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(54) **AGITATOR ARRANGEMENT**

(57) The present disclosure relates to an agitator arrangement (2) for mixing a liquid within a mixing tank (1) and for cleaning the interior of the tank (1). The agitator arrangement (2) comprises a stationary outer pipe (22) extending in an axial direction (5) having an upper end region (14) configured for being fastened to the mixing tank (1) and a lower end region (23) configured to be located within the tank (1), a rotatable inner pipe (4) located partly within and extending coaxially with the stationary outer pipe (22) and forming a first flow channel (24) within the rotatable inner pipe (4) and a second flow channel (25) in a space between an interior surface (38) of the stationary outer pipe (22) and an exterior surface (55) of the rotatable inner pipe (4), a rotatable outer member (15) fastened to the rotatable inner pipe (4) and including a cleaning unit (28) having at least one opening (9) for spraying a pressurized cleaning liquid supplied through the second flow channel (25) on an interior surface (3) of the tank (1), and a seal (26) for sealing an axial gap (32) between an axial end surface (33) of the lower end region (23) of the stationary outer pipe (22) and an oppositely facing upper axial end surface (34) of the rotatable outer member (15). The seal (26) has a substantially cylindrically shaped portion (35) and a radially inwardly protruding rib (36) located in the axial gap (32). Furthermore, the seal (26) is configured to interact with the pressurized cleaning liquid, such that a lower sealing surface (37) of the seal (26), upon flow of the pressurized cleaning liquid in the second channel (25) to the cleaning unit (28), is arranged to sealingly abut the upper axial end surface (34) of the rotatable outer member (15) while allowing relative motion between the stationary outer pipe (22) and the rotatable outer member

(15) in a radial direction (6).

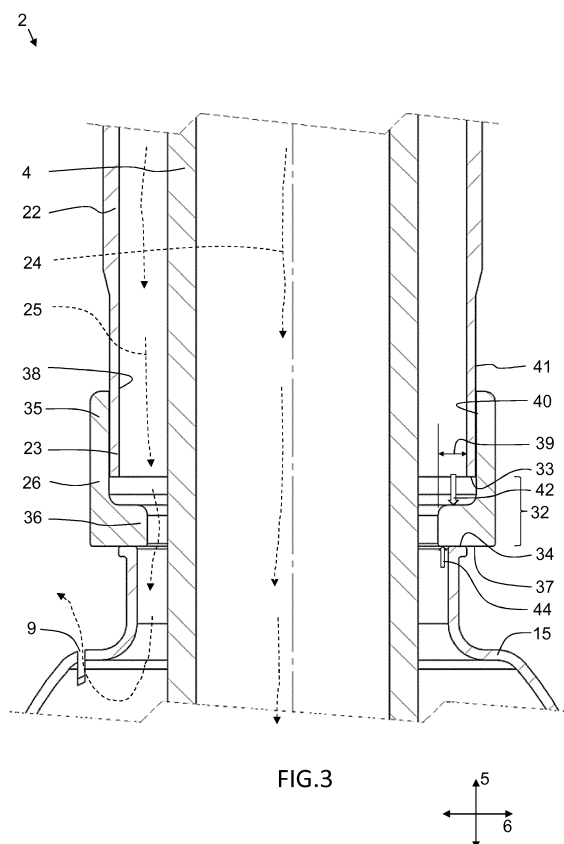


FIG.3

## Description

### TECHNICAL FIELD

**[0001]** The disclosure relates to an agitator arrangement for mixing a liquid in a mixing tank and for cleaning the mixing tank. The disclosure also relates to a mixing tank comprising such an agitator arrangement.

**[0002]** The disclosure can be arranged for example in the liquid food industry of dairy, beverage, brewing, processed foods, pharmaceutical and cosmetics, or the like.

### BACKGROUND ART

**[0003]** In the food and beverage industry mixing tanks and agitators should preferably be designed for providing improved lifetime cost-efficiency, zero in-tank maintenance and eliminating contamination risks.

**[0004]** Consequently, there is a continuous demand for providing more cost-efficient agitator equipment in terms of simplified manufacturing and installation, while also enabling high reliability and adequate cleaning of the agitator arrangement and tank interior.

**[0005]** However, despite the activities in the field, currently known solutions are not entirely satisfactory. There is therefore still a demand for an improved agitator arrangement, which is capable of meeting the above-mentioned requirements.

### SUMMARY OF THE DISCLOSURE

**[0006]** This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

**[0007]** An object of the present disclosure is to provide an agitator arrangement where the previously mentioned problems are avoided. This object is at least partly achieved by the features of the independent claim. The dependent claims contain further developments of the agitator arrangement.

**[0008]** According to a first aspect of the present disclosure, an agitator arrangement for mixing a liquid within a mixing tank and for cleaning the interior of the tank is disclosed. The agitator arrangement comprises: a stationary outer pipe extending in an axial direction having an upper end region configured for being fastened to the mixing tank and a lower end region configured to be located within the tank, a rotatable inner pipe located partly within and extending coaxially with the stationary outer pipe and forming a first flow channel within the rotatable inner pipe and a second flow channel in a space between an interior surface of the stationary outer pipe and an exterior surface of the rotatable inner pipe, a rotatable outer member fastened to the rotatable inner pipe and including a cleaning unit having at least one opening for spraying a pressurized cleaning liquid supplied through the second flow channel on an interior surface of the tank, and a seal for sealing an axial gap between an axial end

surface of the lower end region of the stationary outer pipe and an oppositely facing upper axial end surface of the rotatable outer member.

**[0009]** The seal has a substantially cylindrically shaped portion and a radially inwardly protruding rib located in the axial gap. Furthermore, the seal is configured to interact with the pressurized cleaning liquid, such that a lower sealing surface of the seal, upon flow of the pressurized cleaning liquid in the second channel to the cleaning unit, is arranged to sealingly abut the upper axial end surface of the rotatable outer member while allowing relative motion between the stationary outer pipe and the rotatable outer member in a radial direction.

**[0010]** In this way, increased level of radial play between the stationary outer pipe and the rotatable outer member in a radial direction is accomplished with maintained sealing performance of the seal and without damages to the seal. Consequently, a more reliable sealing design is provided that enables larger flexibility in terms of agitator arrangement design.

**[0011]** For example, since the novel seal design allows increased level of bending of the rotatable inner pipe, i.e. increased level of radial play between the stationary outer pipe and the rotatable outer member in a radial direction, a smaller material thickness of the rotatable inner pipe, or a longer rotatable inner pipe can be used although this may result in larger bending of the rotatable inner pipe during mixing or cleaning operation. Moreover, the agitator arrangement may be designed with less support points between the agitator arrangement and the mixing tank although also this typically result in larger bending of the rotatable inner pipe during mixing or cleaning operation.

**[0012]** To conclude, the new seal design contributes to providing improved lifetime cost-efficiency due to larger freedom for more cost-efficient design of the agitator arrangement, reduced in-tank maintenance due to reduced maintenance requirement of the seal, and reduced contamination risk due to maintained sealing performance over a larger span of operating conditions so that cleaning spray efficiency of the cleaning unit is maintained.

**[0013]** Further advantages are achieved by implementing one or several of the features of the dependent claims.

**[0014]** In one example embodiment, the seal is movable a certain distance in the axial direction relative to the stationary outer pipe and the rotatable outer member, and the rib extends radially inwardly beyond the interior surface of the stationary outer pipe and is configured to interact with the flow of pressurized cleaning liquid, such that the lower sealing surface of the seal, upon flow of pressurized cleaning liquid in the second channel to the cleaning unit, is arranged to sealingly abut the upper axial end surface of the rotatable outer member. A floating installation of the seal provides improved cleaning of the sealing area, reduced risk for contamination and reduced sealing wear, and automatic positioning of the seal in

sealingly abutment with the upper axial end surface of the rotatable outer member upon flow of pressurized cleaning liquid in the second channel to the cleaning unit ensures low leakage at the sealing area during for example cleaning mode operation.

**[0015]** In a further example embodiment, the seal is axially moveable between an axially uppermost position, in which a portion of the seal abuts the axial end surface of the lower end region of the stationary outer pipe, and an axially lowermost position, in which the lower sealing surface of the seal abuts the upper axial end surface of the rotatable outer member. Thereby, a floating installation of the seal with clear boundaries is provided.

