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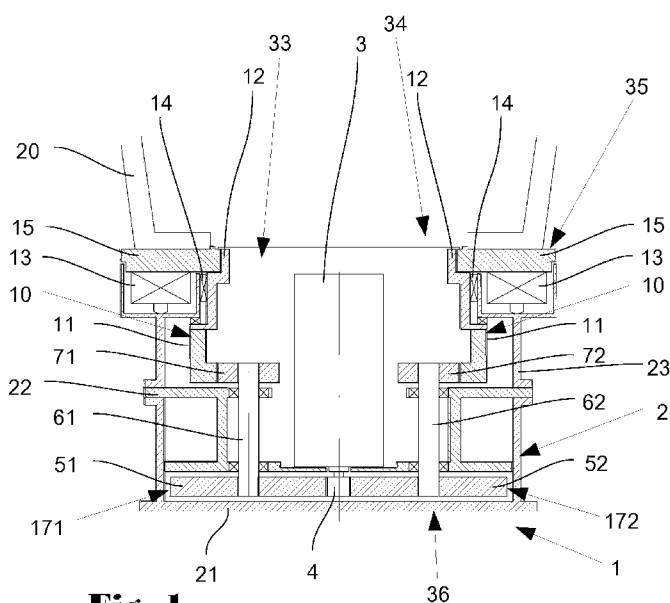


Fig. 1

(57) Abstract: Drive arrangement (1), especially for a vertical roller mill, comprising a support structure (2) including an upper end (35) and a lower end (36) as well as an electric motor (3) arranged within said support structure (2), said electric motor (3) comprising a drive pinion (4). Further, at least one gear arrangement (171, 172) is also arranged within the support structure (2), said gear arrangement (171, 172) being coupled to said drive pinion (4). A rotatable transmission element (10) is additionally arranged on the support structure (2). The transmission element (10) is coupled to the gear arrangement (171, 172) and is further connectable to a milling table (20). The electric motor (3) is arranged within the support structure (2) such that the drive pinion (4) is oriented towards the lower end (36) of the support structure (2).

DRIVE ARRANGEMENT FOR A MILL

Technical Field

5 The invention relates to a drive arrangement for a mill, preferably for a vertical roller mill.

Background Art

Various types of drive arrangements for mills are known in the art.

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For example, EP 2 323 771 B1 (FLSmidth A/S) discloses a heavy duty drive arrangement for a mill wherein the motor is integrated within a housing of the mill drive. The motor is thereby supported by the casing and transmits torque to a milling table by means of a planetary drive also arranged within the housing.

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WO 2008/031694 (Siemens) discloses a mill for milling rough, stone-like material with a parallel axis drive. The mill comprises a milling table being rotatable around a vertical axis, wherein the milling table is driven by an electric motor. The motor is thereby arranged directly beneath the milling table. The motor is preferably directly coupled to the milling table but can alternatively also be coupled by means of a gear, wherein the gear may be a planetary gear. Specifically, the motor may comprise a stator holder and a stator winding. The stator winding acts on the rotor by means of permanent magnets arranged thereon. The rotor is coupled to a planetary gear arranged between the rotor and the milling table.

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BE 809236 (Gebr. Pfeiffer Barbarossawerke AG) describes a roller mill where the outer perimeter of the milling table constitutes a rotor part of an electric motor which is surrounded by a stator part affixed to a housing of the mill. In one embodiment, the milling table is arranged onto a cylindrical support structure which comprises windings of an electric rotor on its lower area. The windings of the stator are arranged on a part of the housing encircling the cylindrical structure.

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WO 2007/004082 (FLSmidth A/S) describes a roller mill having a stator of an electric motor which constitutes an integral part of a support for a grinding table, so that at least some of the load imposed by a roller on the grinding table is transmitted via the stator to the machine foundation. As none of the parts of the rotor are connected to the housing of

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the mill, the motor may be installed and replaced as a single unit which has been pre-assembled at a specialized workshop.

The drive arrangements of the prior art have the disadvantage that they either have rather big dimensions due to the integration of the motor within the housing of the drive arrangement or that maintenance of the motor is cumbersome and time intensive since the motor is configured as part of the housing of the drive.

Summary of the invention

It is the object of the invention to create a drive arrangement for a mill pertaining to the technical field initially mentioned which avoids the use of a bevel gear, has a compact configuration and provides for a simple and low-cost maintenance.

The solution of the invention is specified by the features of claim 1. According to the invention the drive arrangement comprises a support structure including an upper and a lower end as well as an electric motor arranged within said support structure, said motor comprising a drive pinion. Further, at least one gear arrangement is also arranged within the support structure, said gear arrangement being coupled to said drive pinion. A rotatable transmission element is arranged on the support structure. The transmission element is coupled to the gear arrangement and is further connectable to a milling table. The motor is arranged within the support structure such that the drive pinion is oriented towards the lower end of the support structure.

As the motor is arranged within the support structure of the drive arrangement the drive of the mill is very compact and does not require any further structural elements, such as a ditch or separate foundations for the motor. Further, no shaft has to be lead into the support structure of the drive arrangement, e.g. through an opening, such that any weight born by the support structure, like e.g. the weight of a milling table or the like may be equally distributed around the entire circumference of the support structure. Hence, the inventive configuration results in a compact and yet highly stable mill drive.

The upper end and the lower end of the support structure are preferably planar structures being parallel to each other. The lower end is most preferably configured to be placed on a fundament or on the ground supporting the drive arrangement. Most

preferably, a circumferential housing is provided between the upper end and the lower end, thus encasing the entire drive arrangement.

5 The mill drive is preferably used for a vertical roller mill, but might also be used for any other type of mill known in the art. Preferably, the mill drive is of the heavy duty type with a motor having more than 500 kW, preferably more than 1 MW of power. Such mill drives are especially suited to drive rock or cement mills or the like. Preferably, the motor is an asynchronous electric motor.

10 Preferably, the motor is arranged centrally within the support structure, most preferably having the rotation axis of the rotor of the motor coaxially arranged with the rotation axis of a milling table driven by said drive arrangement. Thereby, a motor having a longitudinal shape may be used, which allows the reduction of ohmic losses. Further, this also allows using a motor with rather "standard" proportions, thus reducing the costs
15 of manufacture of the drive as no motor with customized sizes needs to be used.

Alternatively, a wound rotor motor may be used. A wound rotor motor has the advantage that a higher start-up torque is provided, which is of advantage in heavy duty drives. Access to the motor may be realized by providing an access hatch, e.g. centrally located
20 on a milling table.

In the present application, the term "coupled" means that a first element of the drive arrangement is in connection to a further element of the drive arrangement such that torque may be transmitted from said first element to said further element. For example,
25 the drive pinion may be coupled to at least one gear wheel, said gear wheel meshing with said drive pinion such as to transmit torque from said drive pinion to said at least one gear wheel. The coupling may be performed by any suitable mechanical means, such as gear wheels or shafts or any other type of mechanical connection able to transmit torque, such as planetary gears, transmission chains or the like.

30 A "gear arrangement" is understood in the present application as comprising a sequence of mechanical elements acting together to transmit a torque from an input element towards an output element thereby impairing a change of the torque and/or of the rotational speed between the input element and the output element. Preferably, a gear
35 arrangement according to the present invention comprises at least one gear wheel, more preferably a sequence of gear wheels meshing sequentially with each other. In the

inventive drive arrangement, the input element of the gear arrangement is meshing with the drive pinion while the output element acts on the transmission member, such that torque may be transferred from the drive pinion to the transmission element.

- 5 The upper end of the support structure preferably comprises an axial and/or radial bearing to support a milling table. The milling table is connectable to the rotatable transmission element, e.g. by means of bolts, screws or the like. Alternatively, a connection between the milling table and the transmission element may also be realized by a set of interlocking teeth. Hence, a torque of the transmission element is directly
10 transmitted to the milling table by means of these inter-fitting teeth.

Most preferably, the support structure comprises an axial and a radial bearing for a milling table, preferably both of the friction type. Most preferably, both the axial and the radial bearings are located close to another, the radial bearing being located further
15 towards the lower end of the support structure, such that excess lubricant applied to the axial bearing by a lubrication system automatically flows towards the radial bearing.

The transmission element is preferably located between the upper end and the lower end of the support structure. Most preferably, the transmission element is located in the
20 upper half of the support structure, i.e. between the upper end and a plane being located halfway between the upper end and the lower end. In the case where a milling table is directly supported by the support structure at the upper end it is mostly preferred that the transmission element is arranged in an area close to said upper end.

