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(54) A LIQUID EJECTION APPARATUS

(57) A liquid ejection apparatus (1) for cleaning an interior surface (2) of a tank (3), wherein the liquid ejection apparatus (1) is configured to be attached to a flow pipe (4) that extends into the tank (3) and to receive a liquid from the flow pipe (4). The liquid ejection apparatus (1) comprises a stationary support assembly (6) configured to be attached to the flow pipe (4) that extends into the tank (3), and to receive a liquid from the flow pipe (4), a rotary head assembly (7) having at least one liquid ejection outlet (8) for ejecting the liquid on the interior surface (2) of the tank (3), and a drive system (9) for rotating the rotary head assembly (7). The drive system (9) includes an impeller (10) arranged in a flow path (11) of the liquid and the impeller (10) is configured to be rotated by the flow of liquid that passes the impeller (10). The drive system (9) is configured to cause rotation of the rotary head assembly (7) when there is a flow of liquid that passes the impeller (10), and the drive system (9) is configured to prevent rotation of the rotary head assembly (7) when there is a flow of gas, steam or air that passes the impeller (10).

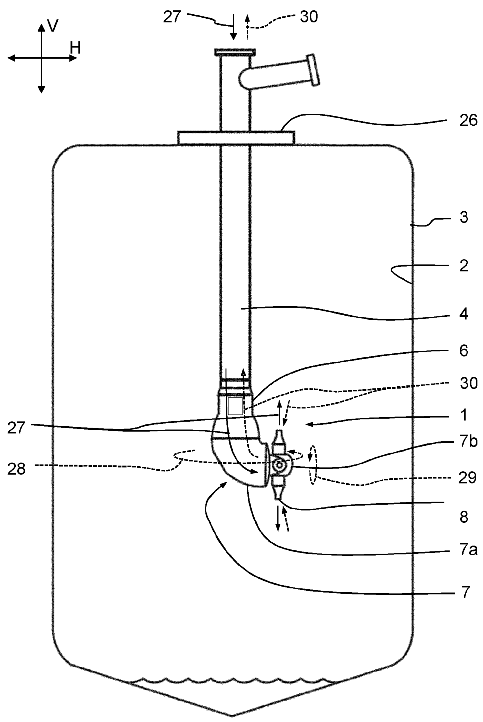

FIG.1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a liquid ejection apparatus for cleaning an interior surface of a tank. The disclosure further relates to a method for cleaning an interior surface of a tank by ejecting a liquid by a liquid ejection apparatus located within the tank, and for supplying or releasing air, gas or steam to or from an interior of a tank via the liquid ejection apparatus.

[0002] The liquid ejection apparatus and associated method according to the disclosure can for example be used and implemented in tanks in the brewery and beverage, dairy, personal care and biopharma industries. Furthermore, although the liquid ejection apparatus is particularly suitable for tank cleaning, the liquid ejection apparatus according to the disclosure may alternatively, or in addition, be used for liquid mixing, gas dispersion, powder mixing, tank gas release, etc.

BACKGROUND

[0003] In the process technology field having tanks for holding, storing, mixing and preparing a liquid or powder products, such as for example food products, dairy products, beverage products, pharmaceutical products, personal care products, it is necessary to provide good cleaning solutions for cleaning of the interior of the tanks between consecutive batches of product preparation for ensuring a high hygienic level. It is known to use rotary tank cleaning heads for injecting a cleaning liquid, such as water, into the tank for performing tank cleaning. However, there is demand for further improving the versatility of the rotary tank cleaning heads without negatively effecting long-term operational reliability and maintenance requirements.

SUMMARY

[0004] An object of the present disclosure is to provide a liquid ejection apparatus and associated method where the previously mentioned problems are avoided. This object is at least partly achieved by the features of the independent claims. The dependent claims define further developments of the liquid ejection apparatus.

[0005] According to a first aspect of the present disclosure, there is provided a liquid ejection apparatus for cleaning an interior surface of a tank, the liquid ejection apparatus being configured to be attached to a flow pipe that extends into the tank and to receive a liquid from the flow pipe. The liquid ejection apparatus comprises a stationary support assembly configured to be attached to the flow pipe that extends into the tank, and to receive a liquid from the flow pipe, a rotary head assembly having at least one liquid ejection outlet for ejecting the liquid on an interior surface of the tank, and a drive system for rotating the rotary head assembly. The drive system includes an impeller arranged in a flow path of the liquid and configured to be rotated by the flow of liquid that passes the impeller, and the drive system is configured to cause rotation of the rotary head assembly when there is a flow of liquid that passes the impeller, and wherein the drive system is configured to prevent rotation of the rotary head assembly when there is a flow of gas, steam or air that passes the impeller.

[0006] According to a second aspect of the present disclosure, there is provided a method for cleaning an interior surface of a tank by ejecting a liquid by a liquid ejection apparatus located within the tank, and for supplying or releasing air, gas or steam to or from an interior of a tank via the liquid ejection apparatus, wherein the liquid ejection apparatus is attached to a flow pipe that extends into the tank, and wherein liquid ejection apparatus comprises a stationary support assembly configured to be attached to the flow pipe that extends into the tank and a rotary head assembly having at least one liquid ejection outlet for ejecting the liquid on the interior surface of the tank, the method comprises: supplying a flow of liquid to the liquid ejection apparatus via the flow pipe, wherein the flow of liquid induces a fluid force that drives an impeller of a drive system of the liquid ejection apparatus, and wherein rotation of the impeller results in rotation of the rotary head assembly, and subsequently stopping the supply of liquid to the liquid ejection apparatus via the flow pipe; and supplying a flow of air, gas or steam to the liquid ejection apparatus via the flow pipe or releasing a flow of gas from the interior of the tank via the liquid ejection apparatus and the flow pipe, wherein the drive system prevents rotation of the rotary head assembly when there is a flow of gas, steam or air that passes the impeller.

[0007] In many industrial processes, it is desirable to add gas, steam or air to the tank, and/or to remove gas from the tank. Such supply and release of air, gas or steam to or from the tank may for example be performed via a separate gas inlet/outlet. However, supplying or releasing air, gas or steam via a separate gas inlet/outlet generally results in cost associated with manufacturing, installing and maintenance of the separate gas inlet/outlet. Therefore, tests have been made to evaluate the possibility to use the liquid ejection apparatus, which is typically used for tank cleaning, also for supplying and/or releasing gas, air or steam to or from the tank. However, when adding or releasing gas, air or steam though the liquid ejection apparatus, there is a risk that an impeller in the liquid ejection apparatus will start rotating, which may cause rotation of liquid ejection apparatus, and rotation of the liquid ejection apparatus in the absence of the lubricating effect provided by the flow a liquid may cause increased wear and even breakdown of the liquid ejection apparatus.