**[0016]** In still a further example embodiment, when the lower sealing surface of the seal sealingly abuts the upper axial end surface of the rotatable outer member, a first axial force acting on the seal in a downwards direction and caused by hydraulic pressure of the pressurized cleaning liquid acting on upwards facing surface area of the seal, is larger than any second axial force acting on the seal in an upwards direction caused by hydraulic pressure of the pressurized cleaning liquid acting on any downwards facing surface area of the seal. Thereby, the seal is forced into sealing contact with upper axial end surface of the rotatable outer member such that high sealing performance is provided.

**[0017]** According to one example embodiment, when the lower sealing surface of the seal sealingly abuts the upper axial end surface of the rotatable outer member, the upwards facing surface area of the seal on which pressurized cleaning liquid is acting is larger, specifically at least 5% larger, more specifically at least 10% larger, even more specifically at least 20 % larger, and still more specifically at least 100% larger, than any downwards facing surface area of the seal on which pressurized cleaning liquid is acting. The difference in surface area between the upwards and downwards facing surface area of the seal on which pressurized cleaning liquid is acting is decisive for the total axial force acting on the seal in a downwards direction and caused by hydraulic pressure of the pressurized cleaning liquid. With larger difference in sealing surface larger sealing force is provided.

**[0018]** According to one example embodiment, the radially inwardly protruding rib has an annular shape and extends along the entire interior circumference of the seal. Thereby a continuous sealing contact is provided between the lower sealing surface of the seal and the upper axial end surface of the rotatable outer member.

**[0019]** According to one example embodiment, the radially inwardly protruding rib is located at a lower axial end of the seal, and the lower sealing surface is located at a lower axial end of the rib. Thereby, there is reduced risk for undesirable interference between the seal and the rotatable outer member upon relative radial motion there between.

**[0020]** In some example embodiments, the lower sealing surface extends primarily in the radial direction.

Thereby relative motion between the stationary outer pipe and the rotatable outer member in a radial direction is accomplished.

**[0021]** According to a further example embodiment, the lower sealing surface and the upper axial end surface of the rotatable outer member are configured for enabling a radial relative displacement between the seal and the rotatable outer member with maintained sealing contact between the lower sealing surface and the upper axial end surface of the rotatable outer member along the entire circumference of the lower sealing surface. Thereby it is ensured that the sealing performance between the seal and the rotatable outer member is maintained also upon relative motion between the stationary outer pipe and the rotatable outer member in a radial direction.

**[0022]** According to a further example embodiment, a maximal radial relative displacement between the seal and the rotatable outer member is in the range of 3 - 25 mm, specifically 3 - 15 mm, and more specifically 5 - 10 mm. These ranges enable a significant increased freedom in terms of more cost-efficient design of the agitator arrangement, reduced maintenance requirement of the seal, and improved sealing performance over a larger span of operating conditions.

**[0023]** According to yet a further example embodiment, a difference between an outer radius of the lower sealing surface and an inner radius of the lower sealing surface is in the range of 3 - 50 mm, specifically 3 - 25 mm, and more specifically 5 - 10 mm. A relatively large flat lower sealing surface enables large relative radial motion of the upper axial end surface of the rotatable outer member with maintained effective sealing contact with the lower sealing surface.

**[0024]** According to still a further example embodiment, the substantially cylindrically shaped portion of the seal is mounted on an exterior surface of the lower end region of the stationary outer pipe. Thereby the seal is kept in place while still allowing a floating installation in the axial direction.

**[0025]** In some example embodiments, the seal and the rotatable outer member do not overlap in the axial direction. This enables a particularly large relative motion between the lower sealing surface and the upper axial end surface of the rotatable outer member because all types of undesirable interference there between is avoided.

**[0026]** In some example embodiments, a cross-section of the seal, as seen in a plane extending through the centre of the seal and parallel with the axial direction, has two cross-sectional areas, of which a first cross-sectional area is substantially L-shaped. This shape has proven to be particularly cost-efficient because the lower portion of the L-shape provides a large lower sealing surface extending in the radial direction, such that a relatively large relative motion between the lower sealing surface and the upper axial end surface of the rotatable outer member is enabled.

**[0027]** Further features of, and advantages with, the

present disclosure will become apparent when studying the appended claims and the following description. The skilled person realize that different features of the present disclosure may be combined to create embodiments other than those described in the following, without departing from the scope of the present disclosure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0028]** The various example embodiments of the disclosure, including its particular features and example advantages, will be readily understood from the following illustrative and non-limiting detailed description and the accompanying drawings, in which:

Fig. 1 is a sectional view through a mixing tank and further including an agitator arrangement;

Fig. 2 is a cross-sectional view of a portion of the agitator arrangement of figure 1;

Fig. 3 is a cross-sectional view of the seal in assembled state and with the stationary outer pipe coaxial with the rotatable outer member;

Fig. 4 is magnification of the sealing arrangement of figure 3;

Fig. 5 is a cross-sectional view of the seal in assembled state and with the rotatable outer member radially displaced relative the stationary outer pipe; and

Fig. 6 is a cross-sectional view of the seal.

#### DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE DISCLOSURE

**[0029]** The present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the disclosure are shown. The disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness. Like reference characters refer to like elements throughout the description. The drawings are not necessarily to scale and certain features may be exaggerated in order to better illustrate and explain the exemplary embodiments of the present disclosure.

**[0030]** Referring now to figure 1, there is depicted a partly sectional view of a mixing tank 1 and an outside view of an agitator arrangement 2 located within the mixing tank 1 according to the disclosure.

**[0031]** The mixing tank 1 and agitator arrangement 2 are configured for being employed in the food and beverage industry, but also pharmaceutical and cosmetics industry, and should thus preferably be designed for providing highly efficient mixing, improved cost-efficiency, zero in-tank maintenance and very low contamination risk.

**[0032]** Low contamination risk is partly realised by manufacturing the mixing tank 1 and the agitator arrangement 2 primarily from stainless steel, and to provide a

Clean-in-place (CIP) technology for enabling automatic cleaning the interior surface 3 of the mixing tank 1 and internal and external surfaces of the agitator arrangement 2 without disassembly and without need for manual cleaning.

**[0033]** CIP cleaning may for example include providing high-energy spray of a cleaning solution to the interior of the mixing tank 1 and the agitator arrangement 2. This is typically performed by supplying high pressure cleaning solution to an interior pipe of the agitator arrangement 2 and further to spray openings at one or more locations along the length of the agitator arrangement 2. CIP cleaning further often involves providing highly turbulent flow of the cleaning solution within the mixing tank 1 by means of the agitator arrangement 2. The cleaning process is generally performed using high temperature cleaning solution with added chemical detergents for improved cleaning effectiveness.

**[0034]** The agitator arrangement 2 is suitable for mixing a liquid in the mixing tank 2 and for cleaning the mixing tank 2. The agitator arrangement thus at least has a dual functionality.

**[0035]** In the example embodiment of figure 1 the agitator arrangement 2 is configured for being attached to a top portion 20 of the mixing tank and to protrude into the mixing tank from said top portion 20. The attachment of the agitator arrangement to the tank may for example be realised by means of a flange of the agitator arrangement and threaded fasteners.

**[0036]** The agitator arrangement 2 comprises a stationary outer pipe 22 extending in an axial direction 5 having an upper end region 14 configured for being directly or indirectly fastened to the mixing tank, 1 and a lower end region 23 configured to be located within the tank 1.

**[0037]** The axial direction 5 is perpendicular to a radial direction 6, and the axial direction 5 may for example be parallel with a vertical direction and the radial direction 6 may for example be parallel with a horizontal direction.

**[0038]** The agitator arrangement 2 further comprises a rotatable inner pipe 4 located partly within and extending coaxially with the stationary outer pipe 22.

**[0039]** A first axial length 18 of the stationary outer pipe 22 within the mixing tank 1 is typically significantly smaller than a second axial length 10 of the rotatable inner pipe 4 within the mixing tank 1. In other words, starting from the top portion 20 of the mixing tank 1, the rotatable inner pipe 4 and stationary outer pipe 22 first extend overlapping and coaxially over the first axial length 18 within the mixing tank 1. At this position, the stationary outer pipe 22 ends and the rotatable inner pipe 4 extends without the stationary outer pipe 22 until the end of the second axial length 10.

**[0040]** The agitator arrangement 2 furthermore comprises a rotatable outer member 15, which is fastened to the rotatable inner pipe 4 and includes a cleaning unit 28, such as a spray ball. The cleaning unit 28 has at least one opening 9 for spraying a pressurized cleaning liquid

supplied through the second flow channel on the interior surface 3 of the tank 1.

