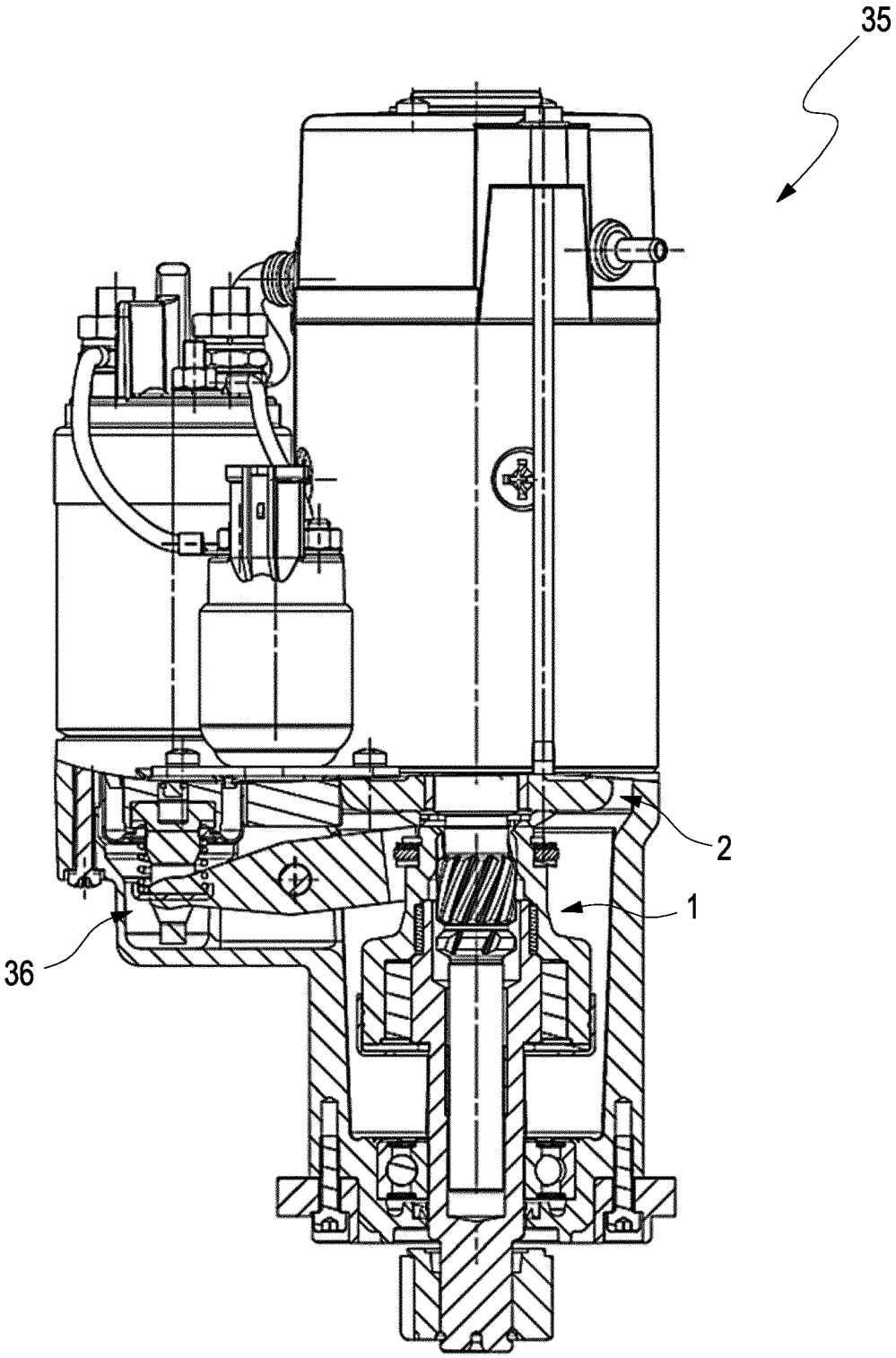

Fig. 1

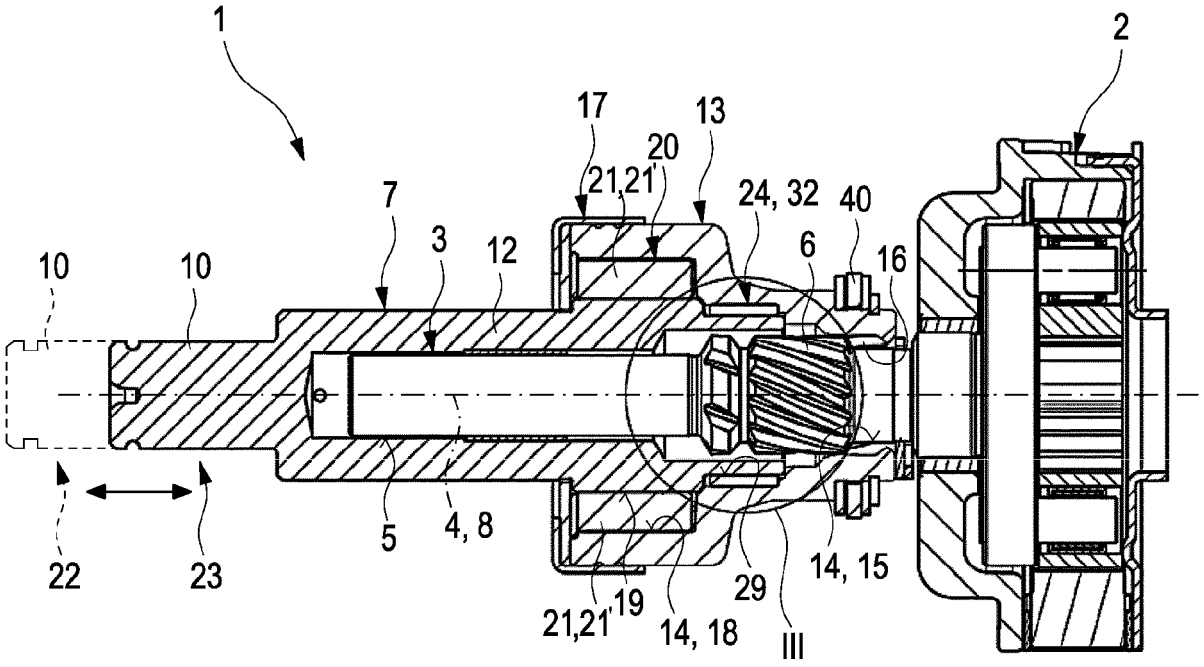
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