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(54) Benævnelse: **PENDULARM TIL EN RULLEKOMPRIMATOR TIL KOMPRIMERING AF AFFALDSMATERIALER I EN ØVERSTE ÅBEN BEHOLDER**

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PENDULUM ARM FOR A ROLLER COMPACTOR FOR COMPACTING WASTE MATERIALS IN A CONTAINER WITH AN OPEN TOP

The invention relates to a pendulum arm for a roller compactor for compacting waste materials in an open-topped container, having the features of the preamble of claim 1.

EP 0 106 268 A1 shows a waste compacting device in which an approximately cylindrical container is provided, in the centre of which an axis is arranged. A driven roller member is arranged to be perpendicular to the axis. It is rotationally driven and runs around the axis on a circular path in the container.

Another roller compactor was first described by the applicant in DE 30 23 508 C1. A roller, which is guided at the end of a pendulum arm mounted in an articulated manner, causes the compaction. The rotation of the roller leads to the shifting of the near-surface layers of the waste in the container and enables their movement in the longitudinal direction of the container. The roller compactor is particularly suitable for dry waste with large hollow spaces such as bulky waste or wooden crates. The capacity of the container is significantly increased compared to uncompacted waste.

In further developments, as described for example in DE 20 2011 000 241 U1 and EP 2 808 161 A1, the carrier arm is positioned on a stand outside the container to be able to use the entire container volume for waste. This also makes it possible to use a stationary roller compactor with several interchangeable containers. Thus a two-part articulated arm is provided. The first part of the articulated arm, which is connected to the stand, can be raised via an actuator, such as a hydraulic cylinder, to lift the roller out of the container. A pendulum arm is connected to the other end thereof via a swivel joint, at the end of which the rotatable roller is in turn mounted. This causes the compaction solely due to its own weight, i.e. without any contact pressure from the arm. Up until now, the roller members have been driven by a hydraulic motor. To do this, a powerful hydraulic pump must be set up adjacent to the stationary part of the roller compactor. A hydraulic line is routed from there via the two-part articulated arm, of which the pendulum arm forms one end section, to the hydraulic motor inside the roller unit. Owing to the great length of the hydraulic supply and discharge lines, a large volume of hydraulic fluid must be kept in stock and circulated during operation. When the direction of rotation of the roller members is reversed, throttle valves are required to slow down the overtravel. Owing to the large moments of inertia that emanate from the roller members, they are also heavily loaded. The hydraulic fluid heats up accordingly, which reduces the viscosity and the power that can be brought into the waste dump via the roller unit decreases. Therefore,

either an additional temperature control in the oil circuit must be provided, or regular interruptions in operation are required for cooling. Especially when using the roller compactor in recycling yards in the vicinity of residential regions, the noise of the hydraulic unit has a disruptive effect. Finally, the assembly or disassembly of the roller unit is time-consuming since, among other things, the oil circuit must be emptied or filled before the hydraulic lines can be removed and the mechanical connection of the roller unit can be released.

The object of the invention is therefore to improve a pendulum arm of the type mentioned at the outset in such a way that the disadvantages mentioned during driving of the roller are eliminated.

This object is achieved by a pendulum arm for a roller compactor having the features of claim 1.

This pendulum arm is a self-sufficient unit so that it can be used to convert existing roller compactors with a pendulum arm. Together with a stand and an at least one-piece support arm, it forms a complete roller compactor.

The advantage consists in particular in the use of an electric drive, wherein the motor is arranged in the pendulum arm and a gearbox for reducing the speed is configured in the roller unit. Since an electric motor of the required power class of around 3 to 7.5 kW is designed for a speed of around 1500 rpm, but the roller members run very slowly at around 6 to 15 rpm, a high reduction in the gearbox is required.

The conversion to an electric drive has the advantage that only one electric control and supply line needs to be routed through the articulated arm to the roller, which alone has a smaller cross section than one of the two hydraulic lines in the prior art. The speed of the roller can be adjusted during operation via a frequency converter. For the first time, it is possible to measure the instantaneous drive power of a roller compactor, from which conclusions can be drawn in a control unit about the material being processed and the processing step of the roller compactor can be adjusted during ongoing operation.

The overtravel of the roller members when the drive is switched off is already reduced by the gearbox. In addition, the electric motor itself can be braked in a known manner. Owing to the fixed coupling of the electric motor and the gearbox, the instantaneous speed and the overtravel of the roller member can be easily captured in the control system without the need for speed sensors.

The special challenge when converting a roller unit for a roller compactor is that it can only have a very flat gearbox holder element, which is to be arranged between the roller members and can therefore hardly be more than twice the sheet metal thickness. The

gearbox holder element is designed to be as narrow as possible so that the interruption between the substantially cylindrical roller members — and thus the proportion of the peripheral surface over which the roller compactor cannot act on the waste — is as small as possible.

A drive and gearbox unit that extends radially to the outside of the roller and — as viewed from the outside — is arranged axially between the roller members would be too wide and would lead to disruptions in waste processing because waste could not be captured in the non-rotating region between the rollers.

Therefore, according to the invention, apart from the narrow marginal sections of the gearbox holder element, which must protrude between the roller members to establish a connection to the pendulum arm, all parts of the gearbox are accommodated within the hollow space of the adjacent roller members. These include the output shaft, the bearings therefor, and the flanges to which the roller members are attached. There is not enough space left inside the hollow space of the roller member to accommodate a conventional electric motor with a flange-mounted gearbox.