**[0041]** The agitator arrangement further comprises at least one mixing tool, such as an impeller, rotationally fastened to the rotatable inner pipe at a location below the rotatable outer member 15 and configured for mixing a liquid within the mixing tank. For example, as shown in the example embodiment of figure 1, a first impeller 7 having impeller blades 31 may be secured to the rotatable inner pipe 4 at a first axial position and a second impeller 8 having impeller blades 31 may be secured to the rotatable inner pipe 4 at a second axial position. However, the agitator arrangement may alternatively comprise one, three or more impellers or other types of mixing tools rotationally attached to the rotatable inner pipe 4.

**[0042]** A lower end 29 of the agitator arrangement 2 may be free from attachment to the mixing tank 1. In other words, the agitator arrangement 2 may be designed to be attached to the mixing tank 1 only at the top portion 20 of the mixing tank 1. This enables simplified installation of the agitator arrangement within the mixing tank, as well as reduced cleaning need and reduced risk for contamination. However, in certain implementations, a bottom bearing support may be provided for giving the agitator arrangement increased support for more controlled rotational motion and less bending of the agitator arrangement.

**[0043]** A mixing mode and a cleaning mode will now be described with reference to figure 2, which shows an enlarged cross-sectional view of an upper portion of the agitator arrangement 2 according to the disclosure.

**[0044]** A first flow channel 24 is formed within the rotatable inner pipe 4 and a second flow channel 25 is formed in a space between an interior surface of the stationary outer pipe 22 and an exterior surface of the rotatable inner pipe 4.

**[0045]** In the cleaning mode, pressurized cleaning liquid from an external source may be supplied to both a first and a second external inlet 13, 17 of the agitator arrangement 2, which first and second external inlets 13, 17 are located outside of the mixing tank 1. The first external inlet 13 is in fluid communication with the first flow channel 24, and the second external inlet 17 is in fluid communication with the second flow channel 25.

**[0046]** Thereby, pressurized cleaning liquid supplied at the first external inlet 13 of the agitator arrangement 2 may flow through the first flow channel 24 and be sprayed out within the mixing tank 1 at suitable spray openings (not shown) located for example at the first and/or second impellers 7, 8, or other cleaning units located along the rotatable inner pipe 4.

**[0047]** Moreover, pressurized cleaning liquid may also be supplied at the second external inlet 17 in the cleaning mode and further conveyed via the second flow channel 25 to one or more openings 9 located in the cleaning unit 28 of the rotatable outer member 15.

**[0048]** Cleaning liquid may be drained from the mixing tank via an outlet (not shown) of the mixing tank 1 and

re-circulated to the first and second external inlets 13, 17 of the agitator arrangement 2.

**[0049]** Depending in the specific circumstances of the implementation, the agitator arrangement may alternatively be configured such that pressurized cleaning liquid from an external source is supplied only to the second external inlet 17 of the agitator arrangement 2 in the cleaning mode.

**[0050]** In the mixing mode of the agitator arrangement a power source 11, such as an electrical motor, drivingly connected to the rotatable inner pipe 4, for example via a transmission unit 12, causes the rotatable inner pipe 4 and associated first and second impellers 7, 8 to rotate and to generate a strong whirl flow and mixing effect of for example a liquid food product located within the tank 2.

**[0051]** A deaeration process of the liquid food product within the mixing tank 1 may also be performed for reducing the oxygen content in liquid food products like soft drinks, beer and edible oil leads to extended shelf life and improved taste stability.

**[0052]** A deaeration process involves injecting a deaeration gas into the liquid food product of the tank 1. The deaeration gas, e.g. N<sub>2</sub> or CO<sub>2</sub>, may be supplied to the liquid food product within the tank via first external inlet 13 and the first flow channel 24. The stripping gas may for example be supplied to the liquid food product using the openings of the agitator arrangement that are configured for spraying a cleaning liquid in a cleaning mode of the agitator arrangement 2.

**[0053]** It is generally preferred to inject the deaeration gas at a low position within the mixing tank for enabling a long reaction time of the deaeration gas bubbles with the liquid food product before the gas bubbles reach the surface of the liquid food product within the tank 1. Consequently, in some example embodiments it may be selected to avoid supplying deaeration gas to the second external inlet 17, because this would allow deaeration gas to be injected at the rotatable outer member 15, which is located at a relatively high position within the mixing tank 1.

**[0054]** The agitator arrangement 2 further comprises a seal 26 for sealing an axial gap between the stationary outer pipe 22 and the rotatable outer member 15. The rotatable outer member 15 may for example comprise a cleaning unit 28 with one or more openings for spraying cleaning liquid and a substantially cylindrical sealing collar configured for contacting the seal 26. The rotatable outer member 15 may for example be made in one piece.

**[0055]** Figure 3 shows a cross-sectional view of a magnification of a sealing arrangement including the seal 26 in assembled state and with the stationary outer pipe 22 substantially coaxial with the rotatable outer member 15 and rotatable inner pipe 4.

**[0056]** The seal 26 is configured for sealing an axial gap 32 between an axial end surface 33 of the lower end region 23 of the stationary outer pipe 22 and an oppositely facing upper axial end surface 34 of the rotatable outer member 15.

**[0057]** The seal 26 may for example be manufactured in one-piece for improved cost-efficiency.

**[0058]** The seal 26 has a substantially cylindrically shaped portion 35 and a radially inwardly protruding rib 36 located in the axial gap 33.

**[0059]** The substantially cylindrically shaped portion 35 of the seal 26 is mounted on an exterior surface 41 of the lower end region 23 of the stationary outer pipe 22.

**[0060]** In addition, the seal 26 is configured to be floatingly installed in the axial gap 32, meaning that the seal 26 is not fastened to neither the stationary outer pipe nor the rotatable outer member. This is accomplished by having a certain play between an inner surface 40 of the substantially cylindrically shaped portion 35 of the seal 26 and the exterior surface 41 of the lower end region of the stationary outer pipe 22. For example, when the stationary outer pipe 22 is positioned coaxially with seal 26, the seal 26 may have a radial play in relation to the stationary outer pipe 22 of 0.3 - 5 mm, specifically 0.4 - 3 mm, and more specifically 0.5 - 1.5 mm on each side in the radial direction.

**[0061]** A floating mounting of the seal 26 enables a small amount of cleaning liquid to escape out from the second flow channel 25 out through said radial play, such that the area where the seal 26 overlaps the outer stationary pipe 22 is properly cleaned.

**[0062]** Moreover, a floating mounting of the seal 26 also provides reduced wear on the seal 26 during mixing mode of the agitator arrangement because the seal is then not pushed against the upper axial end surface 34 of the rotatable outer member 15.

**[0063]** In fact, during for example the mixing mode operation when no flow is present in the second flow channel 25, the seal 26 is moveable a certain distance in the axial direction relative to the stationary outer pipe 22 and the rotatable outer member 15. Specifically, the seal is axially moveable between an axially uppermost position, in which a portion of the seal abuts the axial end surface 33 of the lower end region 23 of the stationary outer pipe 22, and an axially lowermost position, in which the lower sealing surface 37 of the seal 26 abuts the upper axial end surface 34 of the rotatable outer member 15.

Due to the floating mounting of the seal 26, the seal 26 may also during for example the cleaning mode operation begin to rotate together with the rotatable outer member 15, or the seal 26 may alternatively be non-rotating together with the stationary outer pipe 22.

**[0064]** Furthermore, the seal 26 is configured to interact with the pressurized cleaning liquid flowing in the second flow channel 25, such that a lower sealing surface 37 of the seal 26, upon flow of the pressurized cleaning liquid in the second flow channel 25 to the cleaning unit in the rotatable outer member 15, is arranged to sealingly abut the upper axial end surface 34 of the rotatable outer member 15 while allowing relative motion between the stationary outer pipe 22 and the rotatable outer member 15 in a radial direction 6.

**[0065]** The sealing abutment of the seal 26 on the up-

per axial end surface 34 of the rotatable outer member 15 caused by the flow of pressurized cleaning liquid in the second flow channel 25 to the cleaning unit is accomplished by having the rib 36 extending radially inwardly a distance 39 beyond the interior surface 38 of the stationary outer pipe 22, because thereby the rib 36 will protrude out into the flow of pressurized cleaning liquid in the second flow channel 25. As a result, the flow of pressurized cleaning liquid will generate a force that will act on the rib and push the rib towards the upper axial end surface 34 of the rotatable outer member 15, such that the lower sealing surface of the seal will sealingly abut the upper axial end surface of the rotatable outer member and a satisfactory sealing effect is accomplished.