- 25 Preferably, the transmission element is provided as a toothed ring rotatably arranged on the support structure. A toothed ring has the advantage that an output gear wheel of the at least one gear arrangement may mesh with the teeth of the toothed ring such as to transmit torque from the gear arrangement to the transmission element.

- 30 The toothed ring is rotatably supported by the support structure by means of any suitable bearing, like a roller bearing or a friction bearing. Most preferably, the toothed ring comprises teeth arranged on an inner circumference which may mesh with complimentary teeth arranged on a milling table. Further preferably, the toothed ring comprises teeth arranged on its outer circumference such as to mesh with a gear wheel
35 or any other toothed element coupled with said at least one gear wheel.

Alternatively, the transmission element might be in the form of an output shaft of the at least one gear arrangement which may be connected to a milling table. Further alternatively, the transmission element might also be provided as gear wheel acting on a gear rack located on an underside of a milling table.

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The motor is arranged within the support structure such that the drive pinion is oriented towards the lower end, i.e. when the lower end is placed on a fundament or on the ground the motor is arranged upside down. Preferably, the motor is arranged such that the rotation axis of the rotor of the motor is vertical, i.e. at a right angle with the fundament or ground.

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This has the advantage that the motor may be easily inserted and removed from the support structure in a vertical direction, e.g. through a central opening of the toothed ring and/or of a milling table. As no part of the support structure or the at least one gear arrangement has to be removed to insert or remove the motor, this greatly facilitates the replacement of the motor and/or the assembly of the drive arrangement.

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The drive pinion is coupled to the transmission by means of at least one gear arrangement. Said gear arrangement preferably comprises a cascade of gear wheels meshing with each other. This allows providing a gear ratio between the drive pinion and the transmission element. As the motor and hence the drive pinion typically have a rotation speed of 300 RPM to 1'800 RPM, this speed has to be reduced in order for the mill to carry out the milling operation. Hence, the at least one gear arrangement provides for a reduction of the rotational speed.

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At least one gear wheel of the at least one gear arrangement is preferably arranged below the motor, i.e. between the motor and the lower end, such as to be substantially at a same level as the drive pinion in relation to the distance between the upper and the lower end of the support structure. Hence, this at least one gear wheel may mesh with the drive pinion.

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Alternatively, a planetary drive may be arranged between the drive pinion and the at least one gear arrangement. Provision of a planetary drive allows a further increase of the gear ratio while maintaining relatively small dimensions of the mill drive.

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By locating at least one gear wheel of the at least one gear arrangement beneath the motor, it is possible to provide a high gear ratio without increasing the diameter or height of the mill drive arrangement. This allows further reducing the overall dimensions of the mill drive, hence resulting in a more compact configuration of the drive.

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All elements of the inventive mill drive associated with the transmission of torque, i.e. all elements making up the at least one gear arrangement are preferably supported by roller bearings, which do not experience any load in the axial direction with the exception of the weight of the supported element itself. Use of roller bearings allows minimizing the loss of power caused by friction of the various bearings. Preferably, all bearings are connected with a lubrication system, preferably an oil lubrication system.

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Further, the support structure preferably comprises sensors to monitor the operational state of various elements, such as parameters of the motor, temperatures of various gear parts or the like. The sensors may be of any useful type for the parameter to monitor, such as temperature sensors, infrared sensors, cameras, vibration sensors, pressure sensors, distance sensors, etc.

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Preferably, the at least one gear arrangement comprises at least one shaft. The shaft is preferably arranged parallel to the motor.

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In the case that the transmission element is arranged closer to the upper end than the drive pinion, an appropriate transmission of torque between the drive pinion and the transmission element is provided by the at least one shaft, i.e. the at least one shaft bridges the gap between the drive pinion and the transmission element in the vertical direction. Placing the at least one shaft parallel to the motor allows to keep the drive arrangement compact.

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Depending on the overall configuration of the drive arrangement, more than one shaft may be arranged sequentially such as to bridge a gap between the drive pinion and the transmission element, the shafts being coupled to each other such as to transmit torque from the drive pinion to the transmission element, e.g. by means of toothed portions meshing with each other. As such, a sequence of shafts having toothed portions meshing with each other may further contribute to the overall gear ratio of the drive arrangement.

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Preferably, the support structure comprises a radial bearing for a milling table. Said radial bearing further comprising a central opening within which the motor is at least partially arranged.

5 With this configuration, the assembly of the drive arrangement as well as the maintenance of the motor is facilitated, as the motor may be easily moved into and out of the drive arrangement without the need to remove any other part of the drive arrangement. This may be performed e.g. by coupling an upper end of the motor to a crane or winch and subsequently lifting the motor out of or inserting the motor into the
10 drive arrangement by a vertical motion of the crane or winch. Further, it is also possible to access the upper end of the motor for maintenance work, e.g. through a hatch provided in the milling table.

Further preferably, said drive pinion is coupled to said toothed ring by means of more
15 than one gear arrangement, each of these gear arrangements being separately coupled to said transmission element.

This allows dividing the torque amongst a plurality of separate gear arrangements. Splitting of the torque amongst several gear arrangements allows reducing the
20 dimensions of the gear wheels and/or shafts used in each gear arrangement compared to the case where a single gear arrangement is used, as the torque transmitted by each gear arrangement is considerably smaller than the overall torque transmitted from the drive pinion to the transmission element. Hence, this further contributes in keeping the drive arrangement as compact as possible and further allows to reduce the cost of
25 manufacture of the elements used in the drive arrangements, as the dimensions of the gear wheels and/or shafts may be made smaller.

Preferably, the drive pinion is coupled to said transmission element by means of two to twelve, preferably of three to eight gear arrangements.

30 Hence, the overall torque may be divided to a multitude of separate gear arrangements. The total number of gear arrangements used in connection with the inventive drive arrangement is restricted by the dimensions of the drive arrangement and the size of the drive pinion, as the gear arrangements have to be arranged in such a way one to each
35 other that no interference of the gear wheels and/or shafts used for every gear arrangement occurs. As such, it is preferred to use three to eight gear arrangements

each separately coupling the drive pinion with the transmission element. Most preferably, six gear arrangements are used.

5 Preferably, each gear arrangement comprises more than one gear train, each gear train coupling the drive pinion to the transmission element.

10 A "gear train" is understood in the present application as a sequence of elements capable of transmitting torque between the drive pinion and the transmission element and being placed sequentially one after the other. As such, a gear train is similar to a gear arrangement, however constitutes a subdivision of the latter. Hence, the torque carried by a single gear arrangement may be further divided to be carried by a multitude of gear trains arranged within said gear arrangement.

15 For example, a gear arrangement may comprise a first gear wheel meshing with the drive pinion. This first gear wheel further meshes with two second gear wheels, each of these second gear wheels being coupled to the transmission element by a separate cascade of gear elements sequentially coupled to each other. Hence, the torque carried by this gear arrangement is separated into two distinct gear trains.

20 The further division of the torque to be carried within a single gear arrangement by more than one gear train allows for further reduction of the dimensions of the elements used in the gear trains, as each gear train has to transmit substantially less torque than if a gear arrangement with only one gear train was used. This therefore further allows a reduction in size of the drive arrangement thus resulting in a more compact configuration of the drive arrangement.

25 Preferably at least one coupling is arranged in the at least one drive arrangement, said coupling being preferably a dynamic coupling of the friction or multiple plate type.

30 With drive arrangements relying on multiple gear arrangements and/or gear trains it is crucial to synchronize the timing of each gear arrangement and/or gear train, such that the output elements of each gear arrangement and/or gear train are synchronously coupled with the transmission element. Otherwise, the distribution of torque amongst the gear arrangements and/or gear trains might be unequal, leading to a higher strain on some gear arrangements and/or gear trains. Further, by having an asynchronous coupling of different gear arrangements and/or gear trains with the transmission element,

one gear arrangement and/or gear train might even impair a breaking force on the other gear arrangements and/or gear trains leading to higher abrasion of the elements in the gear arrangements and/or trains or even damaging some elements within a gear arrangement and/or train.