[0008] This problem is solved by the liquid ejection apparatus according to the disclosure by having the liquid ejection apparatus configured for preventing the liquid ejection apparatus from rotating when gas, air or steam is supplied to the liquid ejection apparatus, or when releasing gas from inside the tank to the outside of the tank via the liquid ejection apparatus. On the other hand, the liquid ejection apparatus is configured to rotate when a flow of liquid, such as water or other type of liquid, is supplied to liquid ejection apparatus. Thereby, a cost-efficient multi-functional liquid ejection apparatus with gas, air or steam inlet/out capability is provided, wherein rotation is only occurring during supply of a liquid that provides lubrication the parts of the liquid ejection apparatus, such that excessive wear and/or increased maintenance is largely avoided.

[0009] Further advantages are achieved by implementing one or several of the features of the dependent claims. For example, in some example embodiments, the drive system further includes a drive clutch arrangement that when set in an engaged state rotationally connects the impeller with the rotary head assembly, and when set in a disengaged state rotationally disconnects the impeller from the rotary head assembly, and/or a locking clutch arrangement that when set in an engaged state rotationally connects the impeller with the stationary support assembly, and when set in a disengaged state rotationally disconnects the impeller from the stationary support assembly. Such clutch arrangements provides a cost-efficient, reliable and easily implemented solution for accomplishing the desire operating behaviour of the liquid ejection apparatus.

[0010] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the drive clutch arrangement is configured to automatically shift from disengaged to engaged state when affected, directly or indirectly, by a fluid force induced by the liquid flowing through the flow path. Thereby, no external control or steering of the clutch arrangement of liquid ejection apparatus is required.

[0011] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the liquid ejection apparatus includes a force generating device that urges the drive clutch arrangement towards the disengaged state, such that the drive clutch arrangement is automatically shifted from engaged to disengaged state in absence of liquid flowing through the flow path. A force generating device is generally a cost-efficient solution for providing the desired clutch operation.

[0012] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the drive clutch arrangement is defined by a first engagement structure located on the impeller or on a part rotationally fastened to the impeller, and a first corresponding engagement structure located on a part of the rotary head assembly, and the engaged state of the drive clutch arrangement corresponds to the first engagement structure being rotationally engaged with the first corresponding engagement structure, and the disengaged state of the drive clutch arrangement corresponds to the first engagement structure being rotationally disengaged from the first corresponding engagement structure. By implementing the drive clutch at or near the impeller ensures that most parts of the rotary head assembly remains immovable in disengaged state of the drive clutch.

[0013] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the drive system further includes a locking clutch arrangement that when set in an engaged state rotationally connects the impeller with the stationary support assembly, and when set in a disengaged state rotationally disconnects the impeller from the stationary support assembly. Thereby, wear on the impeller caused by free-spinning impeller during air, gas or steam supply or release is largely avoided.

[0014] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the locking clutch arrangement is configured to automatically shift from engaged to disengaged state when affected, directly or indirectly, by a fluid force induced by liquid flowing through the flow path. Thereby, no external control or steering of the clutch arrangement of liquid ejection apparatus is required.

[0015] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the locking clutch arrangement is urged towards the engaged state by means of the force generating device or an auxiliary force generating device, such that the locking clutch arrangement is automatically shifted from disengaged to engaged state in absence of liquid flowing through the flow path. A force generating device or an auxiliary force generating device is generally a cost-efficient solution for providing the desired clutch operation.

[0016] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the locking clutch arrangement is defined by a second engagement structure located on the impeller or on a part rotationally and axially secured to the impeller, and a second corresponding engagement structure located on a part of the stationary support assembly, and the engaged state of the locking clutch arrangement corresponds to the second engagement structure being rotationally engaged with the second corresponding engagement structure, and the disengaged state of the locking clutch arrangement corresponds to the second engagement structure being rotationally disengaged from the second corresponding engagement structure. By implementing the locking clutch at or near the impeller ensures that the impeller remain stationary during air, gas or steam supply/release.

[0017] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the impeller and associated first engagement structure is axially displaceable between a first axial position and a second axial position, wherein the first axial position of the impeller corresponds to the disengaged state of the drive clutch arrangement, wherein the second axial position of the impeller corresponds to the engaged state of the drive clutch arrangement, wherein the impeller is pushed towards the first axial position by the force generating device, and wherein the impeller is configured to be pushed to the second axial position by an axial force induced by the flow of liquid that passes the impeller. Using axial motion of the impeller for implementing the clutch operation is a cost-efficient solution, because the impeller is located in the flow path and thus exposed to the fluid force generated by a flow of liquid, and less other clutch parts must be positioned in, and obstructing, the flow path.

[0018] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the first axial position of the impeller corresponds to the engaged state of the locking clutch arrangement, wherein the second axial position of the impeller corresponds to the disengaged state of the locking clutch arrangement.

[0019] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the liquid ejection apparatus has an axial direction that is parallel with the rotational axis of the impeller, and wherein the force generating device pushes the impeller in the axial direction substantially opposite to a liquid flow direction. Thereby, the fluid force acting on the impeller and being generated by the liquid flow is directed opposite to a force provided by the force generating device.

[0020] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the liquid ejection apparatus has an axial direction that is parallel with the rotational axis of the impeller and a radial direction perpendicular to the axial direction, wherein the liquid ejection apparatus comprises an elongated drive shaft carrying the impeller and extending in the axial direction, and wherein the force generating device is mounted on the drive shaft and abutting the drive shaft on one axial side and the impeller on the other axial side, or mounted in a cavity defined by an axial support surface of the drive shaft, an opposite interior axial abutment surface of the impeller, and a radial interior surface of the impeller and/or of the drive shaft. The positioning of the force generating device around or within the drive shaft provides the force generating device with reliable operation behaviour.

[0021] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the liquid ejection apparatus comprises an elongated drive shaft on which the impeller is mounted, and wherein the impeller has an interior sliding surface and/or the drive shaft has an exterior sliding surface for reducing sliding friction between impeller and drive shaft. This is beneficial for reduced wear associated with both rotational and axial sliding of the impeller relative to the drive shaft.

[0022] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the force generating device is a spring, or a hollow O-ring, or a magnet spring, or a rubber diaphragm, or a gas or air spring arrangement.

[0023] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the drive system further includes a transmission arrangement configured for transmitting rotary motion from the impeller to the rotary head arrangement.