**[0066]** However, the sealing effect may be even further improved by means of hydraulic pressure acting on the seal 26 towards a sealing engagement. In particular, when the lower sealing surface 37 of the seal 26 sealingly abuts the upper axial end surface 34 of the rotatable outer member 15, the sealing arrangement may be given a geometry that enables a first axial force 42 acting on the seal 26 in a downwards direction and caused by hydraulic pressure of the pressurized cleaning liquid acting on upwards facing surface area 46 of the seal, to be larger than any second axial force 44 acting on the seal in an upwards direction caused by hydraulic pressure of the pressurized cleaning liquid acting on any downwards facing surface area 47 of the seal 26.

**[0067]** This force relationship acting on the seal 26 is further shown on figure 4, which illustrates a magnification of a cross-sectional view of the sealing arrangement of figure 3. Hydraulic pressure is the force imparted per unit area of a liquid on the surfaces, with which it has contact. A liquid pressure thus exerts a force on the walls of a space in a direction perpendicular to the surface plane of the walls, wherein the force per unit area is proportional to the liquid pressure, and wherein the force acting in any direction is proportional to the effective area perpendicular to said direction.

**[0068]** In a steady-state cleaning mode operation the second flow channel 25 may be deemed representing a space, such that the liquid pressure acting on the seal 26 can be deemed be substantially identical upstream and downstream of the seal 26. Moreover, as clearly showed in figure 4, the geometry of the sealing arrangement, i.e. the geometry of the seal 26, the end surface 33 of the stationary outer pipe 22 and the oppositely facing end surface 34 of the rotatable outer member 15, renders the upwards facing surface area 46 of the seal 26 on which hydraulic pressure of the pressurized cleaning liquid can act, and which is represented by an upper distance 43, clearly larger than the downwards facing surface area 47 of the seal 26 on which hydraulic pressure of the pressurized cleaning liquid can act, and which is represented by a lower distance 45.

**[0069]** Thereby, the first axial force 42 pushing the seal towards a sealing engagement with the upper axial end surface 34 of the rotatable outer member 15 will be larger

than the second axial force 44 pushing the seal upwards and away from said sealing engagement, such that an improved sealing effect is accomplished by means of hydraulic pressure acting on the seal 26.

**[0070]** In detail, when the lower sealing surface 37 of the seal 26 sealingly abuts the upper axial end surface 34 of the rotatable outer member 15, the upwards facing surface area 46 of the seal on which pressurized cleaning liquid is acting is larger, specifically at least 5% larger, more specifically at least 10% larger, even more specifically at least 20 % larger, and still more specifically at least 100% larger, than any downwards facing surface area 47 of the seal on which pressurized cleaning liquid is acting.

**[0071]** The relationship between the sizes of the upwards facing surface area 46 and the size of the downwards facing surface area 47 may be selected taking into account the specific circumstances of each implementation, such as flow rate, liquid pressure level, sealing arrangement geometry, and the like. Too little sealing pressure may result in leakage between the seal and upper axial end surface 34 of the rotatable outer member 15, while too high sealing pressure may cause increased wear of the seal 26, in particular upon relative motion between the stationary outer pipe and the rotatable outer member in a radial direction.

**[0072]** A key aspect of the agitator arrangement according to the disclosure is that the seal 26 is configured to seal the joint between the stationary outer pipe 22 and the rotatable outer member 15 while allowing relatively large level of relative motion between the stationary outer pipe 22 and the rotatable outer member 15 in a radial direction 6, because thereby larger flexibility in terms of agitator arrangement design is enabled.

**[0073]** For example, an agitator arrangement with larger level of bending of the rotatable inner pipe during operation thereof can be provided, which larger level of bending for example may be caused by less support points between the agitator arrangement and the mixing tank, e.g. eliminated bottom bearing support, or use of smaller diameter or material thickness of the rotatable inner pipe, or use of a longer rotatable inner pipe.

**[0074]** To conclude, the new sealing arrangement design contributes to providing improved lifetime cost-efficiency due to larger freedom for more cost-efficient design of the agitator arrangement, reduced in-tank maintenance due to reduced maintenance requirement of the seal, and reduced contamination risks due to maintained sealing performance over a larger span of operating conditions.

**[0075]** The relatively large level of relative motion between the stationary outer pipe 22 and the rotatable outer member 15 in a radial direction 6 with maintained sealing capacity is accomplished by having the lower sealing surface of the seal arranged to sealingly abut the upper axial end surface of the rotatable outer member. In other words, the lower sealing surface extends primarily in the radial direction of the agitator arrangement 2. Thereby,

the lower sealing surface of the seal remains in sealing abutment with the upper axial end surface of the rotatable outer member despite a certain level of relative motion between the sealing parts.

**[0076]** Figure 5 shows a cross-sectional view of a magnification of a sealing arrangement including the seal 26 in assembled state but with the rotatable outer member 15 and rotatable inner pipe 4 displaced towards the right in the figure relative to the stationary outer pipe 22, such that the inner rotatable pipe 4 is in contact with the rib 36 of the seal 26.

**[0077]** Figure 5 thus illustrates an example behaviour of the sealing arrangement upon relatively large level of relative motion between the stationary outer pipe 22 and the rotatable outer member 15 in a radial direction 6. Moreover, figure 5 also shows that the lower sealing surface 37 of the seal remains in sealing abutment with upper axial end surface 34 of the rotatable outer member despite the radial displacement rotatable outer member 15 and rotatable inner pipe 4, i.e. that the sealing arrangement provides maintained sealing capacity.

**[0078]** In other words, the lower sealing surface 37 and the upper axial end surface 34 of the rotatable outer member 15 are configured for enabling a radial relative displacement between the seal 26 and the rotatable outer member 15 with maintained sealing contact between the lower sealing surface 37 and the upper axial end surface 34 of the rotatable outer member 15 along the entire circumference of the lower sealing surface 37.

**[0079]** The relative radial motion with maintained sealing capacity is the result of having at least one, or both, of the lower sealing surface 37 of the seal and the upper axial end surface 34 of the rotatable outer member 15 defining a relatively large flat sealing surface extending in the radial direction 6. Thereby, the lower sealing surface 37 of the seal can be radially displaced without losing sealing contact with the upper axial end surface 34 of the rotatable outer member 15.

**[0080]** In the example embodiment of figures 3-5 the lower sealing surface 37 of the seal 26 defines a relatively large flat sealing surface extending in the radial direction 6, whereas the upper axial end surface 34 of the rotatable outer member 15 defines a much smaller sealing surface.

**[0081]** Specifically, a difference between an outer radius 50 and an inner radius 51 of the upper axial end surface 34 of the rotatable outer member 15 is about 10 - 70 %, specifically about 20 - 40 % of a difference between an outer radius 52 and an inner radius 53 of the lower sealing surface 37 of the seal 26. It is generally more cost-efficient to provide the seal with relatively large flat sealing surface 37 extending in the radial direction 6 than providing the rotatable outer member 15 with a large flat sealing surface.

**[0082]** In absolute terms, the difference between the outer radius 52 of the lower sealing surface 37 and an inner radius 53 of the lower sealing surface 37 may be in the range of 3 - 50 mm, specifically 3 - 25 mm, and more specifically 5 - 10 mm.

[0083] These dimension of the lower seal surface 37 would enable a maximal radial relative displacement between the seal 26 and the rotatable outer member 15 in the range of about 3 - 25 mm, specifically 3 - 15 mm, and more specifically 5 - 10 mm, in each radial direction, when measured in a coaxial position of the seal 26 and rotatable outer member 15, and the upper axial end surface 34 of the rotatable outer member 15 is located approximately in a centred position of the lower seal surface 37.

[0084] It is thus clear that the level of relative radial motion between the seal and rotatable outer member 15 can be easily adjusted for handling various levels of relative motion. For example, increased radial relative motion can be accomplished by increasing the size of the lower sealing surface 37 of the seal 26.

[0085] However, a further aspect to take into account may be the level of radial play between a radially innermost surface 54 of the seal 26 and an exterior surface 55 of the rotatable inner pipe 4. If this level of radial play is small a relatively large radial play provide by the sealing arrangement may not be fully exploited, because the seal abuts the exterior surface 55 of the rotatable inner pipe 4. Consequently, the level of radial play between an radially innermost surface 54 of the seal 26 and an the exterior surface 55 of the rotatable inner pipe 4 is preferable taken into account and matched with the level of radial play provide by the sealing arrangement, as shown in figure 5, where the innermost surface 54 of the seal 26 contacts the exterior surface 55 of the rotatable inner pipe 4 near a limit of the level of radial play provide by the sealing arrangement.