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The couplings may be configured such as to slip when a certain predefined torque is exceeded. This helps to avoid any damage to the elements of a specific gear arrangement and/or train in the case that an unusual high torque is applied. Additionally, by providing such a predefined torque, an automatic timing of multiple gear arrangements and/or trains may be achieved, as the coupling of any asynchronous gear arrangement and/or train will slip until the predefined torque is reached where the gear arrangement and/or train will be synchronous with the other gear arrangements and/or trains. Further preferably, the dynamic couplings may comprise means, such as a hydraulic system to adjust the predefined torque.

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Preferably, a water-tight sealing is provided between said motor and said support structure at the face of the motor facing said second end.

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This allows the use of a water cooling system for the motor. Any pipes needed to deliver or remove water to and from the motor may be lead to the motor either between the elements of the gear trains or from the upper end of the support structure.

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Use of water as a coolant reduces the cost for the mill drive, as such cooling systems are simple and require less maintenance as comparable cooling systems. The water tight sealing thereby avoids any leaking of water toward the drive pinion and the at least one gear wheel.

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Preferably, the support structure is comprised of several elements stacked one upon the other.

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This allows a modular construction of the mill drive. For example, a first element comprising a first set of elements of gear arrangements and/or gear trains located between the second end and the motor may be arranged first on a suitable fundament or ground. After that, further elements of the gear arrangements and/or gear trains comprising the at least one shaft may be arranged on top of the first element. Last, an element comprising the transmission elements as well as a radial bearing for a milling

table may be put on top of the structure. Lastly, a motor is then inserted from the upper end into the support structure and the drive pinion of said motor is then fitted in a meshing manner with the input elements of the gear arrangements located in the first element of the support structure. As such, a mill drive according to the present invention
5 may be pre-fabricated and the elements transported separately to the location of the mill, where they may be re-assembled in a time-saving manner. Further, multiple configurations of mill drives may be realized by using a set with a defined number of pre-fabricated elements.

- 10 Another aspect of the present invention is a mill, preferably of the vertical roller type comprising a mill drive according to the present invention.

The mill preferably comprises a milling table which is rotatably supported on or above the drive arrangement by an axial bearing including a central axial bearing opening and
15 the milling table preferably comprises a central access milling table opening.

The mill preferably comprises a central access milling table opening which is substantially concentric with said central opening of the axial bearing.

- 20 This offers the advantage that service or technical personnel may easily access the electric motor arranged within the drive arrangement. Thus this facilitates any maintenance or repair works on the motor through the central access milling table opening and the central opening of the axial bearing without removing the milling table from its position above the drive arrangement.

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- Further preferably, the mill comprises a closable hatch for closing the access opening in a sealing manner during the operation of the mill. Hence, the access opening may be closed in a sealing manner during the operation of the mill by closing the closable hatch, thus avoiding the contamination of the drive arrangement and/or the motor with debris of
30 the milling operation.

The access opening of the milling table and the central opening of the axial bearing are preferably shaped and dimensioned such that the electric motor of the drive arrangement may be passed through the access opening and the central opening.

- 35 Further preferably, the mill comprises a motor housing extending into a milling chamber above the grinding level of the grinding table. Hence, the electrical motor may extend

through the access openings of the milling table and the axial bearing of the milling table and into a centre portion of the milling chamber, such that very long electrical motors may be used. The function of the motor housing is to close of the access opening in a sealing manner during the operation of the mill by closing the motor housing, thus
5 avoiding the contamination of the drive arrangement and/or the motor with debris of the milling operation.

Preferably, the motor housing comprises a motor housing closable hatch. Hence the motor housing and the access opening may be closed in a sealing manner during the
10 operation of the mill by closing the motor housing closable hatch, thus avoiding the contamination of the drive arrangement and/or the motor with debris of the milling operation, while still having the ability to enter the motor housing for maintenance.

Preferably, the motor housing is fixedly connected to the milling table for closing the
15 access opening in a sealing manner during the operation of the mill.

Such a configuration of both openings greatly facilitates the assembly of the mill as well as any replacement or repair of the electric motor, since the electric motor may simply be inserted into or removed from the drive arrangement by a translocation of the electric
20 motor in the vertical direction, e.g. by means of a crane. Further, since the drive pinion is oriented towards the lower end of the drive arrangement and hence is coupled to the at least one gear arrangement below the core of the electric motor, no element of the at least one gear arrangement needs to be disassembled such as to remove the motor. Rather, the drive pinion may simply be extracted from the meshing connection with the
25 at least one gear arrangement. Consequently, it is also simple to place a new or repaired motor into the drive arrangement of the mill, since the motor may be inserted into the gear arrangement through the access and central openings, while the drive pinion will glide in its meshing connection with the at least one gear arrangement. Furthermore, electrical motors may be very extensive in length since the electrical motors may reach
30 through a central portion of the milling table.

Other advantageous embodiments and combinations of features come out from the detailed description below and the totality of the claims.

35 ***Brief description of the drawings***

The drawings used to explain the embodiments are:

Fig. 1 is a schematic cut view through an inventive drive arrangement;

Fig. 2a, b are schematic representations of two different gear arrangement
5 configurations of a drive arrangement according to Fig. 1;

Fig. 3 is a schematic cut view through a second embodiment of an inventive drive arrangement with couplings;

10 Fig. 4a, b, c are schematic representations of different gear arrangement configurations;

Fig. 5 shows an embodiment of a drive arrangement with a water cooled electric motor;

Fig. 6 is a configuration of gear arrangements with two gear trains per gear
15 arrangement;

Fig. 7 shows an embodiment of a drive arrangement with an additional planetary gear.

In the figures, the same components are given the same reference symbols.

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Preferred embodiments

Fig. 1 shows a cut view of a schematic representation of an embodiment of a drive arrangement 1 according to the present invention. The drive arrangement 1 comprises a
25 support structure 2, which is provided in the form of three stacked elements 21, 22, 23.

All elements of the drive arrangement 1 are supported by at least one of these stacked elements 21, 22, 23. The support structure includes an upper end 35 and a lower end 36. An axial bearing 13 supporting a rotating flange 15 which in turn may support a
30 milling table 20 is arranged on the third stacked element 23 at the upper end 35 of the support structure 2.

Further, an electric motor 3 is arranged centrally within the support structure 2. The electric motor 3 comprises a drive pinion 4. The electric motor 3 is arranged within the
35 support structure 2 in such a way that the drive pinion 4 is oriented towards the lower

end 36, i.e. the electric motor 3 is placed within the support structure 2 in an upside down manner.

The drive pinion 4 is coupled with a transmission element 10 by means of two gear arrangements 171, 172. Each gear arrangement 171, 172 comprises a first gear wheel 51, 52, a shaft 61, 62 as well as a second gear wheel 71, 72, 73, 74, respectively. The first gear wheels 51, 52 constitute an input element of each gear arrangement 171, 172 and mesh with the drive pinion 4. To enable the meshing of the first gear wheels 51, 52 with the drive pinion 4, both first gear wheels 51, 52 are arranged in the same plane as the drive pinion 4, i.e. they are located between the electric motor 3 and the lower end 36 of the support structure 2.

The first gear wheels 51, 52 are each connected to a shaft 61, 62 being arranged parallel to the electric motor 3. The shafts 61, 62 thereby bridge a gap between the plane in which the drive pinion 4 is located and a plane in which the transmission element 10 is located. On their upper ends, both shafts 61, 62 are connected with a second gear wheel 71, 72, 73, 74 each.

The second gear wheels 71, 72, 73, 74 are coupled to the transmission element 10. The transmission element 10 includes a toothed ring 11 meshing with both second gear wheels 71, 72, 73, 74. Hence, the second gear wheels 71, 72, 73, 74 constitute the output elements of both gear arrangements 171, 172. The toothed ring 11 is connected to the rotating flange 15 by means of an intermediate element 12. The toothed ring 11 and the intermediate element 12 together constitute the transmission element 10 which is connectable to the milling table 20 via the rotational flange 15.

On the inner side of the third stacked element 23 a radial bearing 14 is provided which allows a rotation movement of the intermediate element 12 relative to the third stacked element 23.

Further, the axial bearing 13 of the drive arrangement 1 comprises a central opening 33 through which the electric motor 3 may be moved in a vertical direction. Additionally, the milling table 20 comprises an access opening 34 which is concentric with the central opening 33. The access opening 34 may further comprise a closable hatch (not shown) such as to close the access opening in a sealing manner to avoid any debris from the milling operation to damage the electric motor 3. Provision of these two concentric

openings 33, 34 facilitates access to the motor by maintenance or repair personnel and provides for a simple and quick removal or insertion of the electric motor 3.