[0024] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the rotary head assembly includes a rotary head and a rotary outlet hub that is rotatably connected to the rotary head, wherein the rotary head being rotatable about a first rotational axis and the rotary outlet hub being rotatable about a second rotational axis that is arranged at an angle relative to the first rotational axis, and wherein the at least one liquid ejection outlet is located on the rotary outlet hub. Thereby, increased coverage of a liquid stream exiting the liquid ejection outlet over a tank internal surface is accomplished.

[0025] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the flow of liquid sets a drive clutch arrangement in an engaged state against a counter force provided by a force generating device of the liquid ejection apparatus, such that the impeller becomes rotationally connected with a rotary head assembly and rotation of the impeller results in rotation of a part of the rotary head assembly, and wherein the force generating device, in the absence of liquid supply to the liquid ejection apparatus, sets the drive clutch arrangement in a disengaged state, such that the impeller becomes rotationally disconnected from the rotary head assembly; wherein a fluid force induced by the flow of air, gas or steam and acting for setting the drive clutch arrangement in the engaged state is lower than a counter force provided by the force generating device acting for setting the drive clutch arrangement in the disengaged state, such that the drive clutch arrangement is maintained in the disengaged state, or wherein a fluid force induced when releasing gas acts for setting the drive clutch arrangement in the disengaged state together with the force generating device, such that the drive clutch arrangement is maintained in the disengaged state.

[0026] In some example embodiments, which may be combined with any one or more of the above-described embodiments, the flow of liquid sets a locking clutch arrangement in a disengaged state against a counter force provided by a force generating device of the liquid ejection apparatus, such that the impeller becomes rotationally disconnected from the stationary support assembly and rotation of the impeller results in rotation of a part of the rotary head assembly, and wherein the force generating device, in the absence of liquid supply to the liquid ejection apparatus, sets the locking clutch arrangement in an engaged state, such that the impeller becomes rotationally connected with the stationary support assembly; wherein a fluid force induced by the flow of air, gas or steam and acting for setting the locking clutch arrangement in the disengaged state is lower than a counter force provided by the force generating device acting for setting the locking clutch arrangement in the engaged state, such that the locking clutch arrangement is maintained in engaged state, or wherein a fluid force induced when releasing gas acts for setting the locking clutch arrangement in the engaged state, together with the force generating device, such that the locking clutch arrangement is maintained in the engaged state.

[0027] Further features and advantages of the invention will become apparent when studying the appended claims and the following description. The skilled person in the art realizes that different features of the present disclosure may be combined to create embodiments other than those explicitly described hereinabove and below, without departing from the scope of the present disclosure.

BRIEF DESCRIPTION OF DRAWINGS

[0028] The liquid ejection apparatus and associated method for cleaning a tank using such a liquid ejection apparatus according to the disclosure will be described in detail in the following, with reference to the attached drawings, in which

Fig. 1	shows schematically a side-view of an example embodiment of a tank having a liquid ejection apparatus installed therein,
Fig. 2	shows a cross-sectional view of an example embodiment of the liquid ejection apparatus,
Fig. 3-4	show two different cross-sectional views of an impeller-shaft assembly,
Fig. 5A	shows the impeller-shaft assembly of figures 3-4 in a neutral state or a steam supply operating state,
Fig. 5B	shows the impeller-shaft assembly of figures 3-4 in a liquid supply operating state,
Fig. 5C	shows the main axial forces acting on the impeller,
Fig. 6-7	show two different cross-sectional views of a further example embodiment of the impeller-shaft assembly,
Fig. 8A	shows the impeller-shaft assembly of figures 6-7 in a neutral state or a steam supply operating state,
Fig. 8B	shows the impeller-shaft assembly of figures 6-7 in a liquid supply operating state,
Fig. 9A-9B	show a further example embodiment of the liquid ejection apparatus in a neutral state and liquid supply operating state, respectively,
Fig. 10A-10B	show a further example embodiment of the impeller-drive shaft assembly of the liquid ejection apparatus in a neutral state or a steam supply operating state, and liquid supply operating state, respectively,
Fig. 11A-11B	show a further example embodiment of the impeller-drive shaft assembly of the liquid ejection apparatus in a neutral state or a steam supply operating state, and liquid supply operating state, respectively,
Fig. 12A-12B	show a further example embodiment of the impeller-drive shaft assembly of the liquid ejection apparatus in a neutral state or a steam supply operating state, and liquid supply operating state, respectively,
Fig. 13A-13B	show a further example embodiment of the impeller-drive shaft assembly of the liquid ejection apparatus in a neutral state or a steam supply operating state, and liquid supply operating state, respectively, and
Fig. 14A-14B	show a further example embodiment of the impeller-drive shaft assembly of the liquid ejection apparatus in a neutral state or a steam supply operating state, and liquid supply operating state, respectively.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[0029] Various aspects of the disclosure will hereinafter be described in conjunction with the appended drawings to illustrate and not to limit the disclosure, wherein like designations denote like elements, and variations of the described aspects are not restricted to the specifically shown embodiments, but are applicable on other variations of the disclosure.

[0030] Figure 1 schematically shows an example installation of the liquid ejection apparatus 1 within a tank 3 for holding, storing, mixing and preparing a liquid or powder product. The tank may for example be in the range of 1 - 20 meters high in a vertical direction V, or more, and be made of stainless steel or other suitable and hygienic material.

[0031] The liquid ejection apparatus 1 is located within the tank 3 and configured for cleaning an interior of the tank 3, such as the interior surface 2 of the tank walls, and possibly also an exterior surface of the liquid ejection apparatus 1 itself.

[0032] The liquid ejection apparatus 1 may for example be mounted on a flow pipe 4 that extends through the wall of the tank 3 and into the tank 3. The flow pipe 4 may be stationary mounted to the tank 3 via a flange connection 26 or the like.

[0033] Cleaning of the interior of the tanks between consecutive batches of product preparation is important for providing hygienic and pure product with high quality. During cleaning a flow of a liquid, such as water or other type of cleaning liquid, may be supplied to the flow pipe 4. The flow of liquid is for example generated by a liquid pump (not showed), which supplies a flow of liquid to the flow pipe 4.

[0034] The pump may for example be configured for pressurizing the liquid to have a working pressure of about 1 - 20 bar, specifically in the range of 2 - 15 bar, or the like, when reaching the liquid ejection apparatus 1.

[0035] The liquid ejection apparatus 1 further includes at least one liquid ejection outlet 8 for ejecting the liquid within the tank 3. The liquid ejection outlet 8 may for example be designed to provide a relatively solid and straight stream of liquid with long throw length, for example about 2 - 20 meters, depending on liquid pressure. Thereby, a stream of liquid with a certain impact force may be directed towards the interior surface for providing a good cleaning effect.