In addition, a specific requirement for a pendulum arm for a symmetrically constructed roller compactor with roller members on both sides of the gearbox holder element is that the mass distribution must be balanced with respect to an axis passing through the gearbox holder element. This is because the pendulum arm, hanging freely on the support arm, only works via the rotation of the roller. Thus, no lateral supporting forces can be applied via the articulated arm, of which the pendulum arm forms a part. Improper mass distribution in the roller unit results in a lateral bending moment loading of the swivel joint between the pendulum arm and the support arm, which cannot be designed for such loads without completely changing the basic design of the roller compactor.

Therefore, the solution according to the invention provides for arranging the electric motor not in the roller unit but in the pendulum arm, namely axially parallel to or even aligned with the central axis thereof, and also as low as possible on the pendulum arm. The gearbox is arranged separately from the motor within at least one hollow space in the roller members and forms a unit with the gearbox holder element that is also balanced in terms of mass distribution.

Furthermore, according to the invention, the gearbox is fastened to a flange which extends around a central recess in the gearbox holder element. The gearbox is thus positioned exactly in the centre of the roller unit.

It is also possible to merge the gearbox and the part of the gearbox holder element located between the roller members into one unit, i.e. for example to form the gearbox holder

element as one half of a gearbox housing.

The drive power is preferably transmitted between the engine and the gearbox via a drive shaft. In view of the high gearbox reduction that is usually required, the drive-side torque is rather low, so that the drive shaft can be made so thin in particular that it can be guided in a recess in the flat part of the gearbox holder element without protruding laterally out of it. This guidance of the drive shaft relates in particular to the section of the gearbox holder element between the end of the pendulum arm and the entry into the roller unit between the roller members.

To be able to achieve the high gear reduction that is usually necessary, a particularly space-saving design of the gearbox is necessary, since only a limited opening cross section is available within the hollow space of the roller members. As a first measure, in a preferred embodiment of a gearbox, a first gear wheel is connected directly to the continuous output shaft, which runs through the gearbox, and the gearbox holder element, namely the spur gear and the pinion engaging there are positioned between the bearings of the output shaft.

Furthermore, a pair of bevel gears is preferably arranged in the radial edge region of the gearbox housing. The rotation of the drive shaft is already deflected by 90° there, so that all subsequent gearbox stages in the gearbox can be oriented axially parallel to the output shaft.

The gearbox stages preferably each have a gear wheel and a pinion on a common shaft. The gear wheel and pinion are each alternately positioned on different sides of the median plane defined by the gearbox holder element.

According to the preferred embodiment of the invention, a satellite-like arrangement of the gearbox stages is provided, i.e. they are arranged to be next to one another in the annular space between the outer circumference of the output shaft and the inner circumference of the hollow space in the roller members. "Next to" here does not mean the arrangement in a linear manner, but — as viewed in the side view of the gearbox — along an arcuate or otherwise curved path. According to the invention, for example in a gearbox with three reduction stages, this arrangement extends between the first gearbox stage, which acts directly on the output shaft, and the inlet opening on the gearbox housing for the drive shaft over approximately 60° to 80°. Of the possible radial expansion within the roller member, only about 50% to 80% is occupied by the mentioned sector of the gearbox with the gearbox stages arranged in the manner of satellites. Accordingly, a sufficiently wide, annular region remains on the gearbox holder element, which extends around the central recess so as not to jeopardise the strength of the gearbox holder

element.

The invention is explained in more detail below with reference to an exemplary embodiment shown in the drawings. The figures show in detail:

Figure 1 shows a roller compactor for compacting waste materials in a side view;

Figure 2 shows a pendulum arm according to the invention having a roller unit, viewed from above;

Figure 3A shows the pendulum arm with a roller unit in a side view;

Figure 3B shows an enlarged detail of figure 3A;

Figure 4 shows a side view of a gearbox with a view of the central plane;

Figure 5 shows a plug-in coupling on the gearbox in section; and

Figure 6 is a perspective rear view of a gearbox holder element.

Figure 1 shows a roller compactor 100 for compacting waste materials 203. A container 200 has a front end wall 201 and a rear end wall 202. The line in the container 200 indicates the top of waste materials 203 piled up therein. A stand 16 of the roller compactor 100 is arranged behind the rear end wall 202, which, with skids jumping forward, reaches under the floor of the container 200 to improve the support. The support arm 10 is connected via a joint 15 with the stand 12. A pendulum arm 20 is connected via a joint 11 to the upper end of the support arm 10. No actuators are provided between the support arm 10 and the pendulum arm 20 so that the pendulum arm 20 can pivot freely about the joint 11. Attached to the end of the pendulum arm 20 is a gearbox holder element which contains, among other things, bearing elements and a gearbox for a roller unit 30 to drive a roller 31. In addition, a lifting cylinder, not shown here, is provided as an actuator between the stand 12 and the support arm 10 to be able to raise and lower the support arm 10. With the raising and lowering of the support arm 10, the joint 11 moves on a path 17 in the form of a circular arc.

The end of the pendulum arm 20 with the roller unit 30 is shown again in the vicinity of the end walls 201, 202 in figure 1. These are the end positions that the roller unit 30 can reach by the support arm 10 moving relative to the stand 16, as a result of which the joint axis 11 is moved on the circular path 17. No pressing force is exerted via the support arm 10, i.e. the compaction of the waste materials 203 in the container 20 takes place solely due to the rotation and the mass of the roller unit 30 and the sharp-edged web elements, attached to the outer shell of the rollers, for conveying and breaking up the waste materials.

The invention relates in particular to the pendulum arm 20 together with the roller unit 30 of the roller compactor 100. The pendulum arm 20 is shown separately in figure 2, in a

view from above a central axis 36 of the roller unit 30. The pendulum arm 20 comprises two outer carrier profiles 22 which connect to a common head element 26 which has bearing mounts 21 for forming the pivot bearing 11. At the other end is a common base element 23 which is hollow and accommodates an electric motor 41 on the inside. On the side facing away from the carrier profiles 22, the base element 23 has a connecting flange 24, to which the gearbox holder element 25 is fastened.