Fig. 2 shows two different configurations of a drive arrangement 1 as shown in Fig. 1 in a schematic manner viewed from the lower end 36 of the drive arrangement 1. The configuration as shown in Fig. 2a comprises two gear arrangements 171, 172. Each gear arrangement 171, 172 comprises a first gear wheel 51, 52 meshing with the drive pinion 4. Both first gear wheels 51, 52 are connected via a shaft 61, 62 (not shown on Fig. 2a) to a second gear wheel 71, 72, 73, 74. The second gear wheels 71, 72, 73, 74 mesh with the toothed ring 11 of the transmission element 10.

Fig. 2b shows a configuration comprising three gear arrangements 171, 172, 173. Each gear arrangement 171, 172, 173 includes a first gear wheel 51, 52, 53, 54 meshing with the drive pinion 4. The first gear wheels 51, 52, 53, 54 are connected by means of shafts (not shown in this figure) to second gear wheels 71, 72, 73, 74. The second gear wheels 71, 72, 73 are meshing with the toothed ring 11 of the transmission element 10.

Fig. 3 shows a second embodiment of an inventive drive arrangement 1 according to the present invention. The drive arrangement 1 comprises a support structure 2 including three elements 21, 22, 23 stacked one on the other and fixed together by appropriate means, like e.g. bolts or screws. An electric motor 3 is centrally placed within the support structure 2, said motor having a drive pinion 4 oriented towards a lower end 36 of the support structure 2. The drive pinion 4 meshes with two first gear wheels 51, 52 of two gear arrangements 171, 172 coupling said drive pinion 4 to a transmission element 10 located in the area of an upper end 35 of the support structure 2 such as to transmit torque between the drive pinion 4 and the transmission element 10. The first gear wheels 51, 52 each mesh with second gear wheels 71, 72. The second gear wheels 71, 72, 73, 74 of both gear arrangements 171, 172 are each connected to a dynamic coupling 91, 92. The dynamic couplings 91, 92 allow to synchronize the timing of both gear arrangements. Access to the dynamic couplings is provided by openings 161, 162 provided on an outside wall of the first stacked element 21. The dynamic couplings 91, 92 are each connected to a shaft 61, 62. The shafts 61, 62 are provided with a third gear wheel 81, 82, 83, 84 each at their end oriented towards the upper end 35 of the support structure 2. Said third gear wheels 81, 82, 83, 84 mesh with a toothed ring 11. The toothed ring 11 together with an intermediate element 12 constitutes the transmission element 10 which is connectable to a milling table 20 via a rotating flange 15. The third

stacked element 23 comprises an axial bearing 13 which rotatably supports the flange 15. Further, a radial bearing 14 is provided between the intermediate element 12 and an inner circumference of the third stacked element 23.

5 Figs. 4a, 4b and 4c show different configurations of gear arrangements of an inventive drive arrangement, preferably used in connection with the embodiment as shown on Fig. 3. In Fig. 4a a drive arrangement comprising two gear arrangements 171, 172 is shown. Each gear arrangement 171, 172 comprises a first gear wheel 51, 52 meshing with the drive pinion 4. The first gear wheels 51, 52 each mesh with a second gear wheel 71, 72,
10 73, 74 which each are connected to a third gear wheel 81, 82, 83, 84, e.g. via a shaft 6 and/or a dynamic coupling 9. The third gear wheels 81, 82, 83, 84 mesh with a toothed ring 11 of a transmission element 10.

Fig. 4b shows a configuration according to Fig. 4a with three distinct gear arrangements
15 171, 172, 173 instead of two. Fig. 4c depicts a configuration according to Fig. 4a, however with four separate gear arrangements 171, 172, 173, 174 coupling the drive pinion 4 with the toothed ring 11 of the transmission element 10. The reference signs refer to the same element e.g. first gear arrangement 17 and the suffix 1, 2, 3, 4 identifying the respective gear arrangement 171, 172, 173, 174 each element belongs to.
20 Fig. 5 shows a further embodiment of a drive arrangement 1 according to the present invention. The drive arrangement 1 comprises a support structure 2 which includes four elements 21, 22, 23, 24 stacked one upon the other, hence one internal stacked element 24 more than the embodiments as shown on Figs. 1 and 3. Again an electric motor 3 is arranged centrally within the support structure 2, the electric motor 3 having a drive
25 pinion 4 and being arranged such that the drive pinion 4 is oriented towards a lower end 36 of the support structure.

In this embodiment, the electric motor 3 comprises a fluid cooling which is connected to a connection box 28 arranged on the outside of a circumferential wall of a first stacked
30 element 21 by means of a duct 27. The connection box 28 allows linking the drive arrangement 1 to an external power and/or coolant fluid supply. The duct 27 is arranged such as to fit between the elements of a gear arrangement. Further, the duct 27 is led to the electric motor 3 from a side facing the upper end 35. Duct 27 is configured such as to carry electricity as well as a coolant fluid to the electric motor 3. Further, duct 27 may
35 also be configured to pump out the coolant fluid from the coolant system of the electric motor 3. A person having skill in the art will understand that a multiplicity of ducts 27 may

be employed, e.g. one duct carrying electrical wires while another duct carries a coolant fluid. Preferably the coolant fluid is water. However, any other suitable coolant fluid may also be used.

- 5 Such as to ensure that no coolant fluid leaks to other parts of the drive arrangement 1, the motor 3 is surrounded by an additional, circumferential fluid barrier 26 which is realized in the form of walls encasing the motor 3. As the motor 3 is arranged onto the internal stacked element 24, a fluid tight sealing is formed between the motor and the internal stacked element 24, thus avoiding the leakage of water or coolant fluid from the
10 motor 3 to elements of the drive arrangement 1 located between the electric motor 3 and the lower end 36.

- The drive pinion 4 meshes with two first gear wheels 51, 52 of two different gear arrangements 171, 172 of the drive arrangement 1. In turn, each of the first gear wheels
15 51, 52 meshes with a second gear wheel 71, 72, 73, 74 which are each coupled to a shaft 61, 62. At the end of each shaft 61, 62 a pinion 241, 242 is located, each pinion 241, 242 meshing with a third gear wheel 81, 82, 83, 84. The third gear wheels 81, 82, 83, 84 are connected with a second shaft 251, 252 which each is bearing a fourth gear wheel 231, 232. Alternatively, the fourth gear wheels 231, 232 may be unitary with the
20 second shafts 251, 252, i.e. made of a single piece. The fourth gear wheels 231, 232 are meshing with a toothed ring 11 of a transmission element 10. The transmission element further comprises an intermediate element 12 which transmits torque to an output flange 15 which is connected to a milling table 20.

- 25 The embodiment according to Fig. 5 therefore provides for an additional gear stage compared to the embodiments shown in Figs. 1 and 3. This allows providing a higher gear ratio. All gear wheels 51, 52, 71, 72, 73, 74, 81, 82, 83, 84, 231, 232 as well as all shafts 61, 62, 251, 252 are connected to the support structure 2 by means of roller bearings.

- 30 Further, it is to be noted that the embodiment of the drive arrangement 1 of Fig. 5 might also comprise dynamic couplings 91, 92 as exemplarily shown in Fig. 3.

- Again, the third stacked element 23 located at an upper end 35 of the support structure 2
35 comprises an axial bearing 13 for the output flange 15 as well as a radial bearing 14

allowing a relative motion between the intermediate element 12 and an inner circumference of the third stacked element 23.

Fig. 6 shows a schematic configuration of an embodiment of the drive arrangement 1 according to the present invention where the torque transmission in the gear arrangements is further divided amongst two separate gear trains. For reasons of clarity, only the gear elements of a first gear arrangement 17 out of three gear arrangements present in total have been included in the figure.

10 A first gear wheel 5 meshes with the drive pinion 4. Two second gear wheels 7a, 7b mesh with the first gear wheel 5. Hence, the transmission of torque in the gear arrangement 17 is divided to two distinct gear trains. Torque transmission is schematically shown by the torque transmission line 18, which shows a division of the torque transmission at the first gear wheel 5. The two second gear wheels 7a, 7b are
15 both coupled to a third gear wheel 8a, 8b each, e.g. by means of a shaft or coupling. The third gear wheels 8a, 8b mesh with a fourth gear wheel 23a, 23b each, said fourth gear wheels 23a, 23b being coupled to a fifth gear wheel 29a, 29b, e.g. by means of a shaft or coupling. Finally, the fifth gear wheels 29a, 29b mesh with a toothed ring 11 of a transmission element 10.