[0086] In absolute numbers, a radial play between the radially innermost surface 54 of the seal 26 and the exterior surface 55 of the rotatable inner pipe is 2 - 25 mm, specifically 2.5 - 10 mm, and more specifically 3 - 5 mm, as measured in a coaxial position of the seal 26 and rotatable outer member 15.

[0087] Since the lower sealing surface 37 of the seal 26 extends primarily in the radial direction of the agitator arrangement 2, there is generally no need for an axial overlap between the seal and rotatable outer member 15. Consequently, the seal 26 and rotatable outer member 15 may be configured to be free from any overlap in the axial direction.

[0088] Figure 6 shows a cross-sectional view of an example embodiment of the seal 26. Figure 6 shows that the radially inwardly protruding rib 36 has an annular shape, and the rib 36 extends along the entire interior circumference of the seal 26.

[0089] Moreover, an axial length 58 of the rib 36 is typically smaller than the axial gap 32 between the axial end surface 33 of the lower end region 23 of the stationary outer pipe 22 and the oppositely facing upper axial end surface 34 of the rotatable outer member 15, such that the seal 26 is axially moveable in the axial gap 32 between the axially uppermost and lowermost positions of the seal 26.

[0090] Figure 6 also clearly illustrates that the radially

inwardly protruding rib 36 is located at a lower axial end of the seal 26, and that the lower sealing surface 37 is located at a lower axial end of the rib 36.

[0091] Figure 6 further illustrates that a cross-section of the seal 26, as seen in a plane extending through the centre of the seal and parallel with the axial direction, has two cross-sectional areas 56, 57, of which a first cross-sectional area 56 is substantially L-shaped and a second cross-sectional area 57 is the mirror image of the first cross-sectional area 56. In other words, the cross-sectional view of the seal 26 in figure 6 has mirror symmetry around a central axis 60 of the seal 26 extending in the axial direction 5.

[0092] Although the disclosure has been described in relation to specific combinations of components, it should be readily appreciated that the components may be combined in other configurations as well which is clear for the skilled person when studying the present application. Thus, the above description of the example embodiments of the present disclosure and the accompanying drawings are to be regarded as a non-limiting example of the disclosure and the scope of protection is defined by the appended claims. Any reference sign in the claims should not be construed as limiting the scope.

[0093] The use of the word "a" or "an" in the specification may mean "one," but it is also consistent with the meaning of "one or more" or "at least one." The term "about" means, in general, the stated value plus or minus 10%, or more specifically plus or minus 5%. The use of the term "or" in the claims is used to mean "and/or" unless explicitly indicated to refer to alternatives only.

[0094] The terms "comprise", "comprises" "comprising", "have", "has", "having", "include", "includes", "including" are open-ended linking verbs. As a result, a method or device that "comprises", "has" or "includes" for example one or more steps or elements, possesses those one or more steps or elements, but is not limited to possessing only those one or more elements.

## Claims

1. Agitator arrangement (2) for mixing a liquid within a mixing tank (1) and for cleaning the interior of the tank (1), wherein the agitator arrangement (2) comprises:

a stationary outer pipe (22) extending in an axial direction (5) having an upper end region (14) configured for being fastened to the mixing tank (1) and a lower end region (23) configured to be located within the tank (1);  
a rotatable inner pipe (4) located partly within and extending coaxially with the stationary outer pipe (22) and forming a first flow channel (24) within the rotatable inner pipe (4) and a second flow channel (25) in a space between an interior surface (38) of the stationary outer pipe (22) and

- an exterior surface (55) of the rotatable inner pipe (4),  
 a rotatable outer member (15) fastened to the rotatable inner pipe (4) and including a cleaning unit (28) having at least one opening (9) for spraying a pressurized cleaning liquid supplied through the second flow channel (25) on an interior surface (3) of the tank (1),  
 a seal (26) for sealing an axial gap (32) between an axial end surface (33) of the lower end region (23) of the stationary outer pipe (22) and an oppositely facing upper axial end surface (34) of the rotatable outer member (15),  
 wherein the seal (26) has a substantially cylindrically shaped portion (35) and a radially inwardly protruding rib (36) located in the axial gap (32), and  
 wherein the seal (26) is configured to interact with the pressurized cleaning liquid, such that a lower sealing surface (37) of the seal (26), upon flow of the pressurized cleaning liquid in the second channel (25) to the cleaning unit (28), is arranged to sealingly abut the upper axial end surface (34) of the rotatable outer member (15) while allowing relative motion between the stationary outer pipe (22) and the rotatable outer member (15) in a radial direction (6).
2. Agitator arrangement according to claim 1, wherein the seal (26) is moveable a certain distance in the axial direction (5) relative to the stationary outer pipe (22) and the rotatable outer member (15), and wherein the rib (36) extends radially inwardly beyond the interior surface (38) of the stationary outer pipe (22) and is configured to interact with the flow of pressurized cleaning liquid, such that the lower sealing surface (37) of the seal (26), upon flow of pressurized cleaning liquid in the second channel (25) to the cleaning unit (28), is arranged to sealingly abut the upper axial end surface (34) of the rotatable outer member (15).
  3. Agitator arrangement according to any one of the preceding claims, wherein the seal (26) is axially moveable between an axially uppermost position, in which a portion of the seal (26) abuts the axial end surface (33) of the lower end region (23) of the stationary outer pipe (22), and an axially lowermost position, in which the lower sealing surface (37) of the seal (26) abuts the upper axial end surface (34) of the rotatable outer member (15).
  4. Agitator arrangement according to any one of the preceding claims, wherein when the lower sealing surface (37) of the seal (26) sealingly abuts the upper axial end surface (34) of the rotatable outer member (15), a first axial force (42) acting on the seal (26) in a downwards direction and caused by hydraulic pressure of the pressurized cleaning liquid acting on upwards facing surface area (46) of the seal (26), is larger than any second axial force (44) acting on the seal (26) in an upwards direction caused by hydraulic pressure of the pressurized cleaning liquid acting on any downwards facing surface area (47) of the seal (26).
  5. Agitator arrangement according to claim 4, wherein when the lower sealing surface (37) of the seal (26) sealingly abuts the upper axial end surface (34) of the rotatable outer member (15), the upwards facing surface area (46) of the seal (26) on which pressurized cleaning liquid is acting is larger, specifically at least 5% larger, more specifically at least 10% larger, even more specifically at least 20 % larger, and still more specifically at least 100% larger, than any downwards facing surface area (47) of the seal (26) on which pressurized cleaning liquid is acting.
  6. Agitator arrangement according to any one of the preceding claims, wherein the radially inwardly protruding rib (36) has an annular shape and extends along the entire interior circumference of the seal (26).
  7. Agitator arrangement according to any one of the preceding claims, wherein the radially inwardly protruding rib (36) is located at a lower axial end of the seal (26), and wherein the lower sealing surface (37) is located at a lower axial end of the rib (36).
  8. Agitator arrangement according to any one of the preceding claims, wherein the lower sealing surface (37) extends primarily in the radial direction (6).
  9. Agitator arrangement according to any one of the preceding claims, wherein the lower sealing surface (37) and the upper axial end surface (34) of the rotatable outer member (15) are configured for enabling a radial relative displacement between the seal (26) and the rotatable outer member (15) with maintained sealing contact between the lower sealing surface (37) and the upper axial end surface (34) of the rotatable outer member (15) along the entire circumference of the lower sealing surface (37).
  10. Agitator arrangement according to claim 9, wherein a maximal radial relative displacement between the seal (26) and the rotatable outer member (15) is in the range of 3 - 25 mm, specifically 3 - 15 mm, and more specifically 5 - 10 mm.
  11. Agitator arrangement according to any one of the preceding claims, wherein a difference between an outer radius (52) of the lower sealing surface (37) and an inner radius (53) of the lower sealing surface (37) is in the range of 3 - 50 mm, specifically 3 - 25

mm, and more specifically 5 - 10 mm.