The pendulum arm 20 according to the invention has a motor unit 40 which, in addition to the electric motor 41, has a compensating coupling 42, a drive shaft 43 and a plug-in coupling, not visible in figure 2.

The roller unit 30 comprises the roller members 31, 32 which are fastened to flanges 33, 34 of an output shaft 57. The two roller members 31, 32 together form an almost uninterrupted cylindrical body, inside which a part of the gearbox holder element 25 is accommodated, to which in turn the gearbox 50 is fastened.

Figure 3A shows the pendulum arm 20 with the roller unit 30 in a side view. The contour of the gearbox holder element 25 with an annular disk-shaped region 25.1, which extends around a central recess on which the gearbox 50 is attached, becomes particularly clear therefrom. The annular disk-shaped region 25.1 runs out towards the pendulum arm 20 in a trapezoidal region 25.2.

The gearbox holder element 25 is shown individually in figure 6 in a perspective view. The annular disk-shaped region 25.1 and the trapezoidal region 25.2 are formed from two sheet metal blanks 25.10, 25.11, of which the sheet metal blank 25.11 has a flange for the gearbox and the sheet metal blank 25.10 lying against it is recessed a little further to be able to attach the gearbox housing unhindered to the flange. Annular webs 25.9 are attached to both sides of the region 25.1. These protrude into the inner, hollow part of the roller member to cover the gap between the roller member and the gearbox holder element 25. The annular disk-shaped region 25.1 encloses a recess 25.8 for accommodating the gearbox. The recess 25.8 continues in the trapezoidal region 25.2 as a narrow recess 25.7, in which the drive shaft can be accommodated. The end of the trapezoidal region 25.2 is closed off by a flange plate 25.4, which contains a recess 25.5 for the passage of the drive shaft. Reinforcing metal sheets 25.3 are used to reinforce the gearbox holder element 25 against bending forces that act between the pendulum arm 12 and the roller unit 30.

In figure 3B, the roller unit 30 with the gearbox 50 is shown in detail as an enlargement from figure 3. The drive shaft 43 runs from the motor 41 via a compensating coupling 42, such as a dog coupling, to a plug-in coupling 44. If the roller unit 30 must be replaced for

maintenance purposes, only a mechanical connection on the flange 24 needs to be released. The roller unit 30 can then be removed completely from the pendulum arm 20 without the need to detach the motor 41 or the control supply lines and/or energy supply lines leading there. Nothing needs to be removed from the roller unit 50 either. During subsequent assembly, only the end of the drive shaft 43 has to be reinserted with a precise fit into the plug-in coupling 44 on the gearbox 50 and the connection on the flange 24 restored.

The gearbox 50 accommodates the output shaft 57 and also has bearings therefor, so that the output shaft 57 and the gearbox 50 form a unit. On the outside of the housing of the gearbox 50, a total of three gearbox stages 51, 52, 53 can be seen from the outside due to the maintenance cover fitted there. The satellite-like arrangement of the gearbox stages 51, 52, 53 around the central output shaft 57 is characteristic of the preferred embodiment of the invention.

Figure 4 shows a side view of a gearbox 50. The gearbox 50 has two housing halves 58.1, 58.2 which are screwed together. The parting plane between them coincides with the central axis of the drive shaft 43. The dashed lines indicate the position of the gearbox holder element 25, which substantially consists of two sheet metal blanks, the connecting plane of which coincides with said parting plane and the central axis. Parts of the output shaft 57 protrude from the housing of the gearbox 50 on both sides. The ends thereof are each provided with a flange 33, 34 to which the roller members are later attached.

Figure 5 shows a detail of the plug-in coupling 44 on the gearbox 50. A short input shaft 59 protrudes from the top of the gearbox housing. For torque transmission to the shafts 43, 59, the plug-in coupling 44 has at least one form-fitting means, such as a feather key 44.1. Otherwise only sealing rings are provided in the plug-in coupling 44 to prevent the ingress of dirt. Appropriate shaping at the ends of the shafts 43, 59 prevents the plug-in coupling from changing the axial position thereof too far. A form-fitting or frictional securing between the ends of the shafts 43, 59 and the plug-in coupling 44 in the axial direction is not provided, however, to facilitate the assembly and disassembly of the roller unit 30 onto or from the pendulum arm 20.

PENDULARM TIL EN RULLEKOMPRIMATOR TIL KOMPRIMERING AF AFFALDSMATERIALER I EN ØVERSTE ÅBEN BEHOLDER

Patentkrav

1. Pendularm (20) til en rullekomprimator (100) til komprimering af affaldsmaterialer (203) i en øverste åben beholder (200), som mindst omfatter:
   - et drejeled (11), der er placeret i en øverste ende, til fri drejelig forbindelse af pendularmen (20) med en bærearm (10) på rullekomprimatoren (100);
   - en rulleenhed (30), der er arrangeret på en gearkasseholder (25) på en nederste ende af pendularmen (20), og som mindst har to drejelige rullelegemer (31, 32), der er arrangeret på begge sider af gearkasseholderen (25) og på indersiden er konfigureret til mindst delvist at være hul, og som mindst delvist omgiver mindst en udgangsaksel (57) og dens lejer, og en motorenhed;

   kendetegnet ved,
   - at motorenheden (40) omfatter en elektromotor (41), der er arrangeret på pendularmen (20), og som er forbundet med en gearkasse (50) ved hjælp af et overførselselement,
   - at gearkassen (50) er arrangeret inden i rullelegemet (31, 32) og fastgjort på gearkasseholderen (25) eller integreret i gearkasseholderen (25).