[0036] The liquid ejection apparatus 1 may have various designs and in the example embodiment of figure 1, the liquid ejection apparatus 1 is provided with a stationary support assembly 6 and a rotary head assembly 7. The stationary support assembly 6 may have a first end region and a second end region, wherein the first end region is attached to the stationary flow pipe 4 and the second end region is attached to the rotary head assembly 7. The rotary head assembly 7 is thus rotatably fastened to the stationary support assembly 6, as illustrated by dashed arrow 28 in figure 1, and a drive system may be provided for rotating the rotary head assembly 7 relative to the stationary support assembly 6. The drive system is for example powered by the flow of liquid supplied by the pump.

[0037] In some example embodiments, the rotary head assembly 7 is more or less a hollow housing, e.g. a rotary head 7a, having at least one liquid ejection outlet 8 in the wall of the rotary head 7a, wherein rotation of the rotary head 7a, as illustrated by dashed arrow 28, causes a stream of liquid exiting the liquid ejection outlet 8 to move over the interior surface 2 of the tank 3.

[0038] However, in the example embodiment illustrated in figure 1, the rotary head assembly 7 includes both a rotary head 7a and a rotary outlet hub 7b, which is rotationally attached to the rotatable rotary head 7a. When a rotational axis of the rotary head 7a is different from a rotational axis of the rotary outlet hub 7b, in particular perpendicular to each other, a good coverage of the stream of liquid exiting the liquid ejection outlet 8 of the interior surface 2 of the tank 3 may be accomplished, provided that the at least one liquid ejection outlet 8 is arranged on the rotary outlet hub 7b and both the rotary head 7a and rotary outlet hub 7b rotates. The rotational motion of the rotary outlet hub 7b is illustrated by dashed arrow 29 in figure 1.

[0039] Specifically, in the example embodiment of figure 1, the rotational axis of the rotary head 7a is parallel with the vertical direction V and the rotational axis of the rotary outlet hub is parallel with the horizontal direction H, but this may of course be changed according to the circumstances of each specific implementation. Similarly, in the example embodiment of figure 1, the flow pipe 4 extends into the tank 3 from a top wall of the tank 3, but this may also be changed, such that flow pipe 4 extends into the tank 3 from a side wall or bottom wall of the tank 3 instead.

[0040] In figure 1, the flow of liquid supplied by the pump to the liquid ejection apparatus 1 via the flow pipe 4 is schematically illustrated by solid arrows 27 in figure 1.

[0041] The liquid ejection apparatus 1 may also be used for releasing air, gas or steam from interior of a tank 3. For example, if a product stored in the tank undergo fermentation, a large amount of carbon dioxide is produced that must be released from the tank 3. The flow of gas being released from the tank 3 via the liquid ejection apparatus 1 and the flow pipe 4 is schematically illustrated by dashed arrows 30 in figure 1.

[0042] A cross-sectional view of a more detailed example embodiment of the liquid ejection apparatus 1 is showed in figure 2. The liquid ejection apparatus 1 is configured to be attached to the flow pipe 4 that extends into the tank 3 and to receive a liquid from the flow pipe 4.

[0043] In particular, the liquid ejection apparatus 1 comprises a stationary support assembly 6 that is configured to be attached to the flow pipe 4 that extends into the tank 3 and to receive a liquid from the flow pipe 4.

[0044] The liquid ejection apparatus 1 further comprises a rotary head assembly 7 having at least one liquid ejection outlet 8 for ejecting the liquid on the interior surface 2 of the tank 3.

[0045] The liquid ejection apparatus 1 further comprises a drive system 9 for rotating the rotary head assembly 7, wherein the drive system 9 includes an impeller 10 arranged in a flow path 11 of the liquid and configured to be rotated by the flow of liquid that passes the impeller 10.

[0046] Moreover, wherein the drive system 9 is configured to cause rotation of the rotary head assembly 7 when there is a flow of liquid that passes the impeller 10, and wherein the drive system 9 is configured to prevent rotation of the rotary head assembly 7 when there is a flow of gas, steam or air that passes the impeller 10.

[0047] In the example embodiment of the liquid ejection apparatus 1 showed in figure 2, the drive system 9 further includes both a drive clutch arrangement 12 and locking clutch arrangement 15 for accomplishing the desired functionality of the liquid ejection apparatus 1. The drive clutch arrangement 12 is configured to, when set in an engaged state, rotationally connect the impeller 10 with the rotary head assembly 7, and when set in a disengaged state, rotationally disconnect the impeller 10 from the rotary head assembly 7. The locking clutch arrangement 15 is configured to, when set in an engaged state, rotationally connect the impeller 10 with the stationary support assembly 6, and when set in a disengaged state, rotationally disconnect the impeller 10 from the stationary support assembly 6.

[0048] Consequently, when the drive clutch arrangement 12 is set in the disengaged state, the impeller 10 is rotationally disconnected from the rotary head assembly 7 and rotation of the impeller 10 cannot be transmitted to the rotary head assembly 7 for generating a rotational motion of the rotary head assembly 7. On the other hand, when the drive clutch arrangement 12 is set in the engaged state, the impeller 10 becomes rotationally connected with the rotary head assembly 7, such that a portion of the rotary head assembly 7 carrying the at least one liquid ejection outlet 8 will rotate when the impeller 10 is rotating, for example due to liquid supplied by a tank external pump and flowing in the flow path 11 extending from the flow pipe 4 to the at least one liquid ejection outlet 8 while passing the impeller 10.

[0049] In the example embodiment of figure 2, the impeller 10 is thus rotationally and axially slidably mounted on a drive shaft 19, which is rotationally connected to the rotary head assembly 7. The impeller 10 may thus move axially between an upper position, as depicted in figure 2, in which the impeller 10 is rotationally disconnected from the shaft 19, and a lower position, in which the impeller 10 is rotationally connected with the shaft 19 via the drive clutch arrangement 12, thereby causing rotation of the rotary head assembly 7 when powered by a flow of liquid.

[0050] The impeller 10 is pushed upwards in figure 2 towards said upper position by means of a force generating device (not showed), such as a mechanical spring or the like. The axial force provided by the force generating device and urging the impeller 10 upwards towards the upper position is selected to be high enough to ensure axial displacement of the impeller to the upper position in the absence of flow of liquid passing the impeller in the flow path 11, while also being low enough for ensuring that the impeller 10 is axially displaced to the lower position when a flow of liquid is supplied to the impeller 10 for driving the impeller 10.