Fig. 2

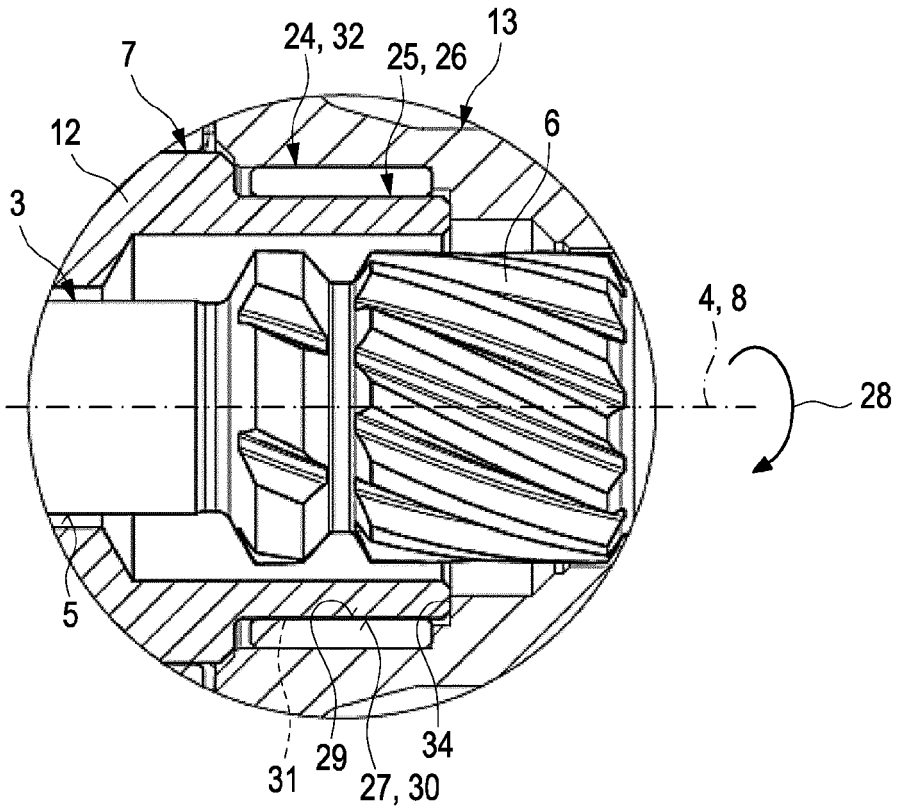
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Fig. 3