2. Pendularm (20) ifølge krav 1, kendetegnet ved, at overførselselementet er en drivaksel (43), der er arrangeret parallelt med midterakslen af pendularmen (20) eller flugter med denne.

3. Pendularm (20) ifølge krav 1 eller 2, kendetegnet ved, at, elektromotoren (41) er arrangeret i enden af pendularmen (20).

4. Pendularm (20) ifølge ethvert af de foregående krav, kendetegnet ved, at pendularmen (20) mindst omfatter to parallelle og med hinanden forbundne bæreprofiler (22), der er forbundet i én ende med en hovedenhed (26), hvorpå holdere (21) til konfiguration af et drejeled (11) er tilvejebragt, og som i den anden ende er forbundet med en grundenhed (24), hvori elektromotoren (41) er arrangeret.

5. Pendularm (20) ifølge krav 4, kendetegnet ved, at en rotoraksel på elektromotoren

(41) er arrangeret parallelt med midterakslen af pendularmen (20) eller flugter med denne.

6. Pendularm (20) ifølge et af kravene 2 til 5, kendetegnet ved, at gearkassen (50) er en tandhjulsudveksling, der mindst omfatter:
   - en indgangsfase, som drivakslen (43) munder ud i, og som omfatter et par koniske tandhjul og
   - et første geartrin (51) med et tandhjul, der er forbundet med udgangsakslen (57), og har et spidshjul, der går i indgreb deri, hvor det første geartrin (51) er arrangeret uden for udgangsakslen (57) og inden for et indvendigt omfang af rullelegemet (31, 32) i et gearkassehus.

7. Pendularm (20) ifølge krav 6, kendetegnet ved, at gearkassen (50) mindst omfatter et yderligere geartrin (52, 53), som har et tandhjul og et spidshjul på en fælles aksel, hvor alle geartrin (51, 52, 53) er arrangeret i en satellitformet arrangement ved siden af hinanden og uden for udgangsakslen (57) i gearkassehuset.

8. Pendularm (20) ifølge ét af kravene 1 til 7, kendetegnet ved, at der er dannet et ringskiveformet område (25.1) og et trapezformet område (25.2) på gearkasseholderen (25) ud af to tilstødende metalpladeemner (25.10, 25.11), hvoraf et metalpladeemne (25.11) har en flange til gearkassen (50), og det metalpladeemne (25.11), der ligger der bagved, er udsparet i området med flangen.

9. Pendularm (20) ifølge krav 8, kendetegnet ved, at en central åbning (25.8) i gearkasseholderen (25) fortsætter som en smal åbning (25.7) til gennemføring af overførselselementet ind i det trapezformede område (25.2), og ved at åbningen (25.7) munder ud i en åbning (25.5) i en flangeflade (25.4).

10. Rullekomprimator (100) til komprimering af affaldsmaterialer (30) i en øverste åben beholder (200), som mindst omfatter:
    - en stationær stativenhed (12);
    - en bærearm (10), der er forbundet med stativenheden (12) ved hjælp af et led (15) og mindst et aktuatorelement og
    - en pendularm (20) med en rulleenhed (30) ifølge ethvert af de foregående krav, som er forbundet med bærearmen (10) ved hjælp af drejeleddet (11).