[0051] In the upper position, the impeller is rotationally engaged with stationary support assembly 6 via the locking clutch arrangement 15, such that the impeller 10 becomes rotationally locked, thereby avoiding undesirable wear on the impeller 10 when supplying or releasing gas, steam or air via the liquid ejection apparatus.

[0052] With reference to the example embodiment of figure 2, the rotary head assembly 7 includes a rotary head 7a and a rotary outlet hub 7b that is rotatably connected to the rotary head 7a. The rotary head 7a is rotatable about a first rotational axis 24 and the rotary outlet hub 7b is rotatable about a second rotational axis 25 that is arranged at an angle, such as for example about 45 - 146 degrees, specifically about 90 degrees, relative to the first rotational axis 24. Moreover, the rotary outlet hub 7b comprises a plurality of liquid ejection outlets 8.

[0053] The rotation of the rotary head 7a and the rotary outlet hub 7b about their respective axes 24, 25 is realized by means of the drive system 9. The drive system is powered by the flow of the liquid entering a first end the stationary support assembly 6. In order to achieve the rotation, the impeller 10 is arranged in the flow path 11 of the liquid, e.g. below the liquid inlet at the first end stationary support assembly 6. In other words, the impeller 10 is arranged inside the stationary support assembly 6, but the impeller may alternative be arranged inside the rotary head 7a. A rotation of the impeller 10 is induced by the flow the liquid that passes by the impeller 10.

[0054] The drive system 9 comprises a transmission arrangement configured for transmitting rotary motion from the impeller 10 to the rotary head arrangement 7. The transmission arrangement comprises the above-mentioned drive shaft 19 and a gearbox in form of a planetary or epicyclical gear. The gearbox reduces a rotation speed as received by impeller 10, resulting in a suitable rotation speed of the rotary head 7a. The epicyclical gear includes a central sun gear 32 provided on the shaft 19, a set of surrounding planetary gear 33 that are in meshing engagement with the sun gear 32, and an outer stationary ring gear 34 that is in meshing engagement with planetary gear 33 and attached to a stationary stem 39 of the stationary support assembly 6. A planetary gear carrier 35 is attached to the rotary head 7a for causing the rotary head 7a to rotate when the impeller 10 causes the drive shaft 19 to rotate. The rotary head 7a is rotatably attached to a second side of the stationary support assembly 6 via a first roller bearing 37. The skilled person realizes that any suitable kind of gearbox may be used.

[0055] The rotary outlet hub 7b is rotatably mounted in a hole in the wall of the rotary head 7a via a second roller bearing 37, and is caused to rotate about the second axis 25 by engagement between a toothed surface 38 of the rotary outlet hub 7b with a corresponding toothed stationary surface 31 of the stationary support assembly 6, in combination with the rotational motion of the rotary head 7a.

[0056] In the example embodiment of figure 2, a lower end region of the drive shaft 19 is supported by the gearbox, such as the planetary gear carrier 35. An upper end region of the drive shaft 19 is supported by a guide member 40, which includes a cylindrical outer portion 41 located in a corresponding recess of a housing 5 of the stationary support assembly 6. The guide member 40 further includes an inner bearing support 42 that is connected to the a cylindrical outer portion 41 via a set of connection arms 43 distributed along the circumference of the guide member 40. The inner bearing support 42 may support the shaft 19 directly or via a bearing member 43, such as a sliding bushing or the like. The flow path 11 configured for receiving liquid for driving the impeller 10 is defined partly by an interior surface of the cylindrical outer portion 41 and an exterior surface of the inner bearing support.

[0057] Assembly of the liquid ejection apparatus may involve the following steps, first the rotary head assembly 7 with the rotary head 7a and the rotary outlet hub 7b is assembled. Thereafter, the planetary carrier 35 and associated planetary gears 33 may be installed and fastened to an interior surface of the rotary head 7a, the stem 39 may be mounted with meshing engagement with the planetary gears 33, the first roller bearing 36 may be mounted on the stem 39 and a stem nut 45 may be threadingly attached to the rotary head 7a. Thereafter, the drive shaft 19 with the impeller 10 and the sun gear 32 at the lower portion thereof may be mounted in meshing engagement with the planetary gears, and the guide member 40 may be mounted on the top side of the drive shaft 19. Finally, the housing of the stationary support assembly 6 may be mounted over the guide member 40 and threadingly engaged with the stem 39.

[0058] A first example embodiment of the drive clutch arrangement 12 will be described with reference to figures 3, 4, and 5A-5C, wherein figure 3 shows a cross-sectional view of the shaft 19, impeller 10 and guide member 40 with its cylindrical outer portion 41 and inner bearing portion 42, as well as force generating device 13 in form of a spring. Figure 4 shows the same design but illustrated in a different cross-sectional view. In figures 3 and 4, the drive clutch arrangement 12 is shown in a disengaged state and the locking clutch arrangement 15 is shown in an engaged state. Figure 5A shows a perspective side-view of shaft-impeller assembly with the drive clutch arrangement 12 in disengaged state, and figure 5B shows the same view of as figure 5A but with the drive clutch arrangement 12 in engaged state. Figure 5C shows schematically the axial forces acting on the impeller 10. Only the shaft-impeller assembly of the liquid ejection apparatus 1 is illustrated, and the remaining portion of the liquid ejection apparatus 1 may for example have a design similar to that described with reference to figure 2.

[0059] In this example embodiment, the drive clutch arrangement 12 is configured to automatically shift from disengaged to engaged state when affected, directly or indirectly, by a fluid force F_F induced by the liquid flowing through the flow path 11.

[0060] With reference to figure 5C, the fluid force F_F, which also is known as drag force in the field of fluid dynamics, is a force developed when a fluid flows past an object. A static level of fluid force F_F may for example be calculated as a function of the density of the fluid, the speed of the liquid relative to the impeller 10, a cross-sectional area of the object in a plane perpendicular to the flow direction, and a drag coefficient, which is a dimensionless number depending on the design of the impeller 10. Consequently, there are various possibilities for selecting a design of the impeller and the operational circumstances for attaining a certain fluid force within a certain operating window, such as for example by changing the cross-sectional area of the impeller, changing the impeller design to influence the drag coefficient, or changing the density and/or flow speed of the fluid. The direction of the fluid force F_F generated when flowing past the impeller 10 is oriented in the axial direction A, substantially parallel with the direction of flow.

[0061] With respect to the impeller 10 shown in for example in figure 3, the design of the impeller blades 44 are particularly relevant for controlling the resulting fluid force F_F.