20

The configuration as shown in Fig. 6 is exemplary. Alternative configurations may be used. E.g. more than three gear arrangements may be arranged within the drive arrangement 1, such as four, five or more gear arrangements 17. Each gear arrangement 17 may comprise a further division to more than two gear trains, such as
25 three, four or more gear trains. Also, the individual elements making up a gear arrangement 17 may be arranged in alternative configurations within the drive arrangement 1.

Fig. 7 shows a further embodiment of an inventive drive arrangement according to the present invention. In this embodiment, an additional planetary drive is arranged between
30 the drive pinion 4 and the first gear wheels 51, 52 of the two gear arrangements 171, 172. The planet wheels 32 of the planetary gear 30 are connected to an output shaft 31 with which the first gear wheels 51, 52 are meshing.

35 Otherwise, the drive arrangement 1 is of a similar configuration as the drive arrangement 1 shown on Fig. 1. The first gear wheels 51, 52 each mesh with second gear wheels 71,

72, 73, 74 which are coupled to a shaft 61, 62. On the output side of the shaft a third gear wheel 81, 82, 83, 84 is arranged, said third gear wheels 81, 82, 83, 84 meshing with a toothed ring of a transmission element 10 to which a milling table 20 is fixed via a rotating output flange 15.

5

A person having skill in the art will recognize that a planetary gear 30 may also be used in connection with any of the other embodiments of a drive arrangement 1 as disclosed in the present application.

Claims

1. Drive arrangement (1) for a mill, comprising:
- a support structure (2) including an upper end (35) and a lower end (36);
 - 5 -an electric motor (3) arranged within said support structure (2), said motor (3) comprising a drive pinion (4);
 - at least one gear arrangement (17) being located within said support structure (2) and being coupled with said drive pinion (4);
 - a rotatable transmission element (10) being arranged on the support structure (2),
 - 10 said transmission element (10) being coupled to said gear arrangement (17) and being connectable to a milling table (20);
- characterized in that**
- said motor (3) is arranged within said support structure (2) such that the drive pinion (4) is oriented towards said lower end (36).
- 15
2. The drive arrangement according to claim 1, **characterized in that** the at least one gear arrangement (17) comprises at least one shaft (61, 62), said shaft (61, 62) preferably being arranged parallel to the electric motor (3).
- 20
3. The drive arrangement according to any of claims 1 or 2, **characterized in that** said support structure (2) comprises an axial bearing (13) for a milling table (20) and said electric motor (2) is at least partially arranged within a central opening of said axial bearing (13).
- 25
4. The drive arrangement according to any of claims 1 to 3, **characterized in that** said drive pinion (4) is coupled to said transmission element (10) by means of more than one gear arrangement (17), each of these gear arrangements (171, 172, 173, 173) being separately coupled to said transmission element (10).
- 30
5. The drive arrangement according to claim 4, **characterized in that** the drive pinion (4) is coupled to said transmission element (10) by means of two to twelve, preferably of three to eight gear arrangements (171, 172, 173, 174) coupled with said drive pinion (4).
- 35
6. The drive arrangement according to any of claims 4 or 5, **characterized in that** each gear arrangement (17) comprises more than one a gear train, each gear train coupling said drive pinion (4) to said transmission element (10).

7. The drive arrangement according to any of claims 1 to 6, **characterized in that** at least one coupling (91, 92) is arranged in said at least one gear arrangement (17), said coupling (91, 92) preferably being a friction or multiple plate coupling.
- 5 8. The drive arrangement according to any of claims 1 to 7, **characterized in that** a fluid tight sealing is provided between said motor (3) and said support structure (2) at the face of the motor (3) facing said lower end (36).
9. The drive arrangement according to any of claims 1 to 8, **characterized in that** the
10 support structure (2) is comprised of several elements (21, 22, 23, 24) stacked one upon the other.
10. Mill, preferably a vertical roller mill, comprising a drive arrangement (1) according to any of claims 1 to 9.