12. Agitator arrangement according to any one of the preceding claims, wherein the substantially cylindrically shaped portion (35) of the seal (26) is mounted on an exterior surface (41) of the lower end region (23) of the stationary outer pipe (22). 5
13. Agitator arrangement according to any one of the preceding claims, wherein the seal (26) and the rotatable outer member (15) do not overlap in the axial direction (5). 10
14. Agitator arrangement according to any one of the preceding claims, wherein a cross-section of the seal (26), as seen in a plane extending through the centre of the seal (26) and parallel with the axial direction (5), has two cross-sectional areas (56, 57), of which a first cross-sectional area (56) is substantially L-shaped. 15 20
15. Agitator arrangement according to any one of the preceding claims, wherein a lower end (29) of the agitator arrangement (2) is configured to be free from attachment to the mixing tank (1). 25

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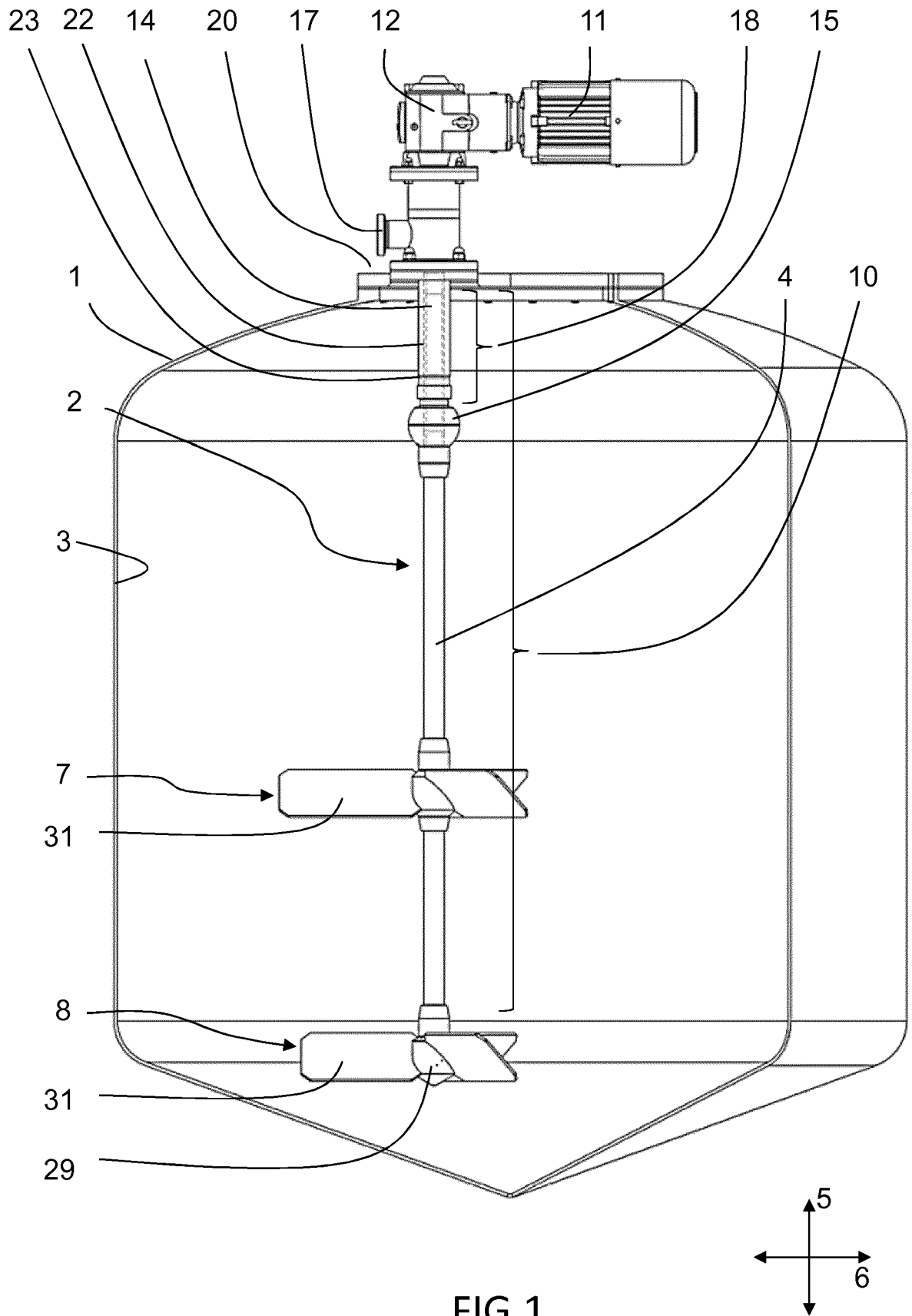
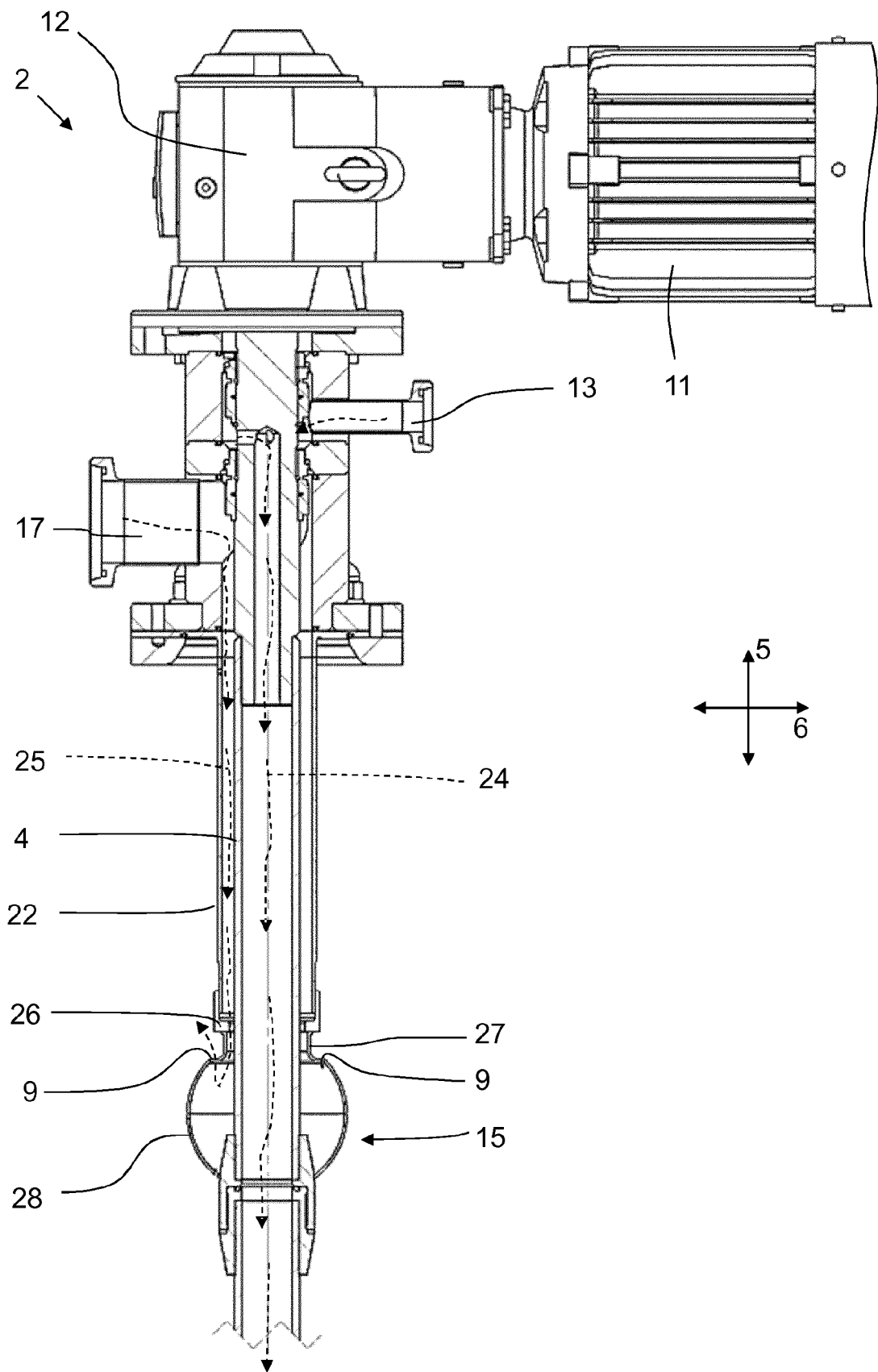
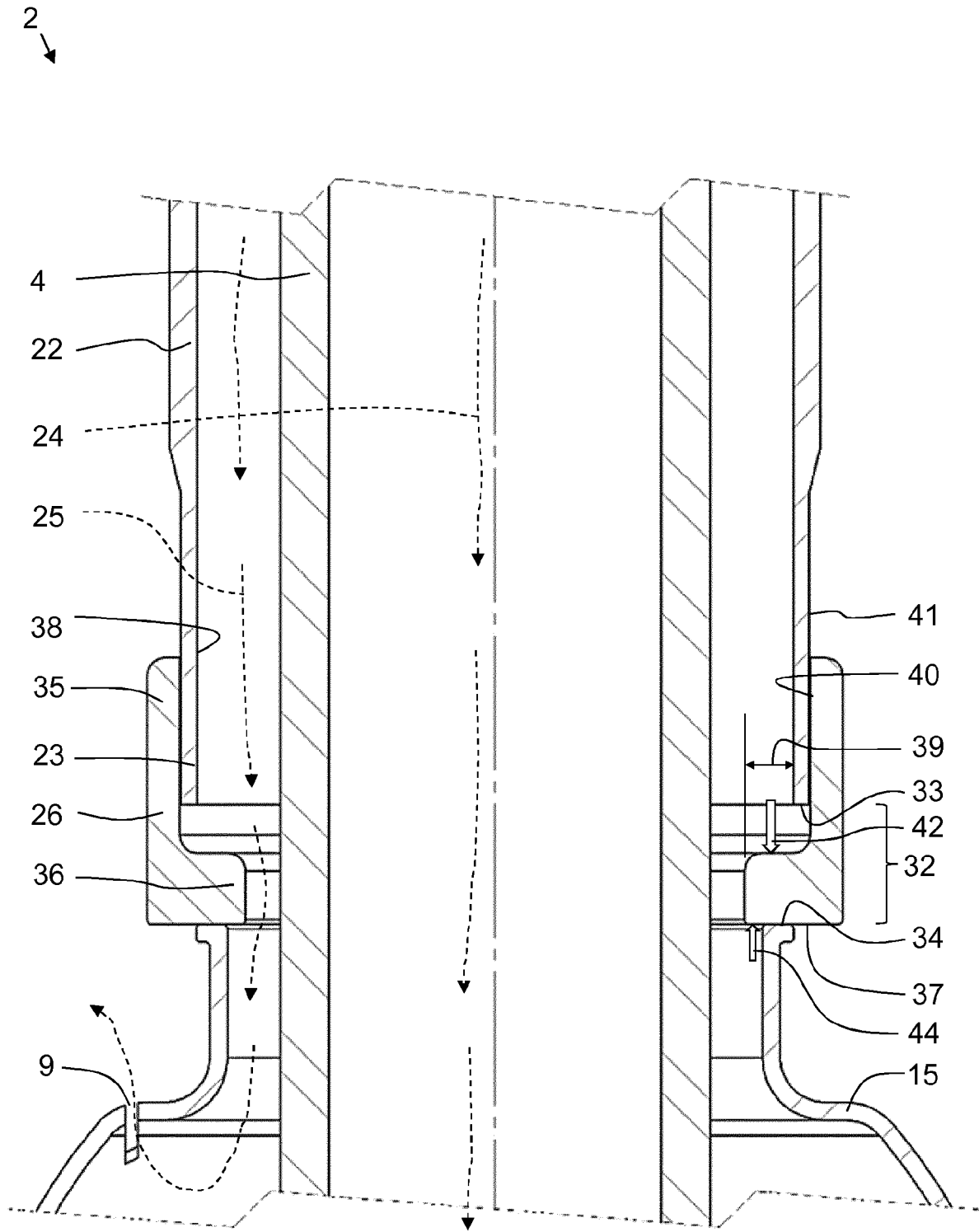
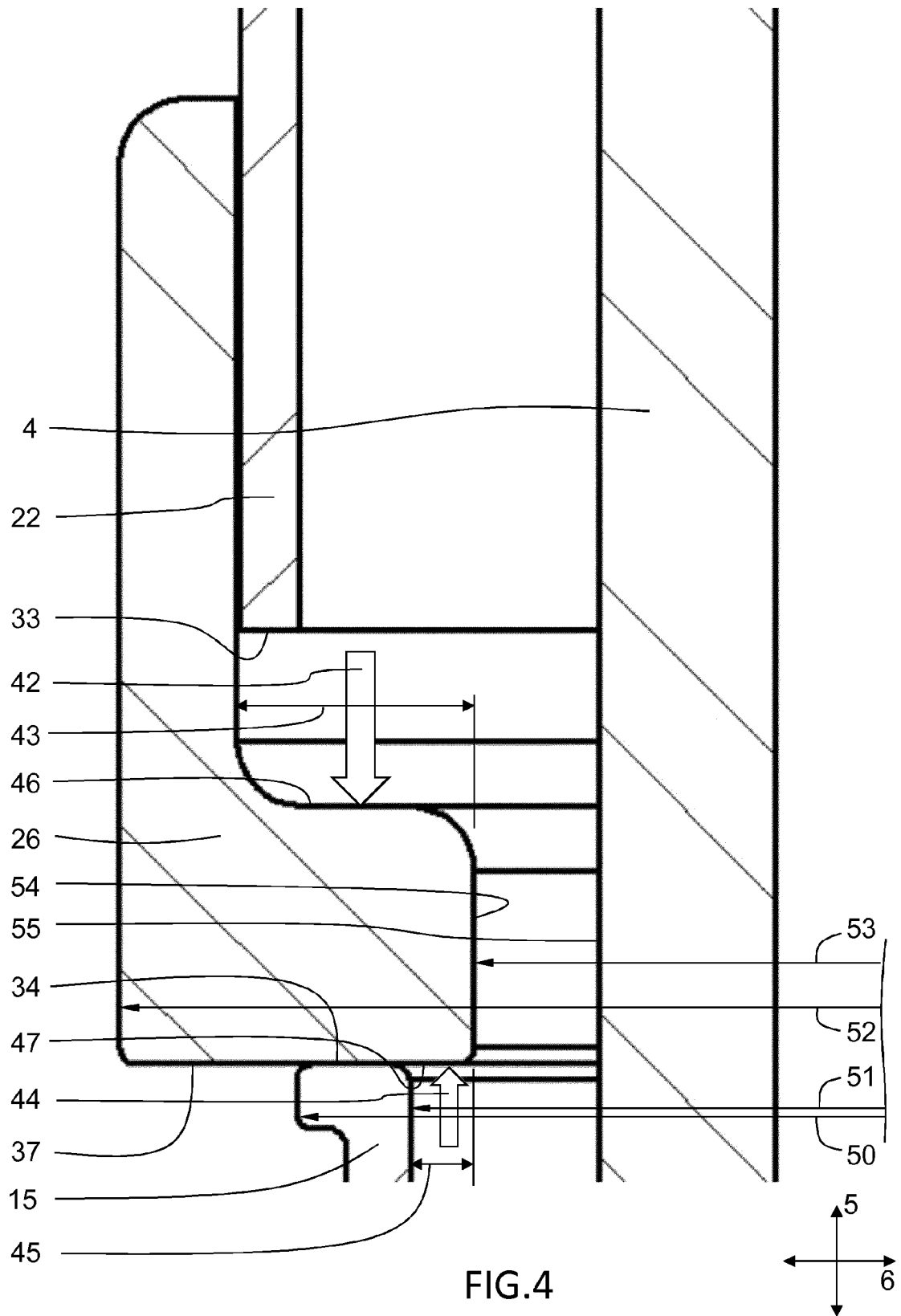