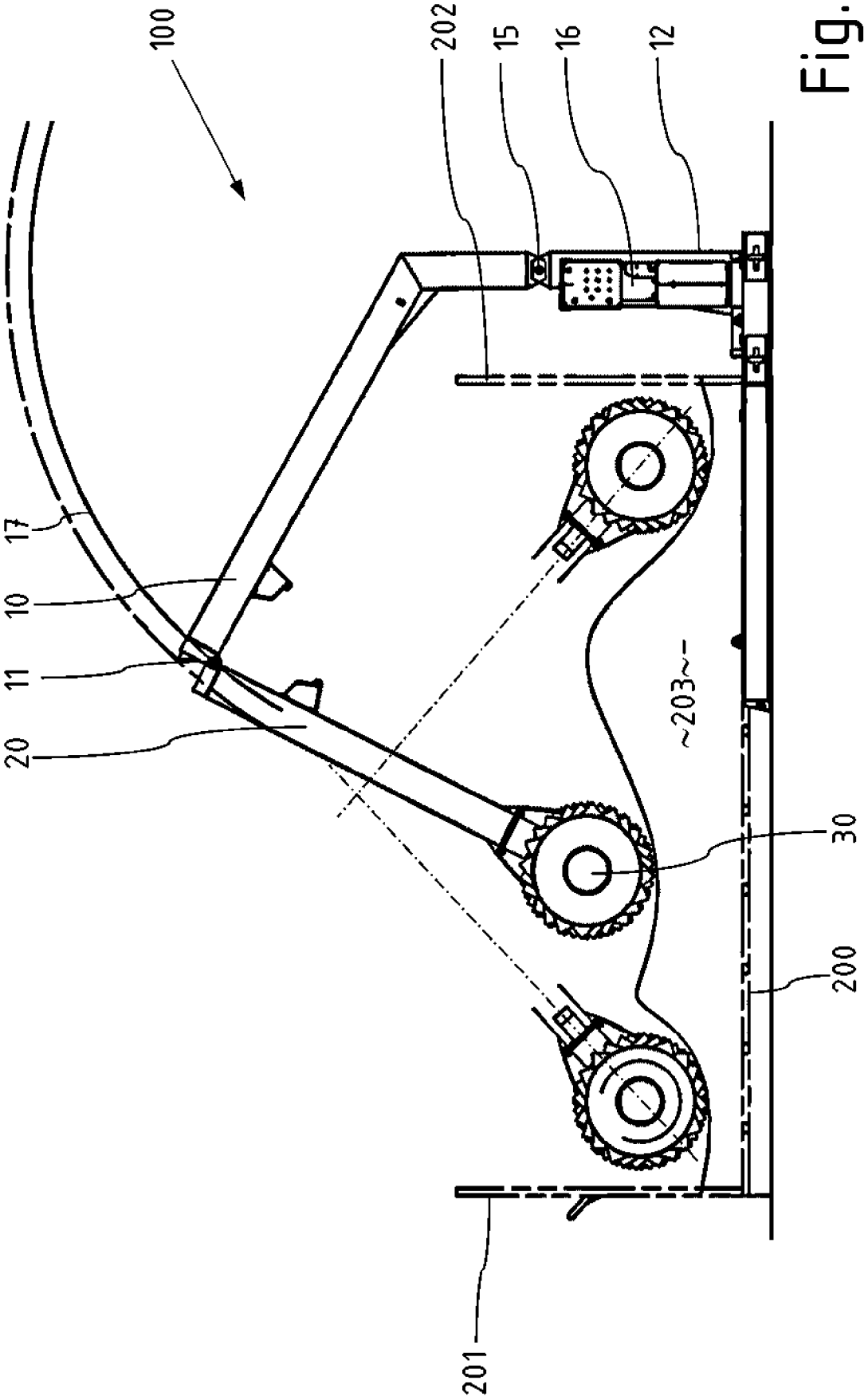
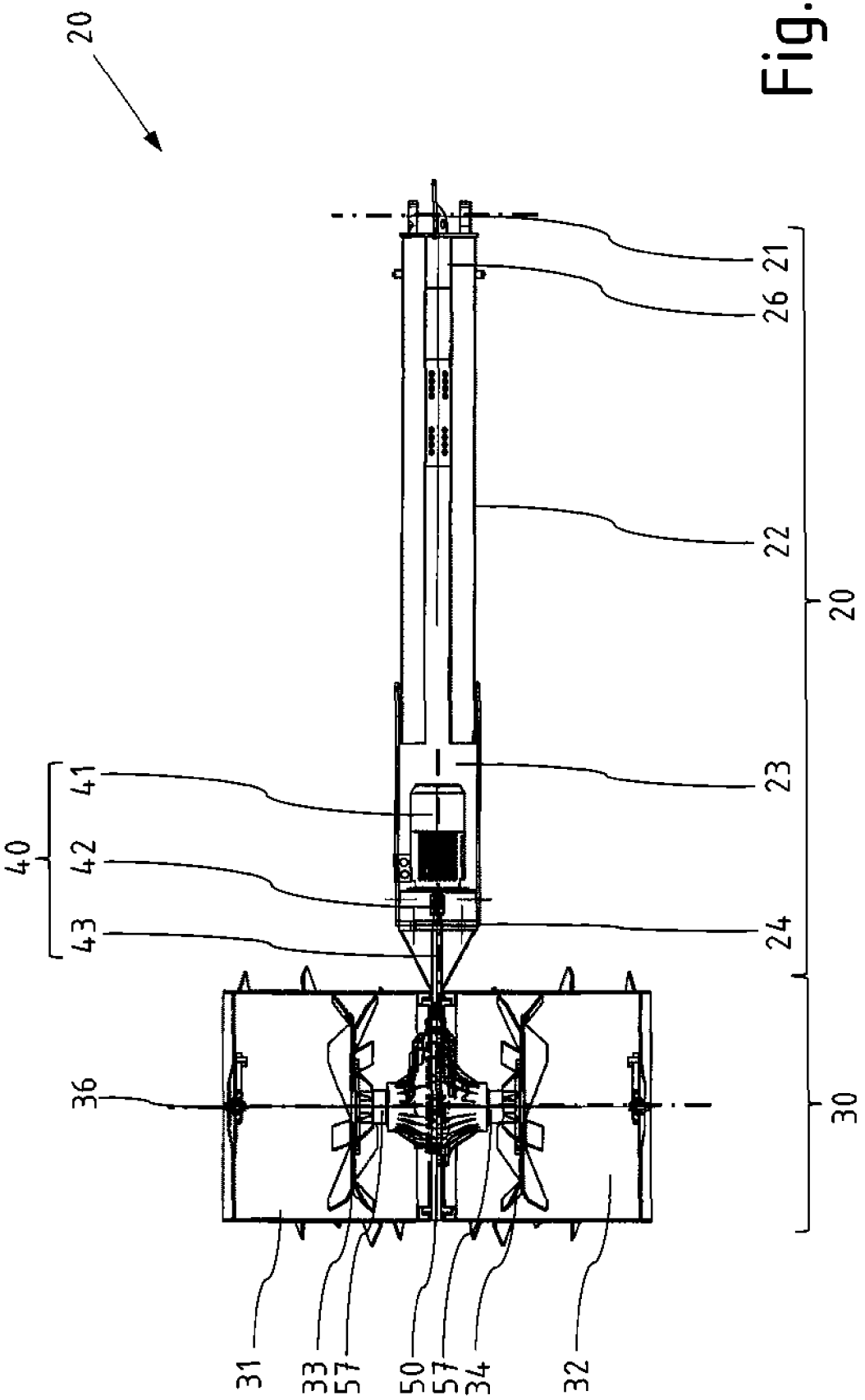