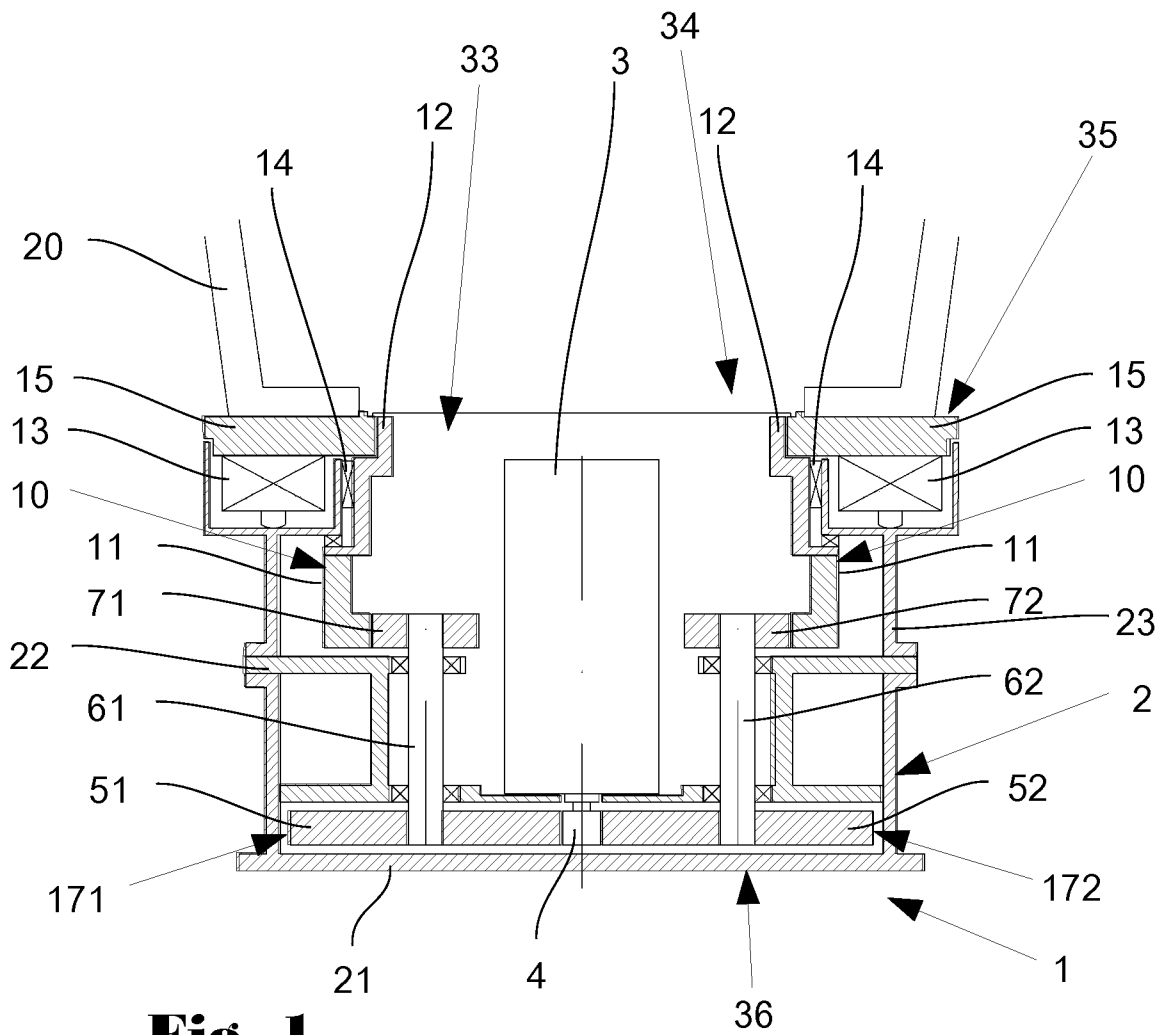


Fig. 1

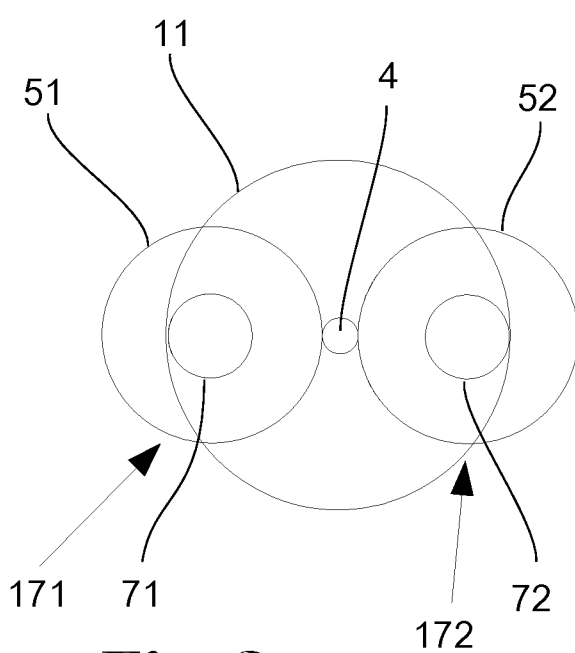


Fig. 2a

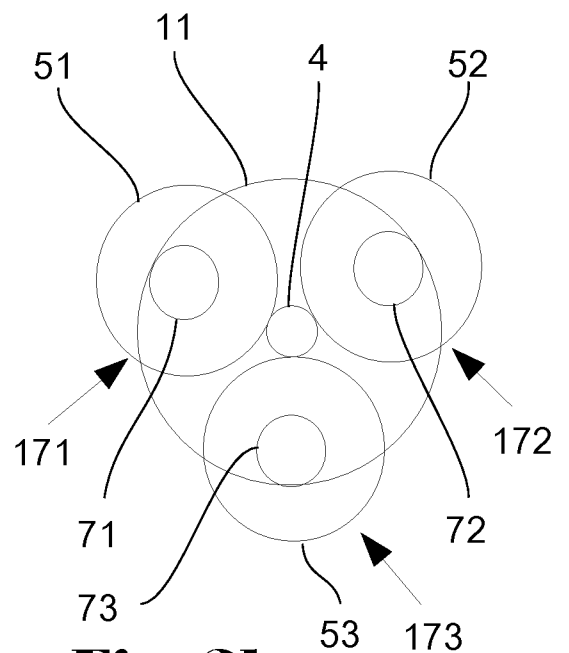
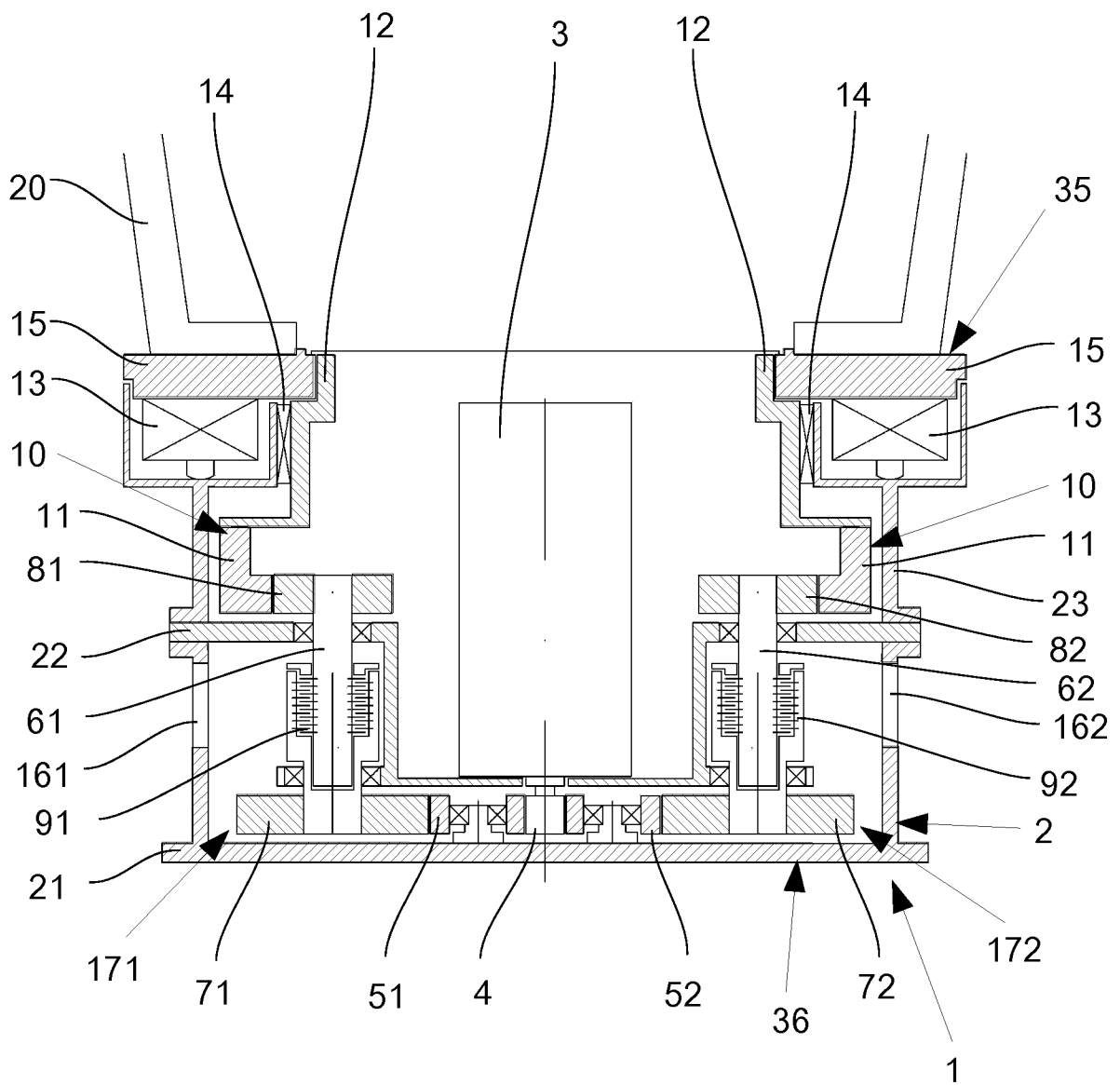