FIG.1





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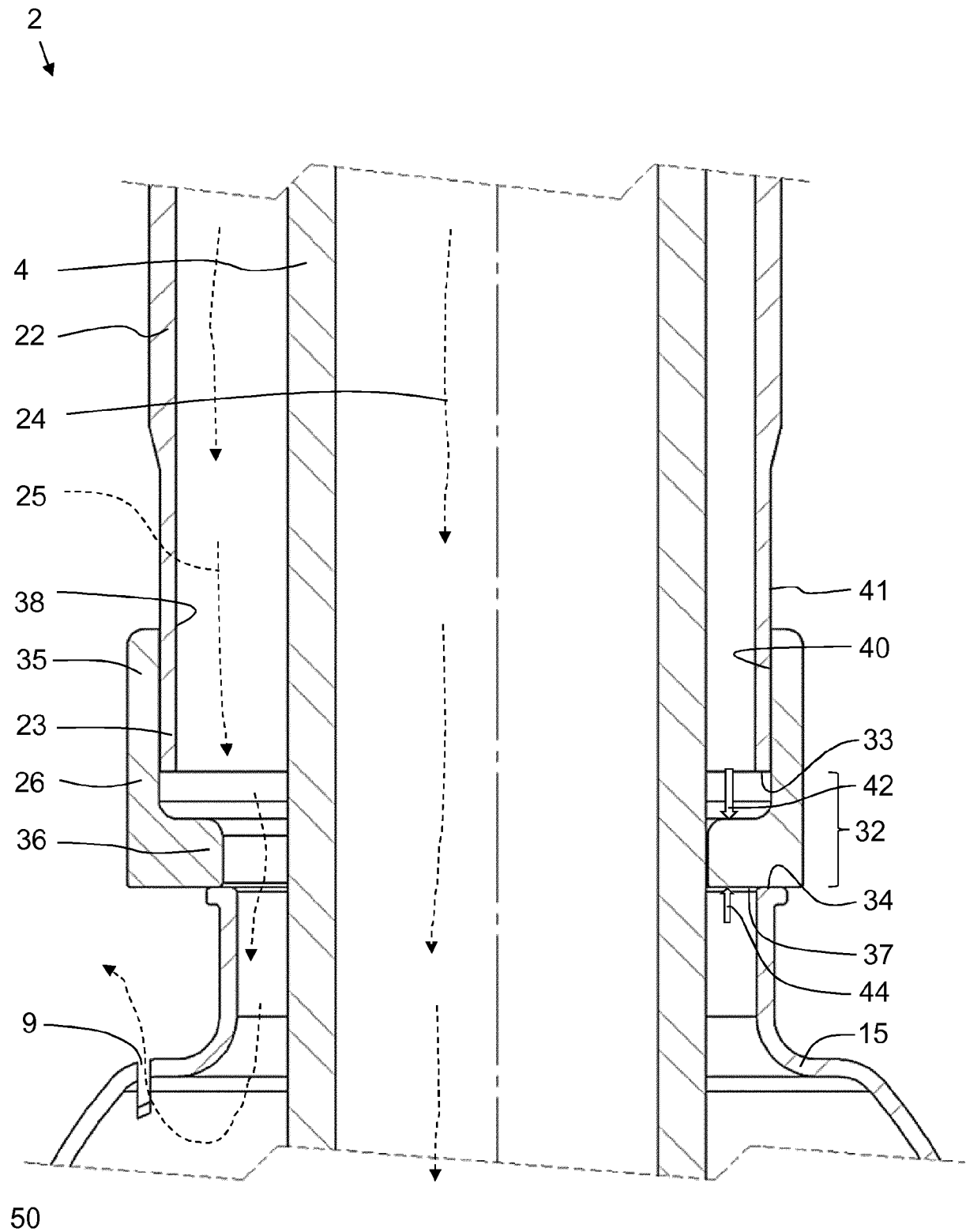
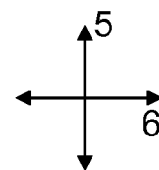


FIG.5



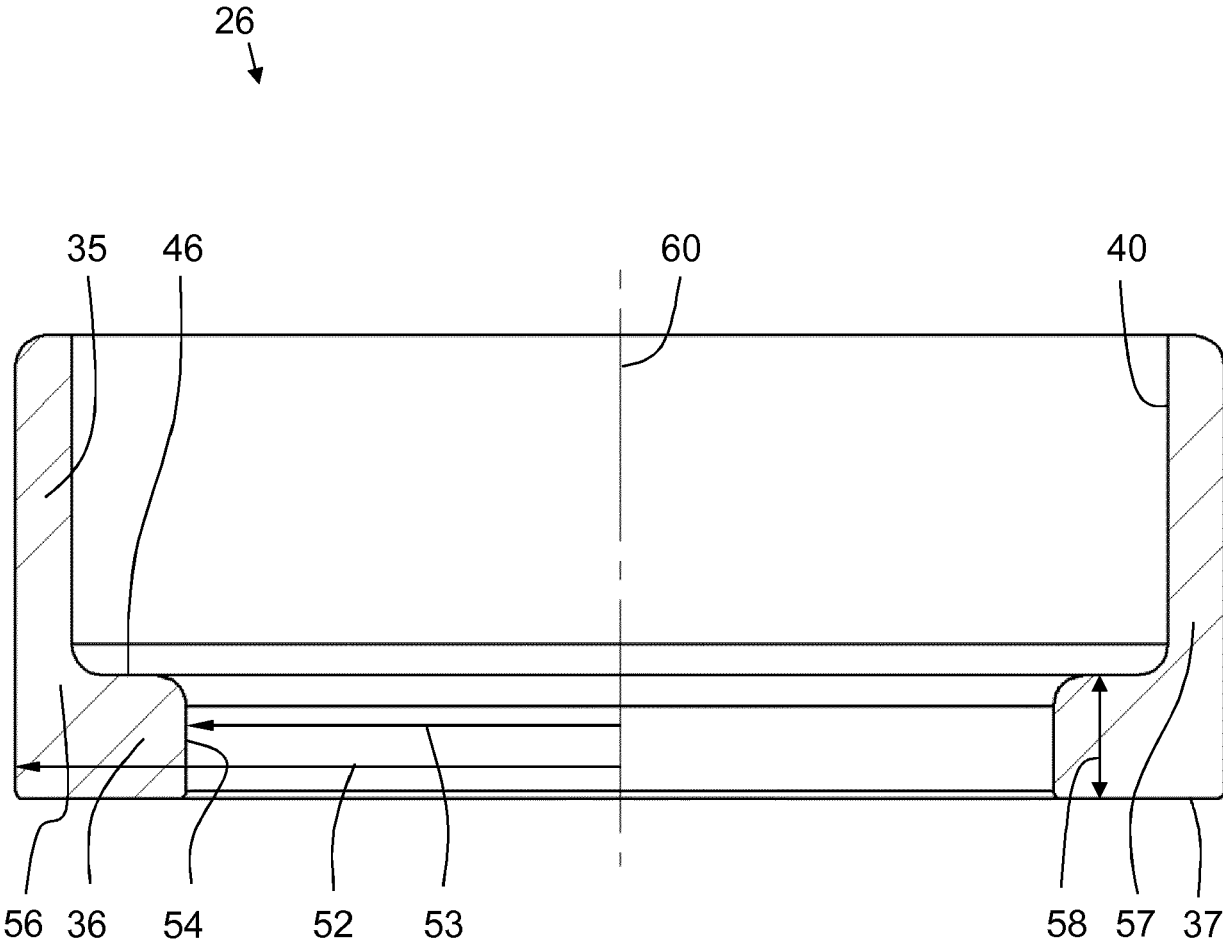
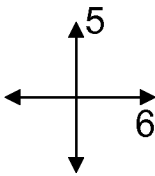


FIG.6





## EUROPEAN SEARCH REPORT

 Application Number  
 EP 18 17 7891

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                                                             |                                                                                                                                                                                                                                                                              |                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                               | Relevant to claim                                                                                                                                                                                                                                                            | CLASSIFICATION OF THE APPLICATION (IPC)                            |
| A                                                                                                                                                                                                                                                      | FR 2 332 819 A1 (KARCHER ALFRED [DE])<br>24 June 1977 (1977-06-24)<br>* page 1, line 1 - line 3 *<br>* page 1, line 39 - page 3, line 14 *<br>* figure 1 *                  | 1-15                                                                                                                                                                                                                                                                         | INV.<br>B01F7/00<br>B01F7/22<br>B01F15/00<br>B08B3/02<br>B08B9/093 |
| A                                                                                                                                                                                                                                                      | -----<br>CN 206 980 591 U (ZHEJIANG YANGTSE RIVER MIXERS CO LTD)<br>9 February 2018 (2018-02-09)<br>* paragraph [0026] *<br>* figures 1,2 *                                 | 1-15                                                                                                                                                                                                                                                                         |                                                                    |
| A                                                                                                                                                                                                                                                      | -----<br>US 4 168 918 A (DE JONGE HEINRICH)<br>25 September 1979 (1979-09-25)<br>* column 3, line 41 - line 64 *<br>* column 4, line 13 - line 37 *<br>* figure 1 *         | 1-15                                                                                                                                                                                                                                                                         |                                                                    |
| A                                                                                                                                                                                                                                                      | -----<br>US 2016/230890 A1 (PIEPEREIT EDWARD J [GB]) 11 August 2016 (2016-08-11)<br>* paragraph [0001] *<br>* paragraph [0050] *<br>* paragraph [0054] *<br>* figures 3-5 * | 1-15                                                                                                                                                                                                                                                                         | TECHNICAL FIELDS SEARCHED (IPC)<br>B01F<br>B08B                    |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                                                             |                                                                                                                                                                                                                                                                              |                                                                    |
| Place of search<br>The Hague                                                                                                                                                                                                                           |                                                                                                                                                                             | Date of completion of the search<br>17 December 2018                                                                                                                                                                                                                         | Examiner<br>Real Cabrera, Rafael                                   |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                                                             | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                    |

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ON EUROPEAN PATENT APPLICATION NO.**

EP 18 17 7891

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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17-12-2018

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