[0062] For example, thicker blades 44 have a larger upstream facing surface area 46 of the impeller blade results in increased downstream directed fluid force F_F. Moreover, a flat upstream facing surface area 46 of the blades 44, as illustrated in figure 3, also generates a higher fluid F_F force compared with a rounded upper surface. Moreover, the pitch of the impeller blades 44 also has an effect on resulting fluid force F_F, as well as an inclination or pitch of the connection arms 43 for introducing a swirl in the flow of supplied liquid upstream of the impeller 10.

[0063] With reference again to figure 5C, the force generating device 13 acts on the impeller 10 and provides a counterforce, i.e. a spring force Fs that is oriented substantially in the axial direction, opposite to the fluid force F_F. The design and specification of the force generating device 13 may be selected while taking the expected fluid force into account for both liquid and gas, air or steam, depending on the specific implementation and the desired operating characteristics of the impeller.

[0064] Consequently, given a certain impeller design, operating conditions and type of liquid/fluid, the person skilled in the art is able to select a suitable force generating device 13 that enables the impeller 10 to be automatically displaced axially to a first axial position, corresponding to figures 3,4, and 5A, in the absence of flow of liquid 27 past the impeller, as well as during flow of air, gas or steam past the impeller 10 in any axial direction A, and that enables the impeller 10 to be displaced axially to a second axial position, corresponding to figure 5B, when a flow of liquid 27 is supplied past the impeller 10, in a direction from the flow pipe 4 towards the rotary head assembly 7.

[0065] The pressure, flow rate and fluid density of the various types of fluids supplied to the liquid ejection apparatus may differ to a large extent. For example, without restricting the scope of the present disclosure, a liquid, such as a cleaning liquid or water or the like, may be supplied with pressure in the range of about 1-20 bar and/or with a flow rate of about 10 - 100 m3/h. Similarly, merely as an example and without restricting the scope of the present disclosure, a gas or steam may be supplied with liquid pressure in the range of about 1-10 bar and/or with a flow rate of about 10 -100 m3/h.

[0066] As described above, the liquid ejection apparatus 1 may include a force generating device 13 that urges the drive clutch arrangement 12 towards the disengaged state, such that the drive clutch arrangement 12 is automatically shifted from engaged to disengaged state in absence of liquid flowing through the flow path 11, e.g. in the presence of gas, air or steam being supplied through the liquid ejection apparatus 1. In other words, rotational motion of the impeller 10 is not transmitted to the shaft 19 due to disengaged drive clutch arrangement, thereby preventing the shaft 19 and associated rotary head assembly 7 from rotating in the absence of liquid.

[0067] Consequently, damages to the drive system 9 caused by feeding for example air, steam of gas through the liquid ejection apparatus can be avoided.

[0068] In some example embodiments, as illustrated in figures 3, 4, and 5A-5B, the drive clutch arrangement 12 is defined by a first engagement structure 14a located on the impeller 10 and a first corresponding engagement structure 14b located on a part of the rotary head assembly 7, and the engaged state of the drive clutch arrangement 12 corresponds to the first engagement structure 14a being rotationally engaged with the first corresponding engagement structure 14b, and the disengaged state of the drive clutch arrangement 12 corresponds to the first engagement structure 14a being rotationally disengaged from the first corresponding engagement structure 14b.

[0069] Two parts being rotationally engaged refers herein to being rotationally locked with each other, and two parts being rotationally disengaged means herein being rotationally released or free with respect to each other.

[0070] As schematically showed in for example figures 5A-5B, the first engagement structure 14a may be provided in form of one or more protrusions or teeth that are arranged on or indirectly connected to the impeller 10, or even the blades 44 of the impeller as such, and the first corresponding engagement structure 14b may be provided in form of one or more corresponding recesses, protrusions or teeth that are arranged on or indirectly connected to the shaft 19. For example, the drive clutch arrangement 12 may be of a dog-clutch type.

[0071] Specifically, the first engagement structure 14a of the drive clutch arrangement 12 may be provided on a downstream side 48 of the impeller 10, and the first corresponding engagement structure 14b of the drive clutch arrangement 12 may be provided on the shaft 19 or a member rotationally fastened to the shaft 19.

[0072] The term upstream herein refers to the side of the impeller 10 facing the flow pipe 4, and the term downstream herein refers to the side of the impeller 10 facing the rotary head assembly 7.

[0073] The first engagement structure 14a of the drive clutch arrangement 12 may also be referred to as a first primary engagement structure, and the first corresponding engagement structure 14b of the drive clutch arrangement 12 may also be referred to as a second primary engagement structure. The first primary engagement structure corresponds to and matches with the second primary engagement structure, such that the drive clutch arrangement 12 may be shifted from a disengaged state, in which that parts of the drive clutch arrangement 12 are free to rotate relative to each other, to an engaged state, in which that parts of the drive clutch arrangement 12 are rotationally locked relative to each other.

[0074] As described above and showed in figure 3 and figure 4, the drive system 9 may in some example embodiments further include a locking clutch arrangement 15 that, when set in an engaged state, rotationally connects the impeller 10 with the stationary support assembly 6, and when set in a disengaged state rotationally disconnects the impeller 10 from the stationary support assembly 6. In embodiments where the impeller 10 is free to rotate relative to the shaft 19, the locking clutch arrangement may be beneficial because the impeller 10 may thereby be rotationally locked to the stationary support assembly 6 when the drive clutch arrangement is in disengaged state, thereby preventing that the impeller is spinning in case of supply or release of gas, air or steam to or from the tank 3 via the liquid ejection apparatus 1. Freely spinning impeller may cause increased wear on the impeller 10 and/or shaft 19, especially in the absence of lubrication effect of a liquid.

[0075] The locking clutch arrangement 15 may be configured to automatically shift from engaged to disengaged state when affected, directly or indirectly, by a fluid force induced by liquid flowing through the flow path 11. In other words, when a liquid is supplied to the liquid ejection apparatus 1, the locking clutch arrangement 15 automatically shifts to disengaged state, thereby enabling the desired rotation of the impeller 10 and associated shaft 19 and rotary head assembly 7.

[0076] The automatic shifting from engaged to disengaged state of the locking clutch arrangement 15 when a liquid is supplied to the liquid ejection apparatus 1 may be accomplished in a similar manner as described above with reference to the drive clutch arrangement, namely by means of the force generating device 13 or separate auxiliary force generating device 16, wherein the fluid force F_F urges the locking clutch arrangement 15 towards disengaged state and the force generating device 13 or the auxiliary force generating device 16 provides a spring force F_S that urges the locking clutch arrangement 15 towards the engaged state.

[0077] Specifically, the locking clutch arrangement 15 may be urged towards the engaged state by means of the force generating device 13 or an auxiliary force generating device 16, such that the locking clutch arrangement 15 is automatically shifted from disengaged to engaged state in absence of liquid flowing through the flow path 11, and/or in the presence of gas, steam or air flowing through the flow path 11.