Fig. 2b

**Fig. 3**

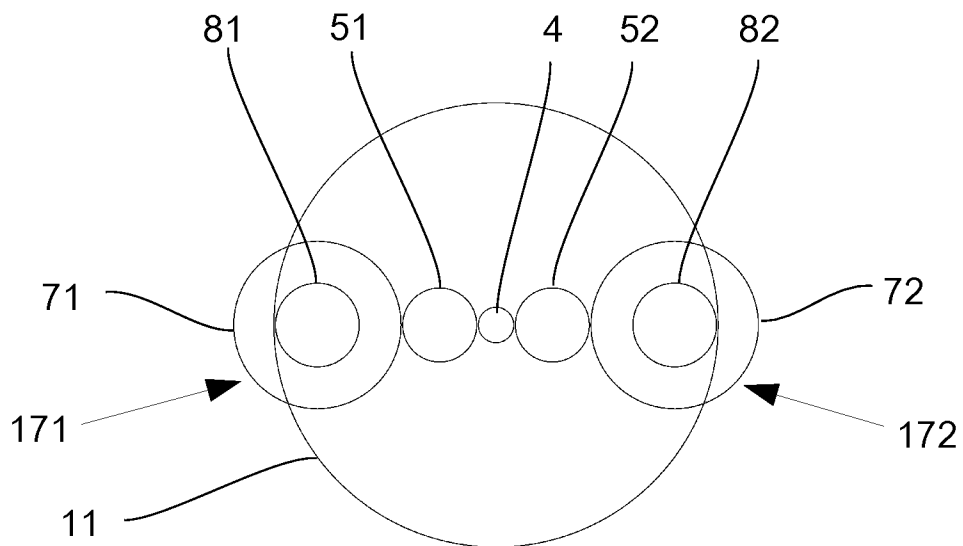


Fig. 4a

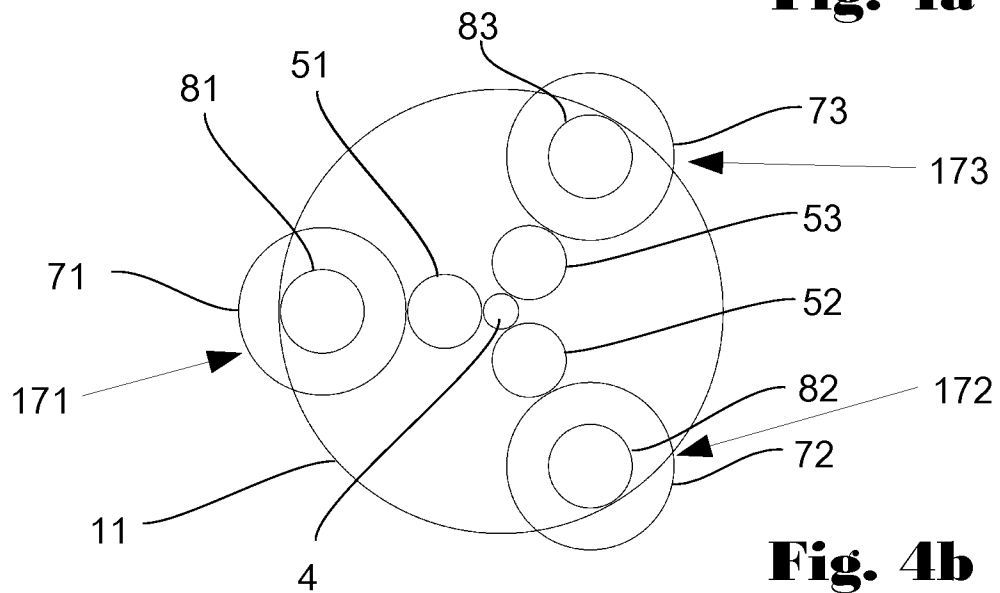


Fig. 4b

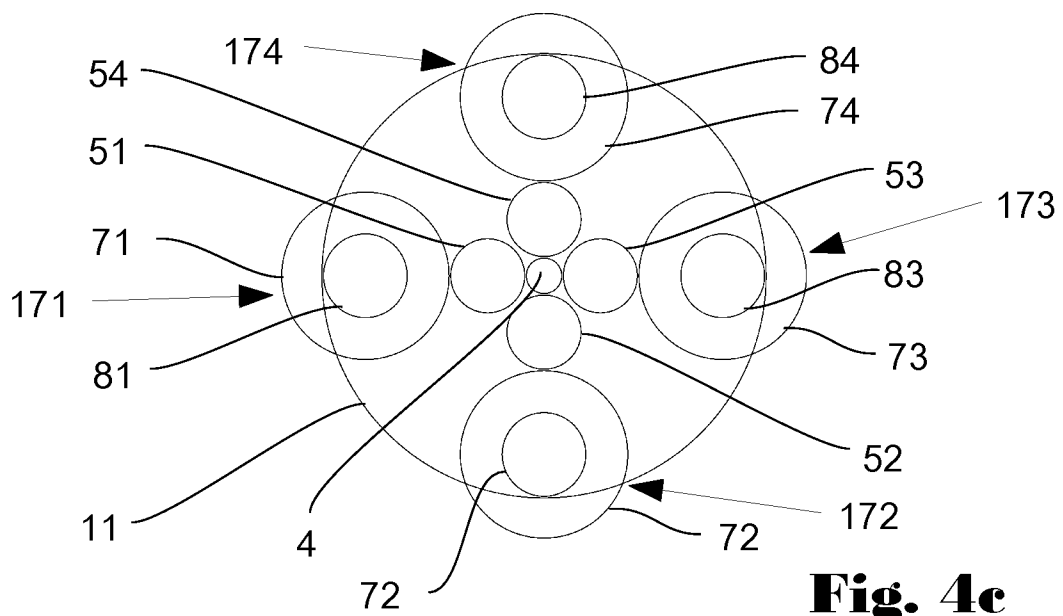
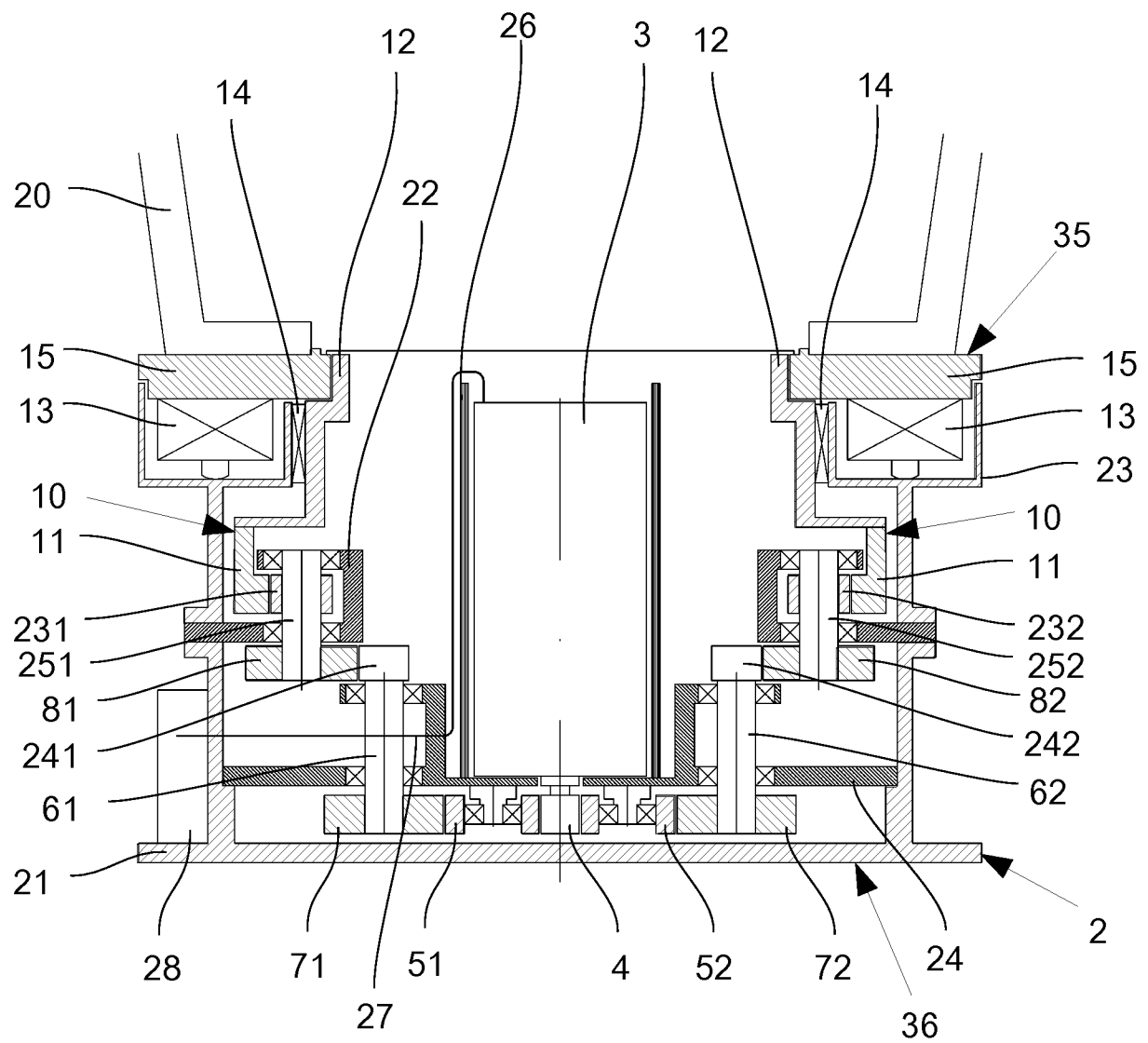
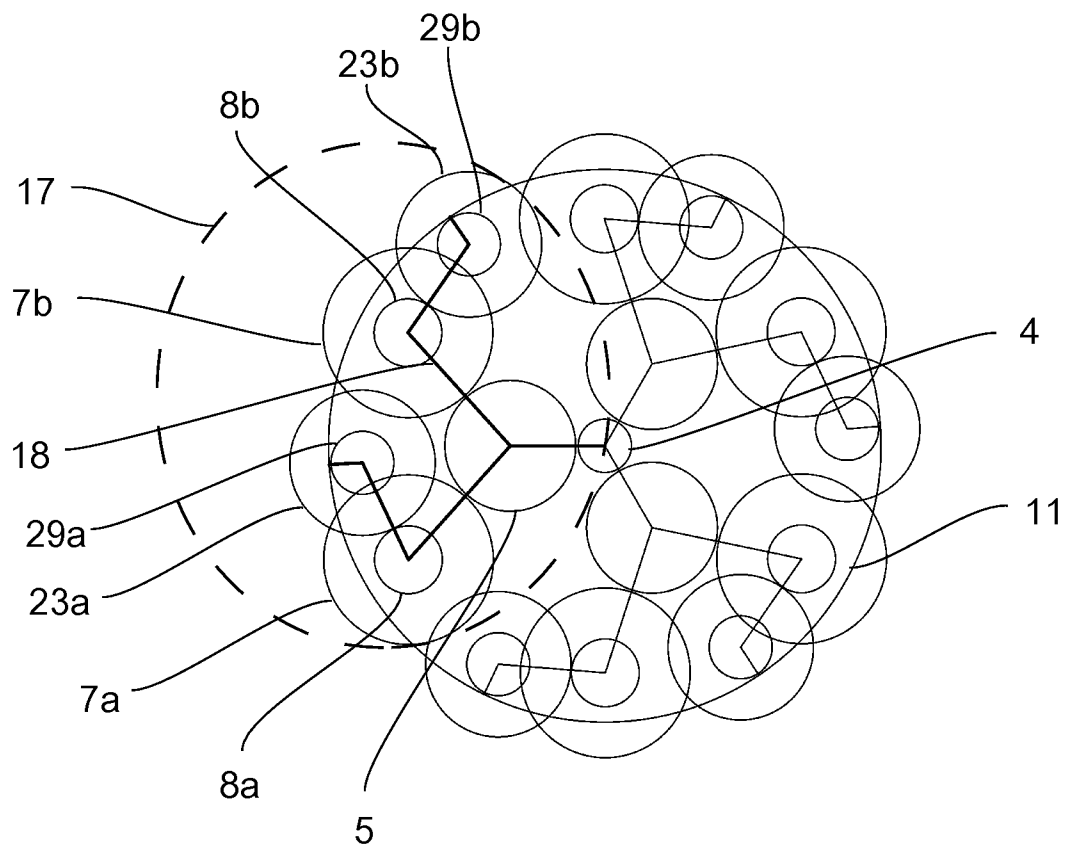