Fig. 1

Fig. 2



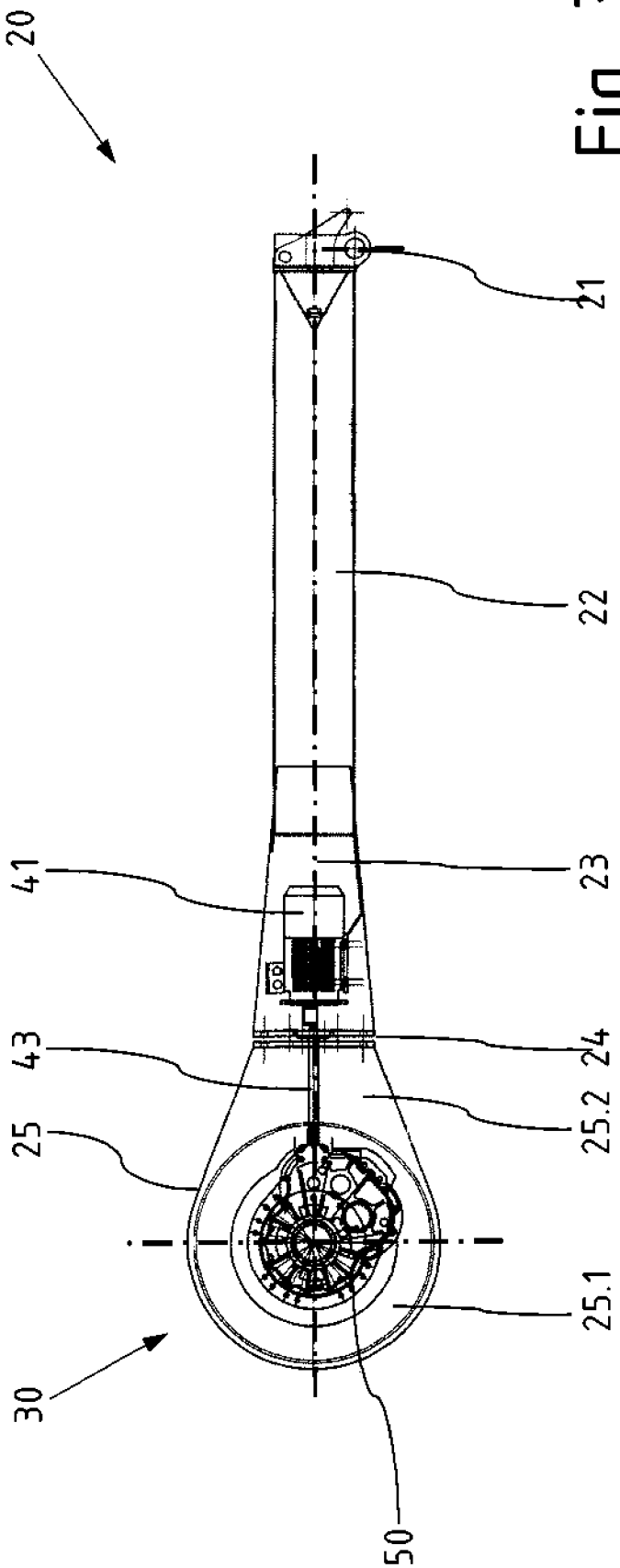


Fig. 3A

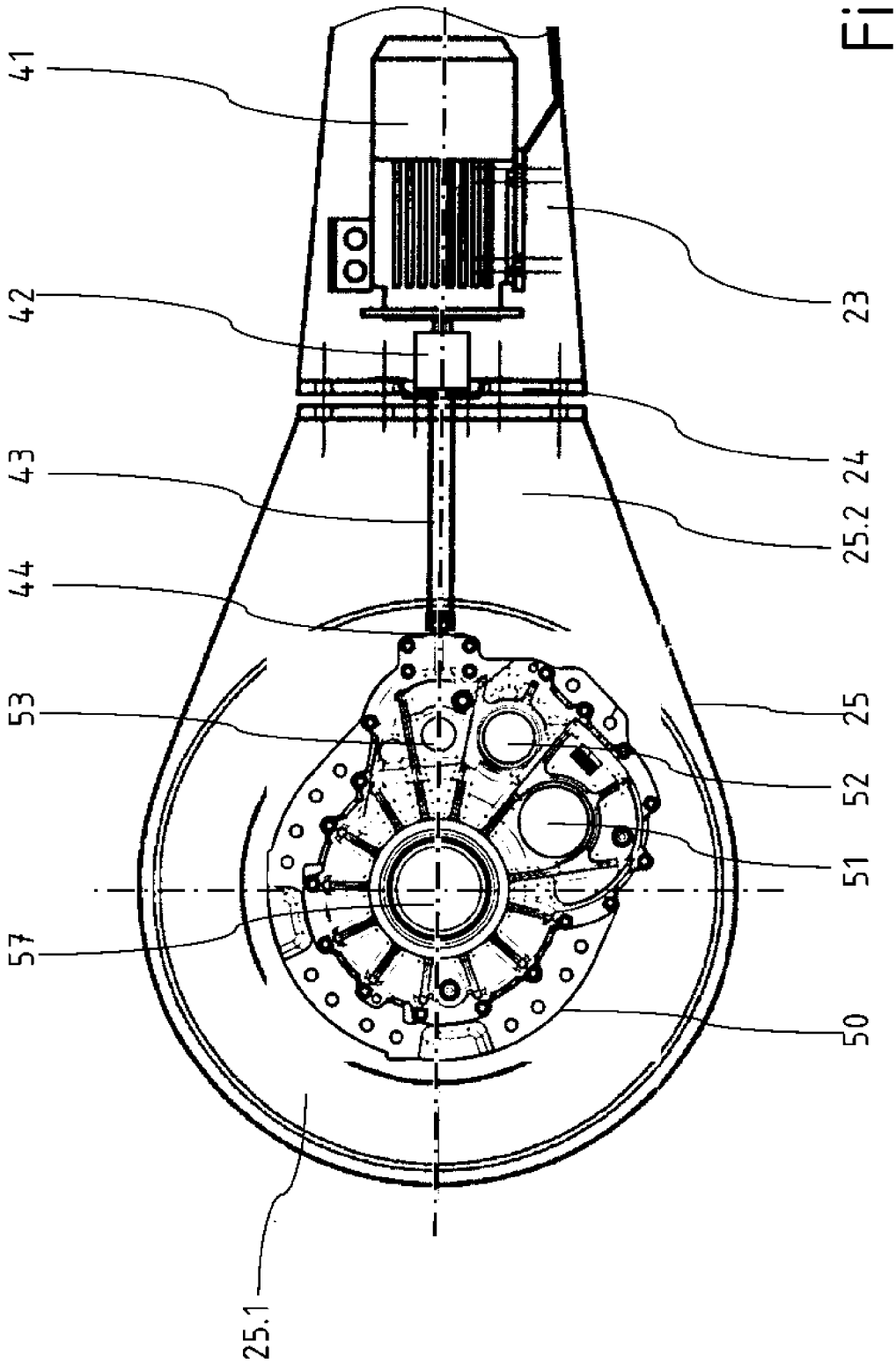