[0078] In the example embodiment described with reference to figure 3 - 4, the locking clutch arrangement 15 is defined by a second engagement structure 17a located on the impeller 10 and a second corresponding engagement structure 17b located on a part of the stationary support assembly 6, and the engaged state of the locking clutch arrangement 15 corresponds to the second engagement structure 17a being rotationally engaged with the second corresponding engagement structure 17b, and the disengaged state of the locking clutch arrangement 15 corresponds to the second engagement structure 17a being rotationally disengaged from the second corresponding engagement structure 17b.

[0079] As schematically showed in figures 3 - 4, and in particular as indicated by the dashed rectangle 47 in figure 4, the second engagement structure 17a may be provided in form of one or more protrusions or teeth that are arranged on or indirectly connected to the impeller 10, or even the blades 44 of the impeller 10 as such, and the second corresponding engagement structure 17b may be provided in form of one or more corresponding recesses, protrusions or teeth that are arranged on or indirectly connected to the stationary support assembly 6. For example, the locking clutch arrangement 15 may be of a dog-clutch type.

[0080] Specifically, the second engagement structure 17a of the locking clutch arrangement 15 may be provided on an upstream side 48 of the impeller 10, and the second corresponding engagement structure 17b of the locking clutch arrangement 15 may be provided on the inner bearing portion 42 or the connection arms 43 of the stationary guide member 40.

[0081] The second engagement structure 17a of the locking clutch arrangement 15 may also be referred to as a first secondary engagement structure, and the second corresponding engagement structure 17b of the locking clutch arrangement 15 may also be referred to as a second secondary engagement structure. The first secondary engagement structure corresponds to and matches with the second secondary engagement structure, such that the locking clutch arrangement 15 may be shifted from a disengaged state, in which that parts of the locking clutch arrangement 15 are free to rotate relative to each other, to an engaged state, in which that parts of the locking clutch arrangement 15 are rotationally locked relative to each other.

[0082] In other words, in those embodiments of the liquid ejection apparatus in which the impeller is axially displaceable relative to the drive shaft 19 and/or the stationary support assembly 6, as showed for example in figures 2-4 and 5A-5B, the impeller 10 and associated first engagement structure 14a is axially displaceable between a first axial position and a second axial position, wherein the first axial position of the impeller 10 corresponds to the disengaged state of the drive clutch arrangement 12, wherein the second axial position of the impeller 10 corresponds to the engaged state of the drive clutch arrangement 12, wherein the impeller 10 is pushed towards the first axial position by the force generating device 13, and wherein the impeller 10 is configured to be pushed to the second axial position by an axial force induced by the flow of liquid passing the impeller 10.

[0083] Consequently, the first axial position corresponds to a natural position, i.e. a return position, to which the impeller 10 moves and remains in the absence of supply of any type of fluid or liquid, and the second axial position corresponds to a position the impeller 10 moves to only when a liquid is supplied with a sufficient high pressure and/or flow rate, such that the resulting fluid force F_F is larger than the spring force F_S.

[0084] Moreover, in those embodiments of the liquid ejection apparatus in which the impeller is axially displaceable relative to the drive shaft 19 and/or the stationary support assembly 6, the first axial position of the impeller 10 corresponds to the engaged state of the locking clutch arrangement 15, and the second axial position of the impeller 10 corresponds to the disengaged state of the locking clutch arrangement 15.

[0085] In addition, in those embodiments of the liquid ejection apparatus in which the impeller is axially displaceable relative to the drive shaft 19 and/or the stationary support assembly 6, the liquid ejection apparatus 1 has an axial direction A that is parallel with the rotational axis of the impeller 10, and the force generating device 13 pushes the impeller 10 in the axial direction A substantially opposite to a liquid flow direction 18. The term substantially here indicated that the liquid flow direction may diverge from the axial direction a certain amount, such as for about plus/minus 30 degrees, due to inclines connection arms 43 forming guide vanes, for increasing the speed of the impeller for a given flow rate, and/or rendering the impeller operation more stable and secure.

[0086] In some example embodiments, as illustrated for example in figures 3 - 4, the liquid ejection apparatus 1 has an axial direction A that is parallel with the rotational axis of the impeller 10 and a radial direction R perpendicular to the axial direction A, wherein the liquid ejection apparatus 1 comprises an elongated drive shaft 19 carrying the impeller 10 and extending parallel with the axial direction A, and wherein the force generating device 13 is mounted in a cavity 20, in particular a sealed cavity 20, defined by an axial support surface 21 of the drive shaft 19, an opposite interior axial abutment surface 22 of the impeller 10, and a radial interior surface 23, 50 of the impeller 10 and/or of the drive shaft 19. As a result, a sealed mounting of the force generating device 13 is provided, such that a more hygienic design of the impeller may be accomplished.

[0087] With reference to figures 3 and 4, if the drive shaft 19 extends through an opening at an upstream end of the impeller 10, this opening may be sealed with a sliding bushing 51 or the like. Moreover, the central opening 52 in the inner bearing portion 42 of the guide member 40 may be closed by a plug, or by an extension of the drive shaft 19, or being left open, as shown in figures 3 and 4, for enabling better cleaning of the liquid ejection apparatus and for enabling generation of larger fluid force acting on the impeller 10 in the liquid flow direction 18 by giving better access to a central upstream facing surface area of the impeller 10.

[0088] A further example embodiment of the liquid ejection apparatus according to the disclosure will be described below with reference to figures 6, 7 and 8A-8B, wherein figure 6 shows a cross-sectional view of the shaft 19, impeller 10 and guide member 40 with its cylindrical outer portion 41 and inner bearing portion 42, as well as force generating device 13 in form of a spring. Figure 7 shows the same design but illustrated in a different cross-sectional view. In figures 6 and 7, the drive clutch arrangement 12 is shown in a disengaged state and the locking clutch arrangement 15 is shown in an engaged state. Figure 8A shows a perspective side-view of shaft-impeller assembly with the drive clutch arrangement 12 in disengaged state, and figure 8B shows the same view of as figure 8A but with the drive clutch arrangement 12 in engaged state. Only the drive shaft-impeller assembly of the liquid ejection apparatus 1 is illustrated, and the remaining portion of the liquid ejection apparatus 1 may for example have a design described with reference to figure 2.

[0089] The difference in design primarily concerns the location of the force generating device 13, which in this example embodiments is arranged more a lower side of the impeller 10, i.e. in a downstream region of the impeller 10. In other words, the force generating device 13 is mounted on the drive shaft 19 and abuts the drive shaft 19 on one axial side and the impeller 10 on the other axial side.