Fig. 4c

**Fig. 5**

**Fig. 6**

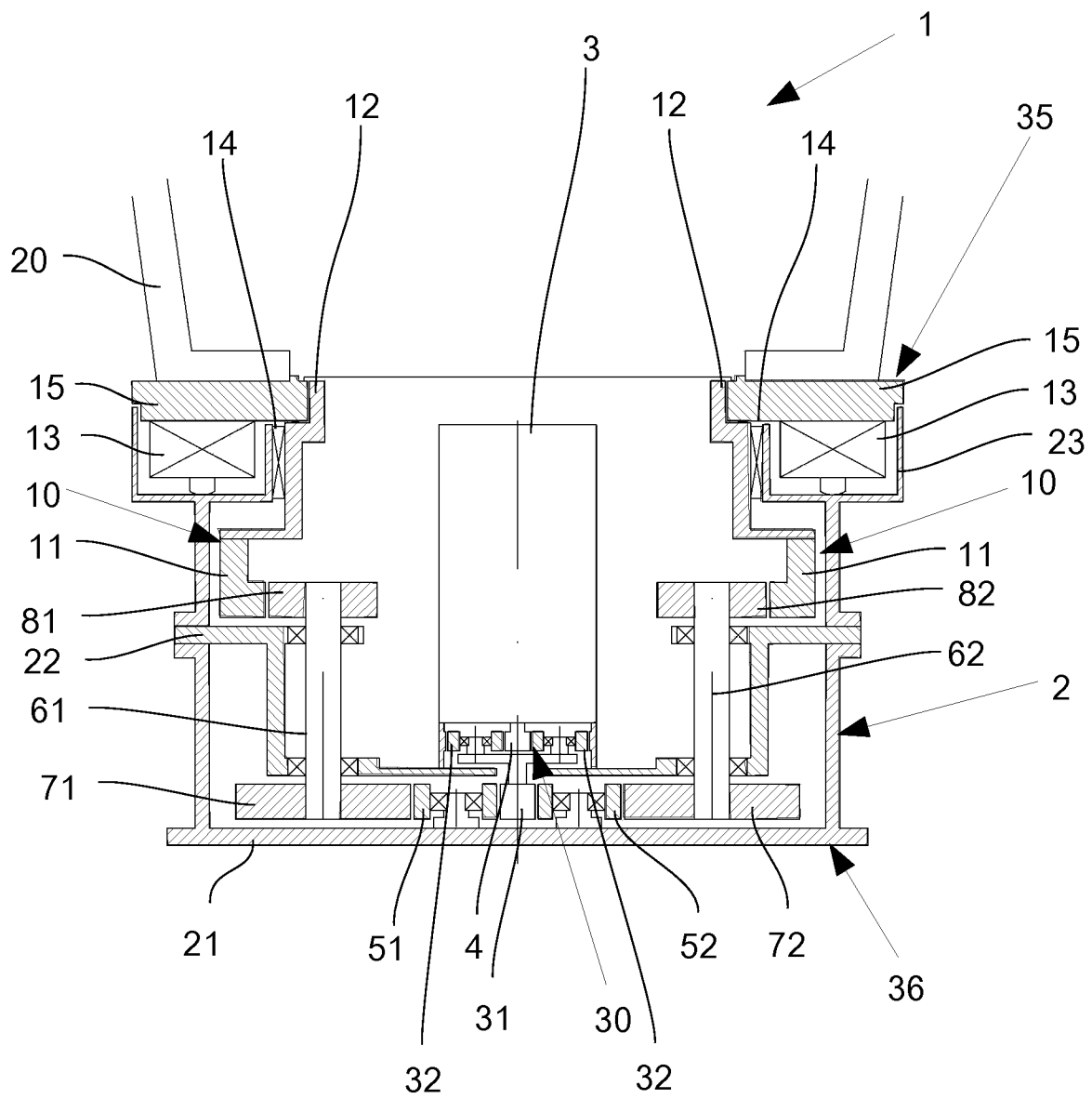


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2014/050439

A. CLASSIFICATION OF SUBJECT MATTER
INV. B02C15/00 F16H1/22
ADD.

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)
B02C F16H

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

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

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/020287 A1 (MAAG GEAR AG [CH]; RITTLER STEFAN [CH]) 25 February 2010 (2010-02-25) figure 1	1-3,7,10
A	----- SU 1 227 238 A1 (VNII TSEMENTNOGO MASH [SU]) 30 April 1986 (1986-04-30) abstract; figure 1	1,2,10
A	----- US 4 887 489 A (SIGG HANS [CH]) 19 December 1989 (1989-12-19) column 3, line 26 - column 4, line 59; figures 1,2	1,2,7,10
A	----- US 2013/008273 A1 (LESSARD FABRICE [FR]) 10 January 2013 (2013-01-10) paragraphs [0061], [0062], [0071] - [0074]; figures 1,2,7	1,2,4-6, 10

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Further documents are listed in the continuation of Box C.

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See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search

5 March 2015

Date of mailing of the international search report

16/03/2015

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/DK2014/050439

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010020287	A1	25-02-2010	AT 553847 T 15-05-2012
		CA 2734784 A1 25-02-2010	
		CN 102186592 A 14-09-2011	
		DK 2323771 T3 16-07-2012	
		EG 26414 A 22-10-2013	
		EP 2323771 A1 25-05-2011	
		JP 2012500714 A 12-01-2012	
		KR 20110059619 A 02-06-2011	
		MA 32649 B1 01-09-2011	
		RU 2011110524 A 27-09-2012	
		US 2011147508 A1 23-06-2011	
		WO 2010020287 A1 25-02-2010	

SU 1227238	A1	30-04-1986	NONE

US 4887489	A	19-12-1989	CH 672603 A5 15-12-1989
		CN 87107436 A 26-10-1988	
		DE 3712562 C1 05-05-1988	
		DK 156388 A 10-10-1988	
		FR 2613637 A1 14-10-1988	
		JP S63256145 A 24-10-1988	
		US 4887489 A 19-12-1989	

US 2013008273	A1	10-01-2013	AU 2011204514 A1 02-08-2012
		CA 2785407 A1 14-07-2011	
		CN 102770688 A 07-11-2012	
		DK 2521870 T3 11-08-2014	
		EP 2521870 A1 14-11-2012	
		ES 2488623 T3 28-08-2014	
		FR 2954964 A1 08-07-2011	
		JP 2013516584 A 13-05-2013	
		KR 20120110142 A 09-10-2012	
		PT 2521870 E 28-08-2014	
		RU 2012133466 A 20-02-2014	
		US 2013008273 A1 10-01-2013	
		WO 2011083274 A1 14-07-2011	