Fig. 3B

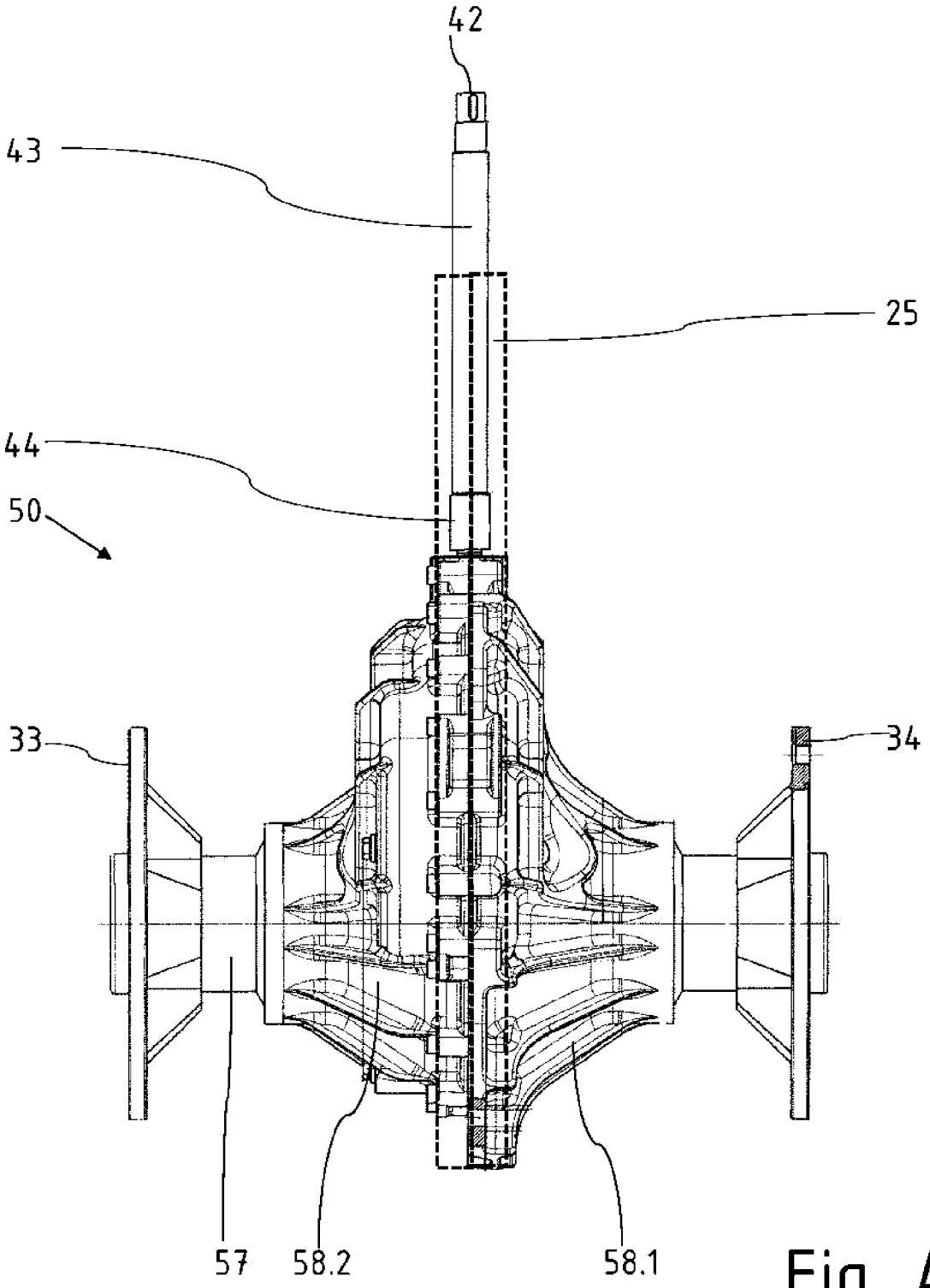


Fig. 4