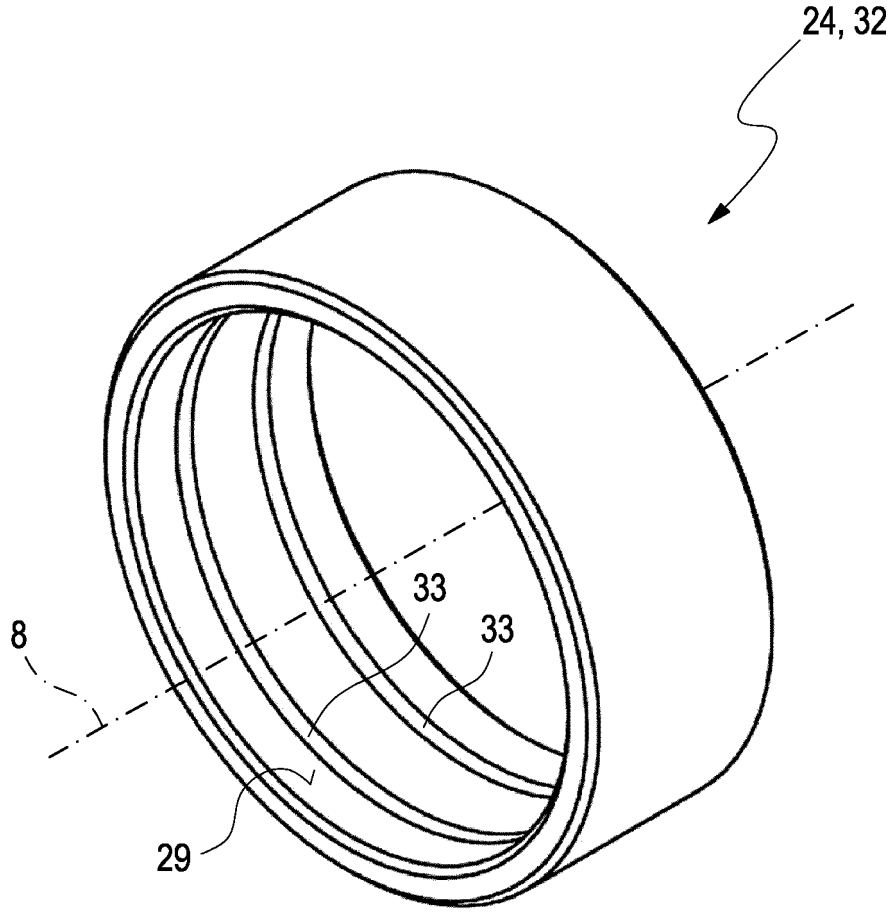

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 1293

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y A	US 2010/132648 A1 (STEINLE MATTHIAS [DE] ET AL) 3 June 2010 (2010-06-03) * paragraph [0015] - paragraph [0021] * * figures *	1-3,7,8, 14 4-6,9-13	INV. F02N15/02 ADD. F02N15/06
Y	GB 2 025 533 A (ERVOR COMPRESSEURS) 23 January 1980 (1980-01-23) * page 5, line 108 - line 125 * * figures *	1-3,14	F02N11/08
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TECHNICAL FIELDS SEARCHED (IPC)
F02N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 July 2020	De Vita, Diego

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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