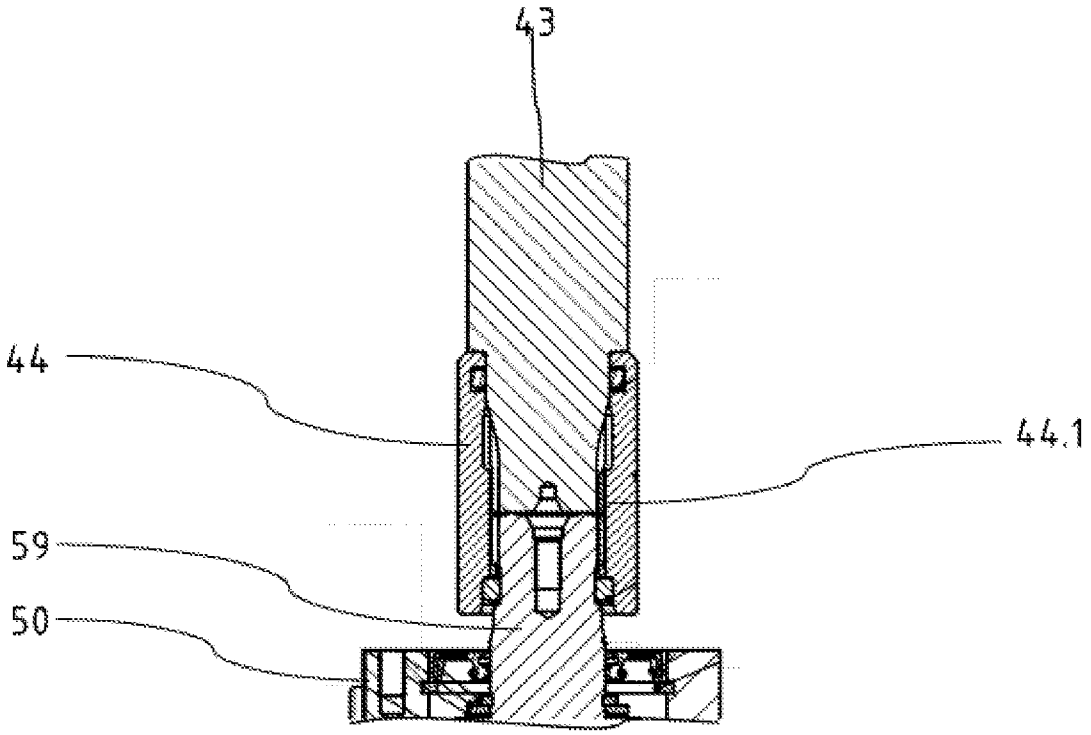


Fig. 5

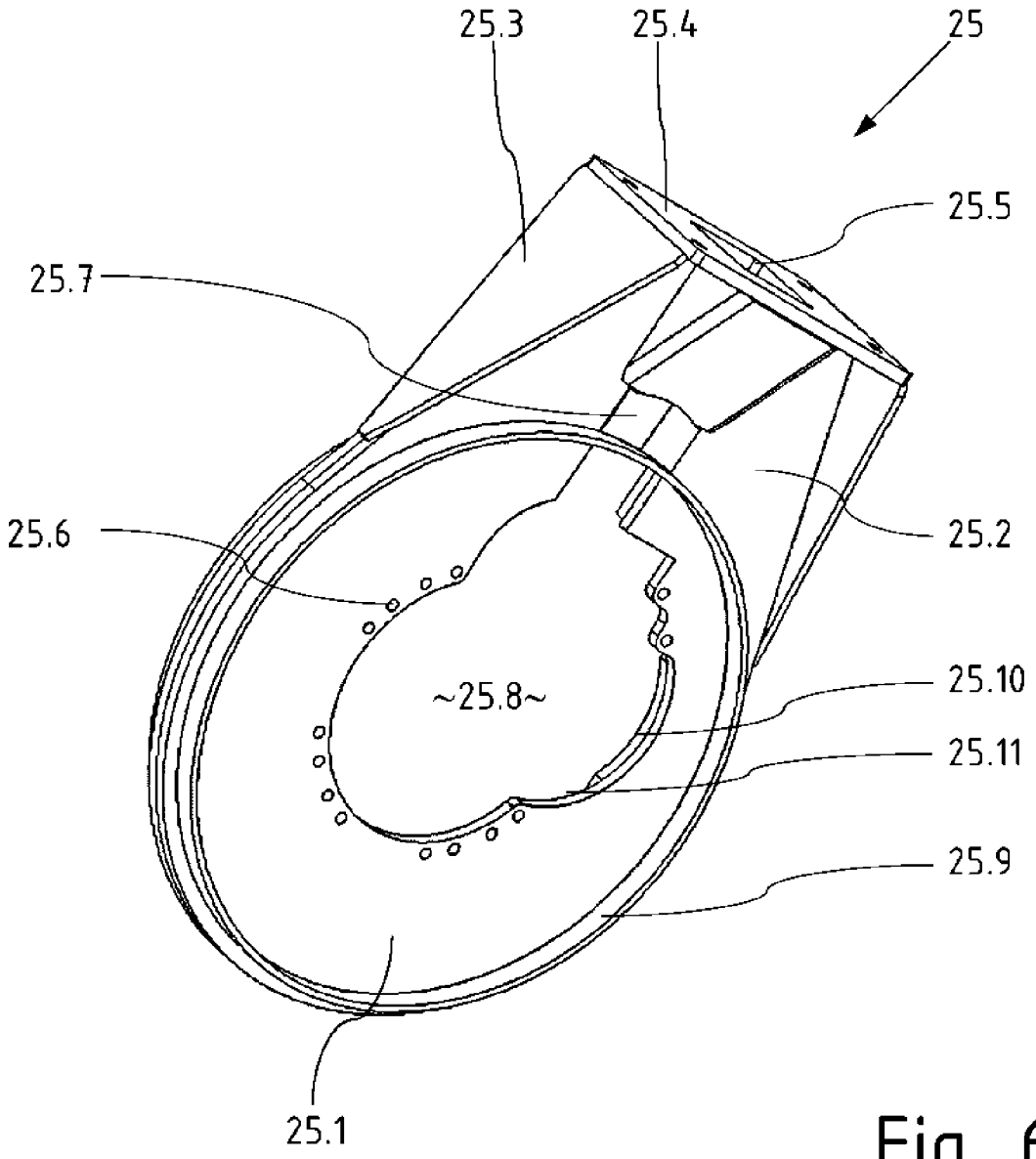


Fig. 6