[0090] The force generating device 13 may for example abut a surface of the drive shaft associated with the first corresponding engagement structure 14b of the drive clutch arrangement 12. In such case, the abutment surface of the drive shaft 10 may additionally be provided with weep holes 54 for improving cleanability of the liquid ejection apparatus 1.

[0091] The impeller 10, which may also be referred to as propeller, turbine or simply a rotation generating device, may for example be manufactured in a rubber or polymeric material. The entire impeller 10 may for example be manufactured in PEEK (Polyetheretherketone) or a similar thermoplastic or resin material having high wear resistance. Alternatively, the impeller 10 may have an interior sliding surface, i.e. a dedicated sliding surface, arranged in the radial contact region between the driving shaft and impeller for reducing sliding friction between impeller 10 and drive shaft 19. The sliding surface may be provided in form of a bushing or sliding bearing that is mounted sandwiched between the impeller and drive shaft, in the radial direction. Alternatively, the bushing may be formed integrally in the impeller by means of for example double injection moulding, or the like.

[0092] In the example embodiments described herein where the impeller 10 is axially slidable relative to the drive shaft 19, the impeller 10 may have an internal step, flange, or cover 53 arranged in connection with the cylindrical hole or opening configured to receive the drive shaft 19. This internal step, flange, or cover may be used as an axial abutment surface between the impeller 10 and drive shaft 19 when the impeller is located in the second axial position, as shown in figures 5B and 8B. This internal step, flange, or cover may for example correspond to the interior axial abutment surface 22 of the impeller described above.

[0093] Furthermore, even if the force generating device 13 has been described above as being a mechanical spring, such as a helical axial mechanical spring, the force generating device 13 may be implemented in many alternative ways. For example, force generating device 13 may be implemented in form of a hollow O-ring, a magnet spring arrangement having for example two permanent magnets arranged with same magnetic pole facing each other to levitate the impeller when no liquid is supplied to the impeller 10, or a rubber diaphragm, or a gas or air spring arrangement, etc. Common for all alternatives is that the force generating device should be provide an operating compression distance of at least about 2 mm, specifically at least 5 mm.

[0094] The liquid ejection apparatus according to the disclosure may have various designs in terms of shape, functionality, drive system design, rotary head assembly design, etc. For example, figures 9A-B schematically show a further example embodiment of a liquid ejection apparatus 1, wherein the rotary head assembly 7 includes a hollow housing defining the rotary head 7a, but in this embodiment without an additional separate rotary outlet hub 7b. In such a design, the liquid ejection outlets 8 may for example be located in the side walls of the rotary head 7a instead, or via outlet nozzles arranged in the side wall of the rotary head 7a.

[0095] Furthermore, the example embodiment of the liquid ejection apparatus 1 of figures 9A-B has a different drive system 9. Specifically, the impeller 10 is rotationally and axially secured to the drive shaft 19, which is axially displaceable between a first axial position, as illustrated in figure 9A, and a second axial position, as illustrated in figure 9B. Consequently, the impeller is thus not rotationally and axially slidable relative to the drive shaft 19, as described with reference to figures 2-8B. Furthermore, the gearbox may have a different design, such as for example a planetary transmission having a sun gear 32 attached to the drive shaft 19, planetary gears 33 mounted a stationary planetary gear carrier 35, and a ring gear 34 rotationally fastened to the rotary head 7a.

[0096] The drive clutch arrangement 12 is defined by a first engagement structure 14a located on a first part 55, such as a flange on the drive shaft 19 , which is rotationally and axially secured to the impeller 10. The drive clutch arrangement 12 is further defined by a first corresponding engagement structure 14b located on the sub gear 32, which is part of the rotary head assembly 7, i.e. rotationally connected to rotary head 7a. The engaged state of the drive clutch arrangement 12 corresponds to the first engagement structure 14a being rotationally engaged with the first corresponding engagement structure 14b, and the disengaged state of the drive clutch arrangement 12 corresponds to the first engagement structure

14a being rotationally disengaged from the first corresponding engagement structure 14b.

[0097] The locking clutch arrangement 15 is defined by a second engagement structure 17a located on a second part 56, such as a flange on the drive shaft 19, which is rotationally and axially secured to the impeller 10. The locking clutch arrangement 12 is further defined by a second corresponding engagement structure 17b located on a part of the stationary support assembly 6, such as for example the inner bearing portion 42 of the guide member 40. The engaged state of the locking clutch arrangement 15 corresponds to the second engagement structure 17a being rotationally engaged with the second corresponding engagement structure 17b, and the disengaged state of the locking clutch arrangement 15 corresponds to the second engagement structure 17a being rotationally disengaged from the second corresponding engagement structure 17b.

[0098] In an operating state involving supply of air, gas or steam to the liquid ejection apparatus, as schematically illustrated by the dashed flow path 11 in figure 9A, the axial fluid force F_F acting on the impeller-shaft unit in a downstream direction, i.e. a flow direction from the flow pipe 4 to the liquid ejection outlet 8, is lower than the axial force F_S needed to compress the force generating device 13. Hence, the impeller-shaft unit remains in the first axial position, as illustrated in figure 9A. However, when a flow of pressurized liquid is supplied to the liquid ejection apparatus 1 via the flow pipe 4, as schematically illustrated by the solid flow path 11 in figure 9B, the axial fluid force F_F acting on the impeller-shaft unit in a downstream direction is higher than the axial force Fs needed to compress the force generating device 13. Hence, the impeller-shaft unit displaces a distance 57, such that the locking clutch arrangement 15 becomes disengaged and the drive clutch arrangement 12 becomes engaged, thereby causing rotation of the rotary head 7a due to rotational connection between impeller 10 and rotary head 7a.

[0099] A few further example embodiments of the liquid ejection apparatus 1 will be described below with reference to figures 10A - 14B, wherein only parts associated with the impeller 10, the stationary support assembly 6 and the drive shaft 19 are included in the figures. Specifically, the stationary support assembly 6 is here represented by a stationary stem 39 with external threads 62 and stationary guide member 40, but also this may have a different design. For example, the stem 39 and guide member 40 may be made in one piece, or integrated in the housing or another part of the stationary support assembly 6. Furthermore, the design of the other parts of the liquid ejection apparatus, such as housing 5, drive system 9 or rotary head assembly 7 may be similar to that described with reference to figure 2 or figure 9 and selected according to the specific circumstance.

[0100] The example embodiments of figure 10A-14B, the drive shaft is configured to be permanently rotationally engaged with the rotary head assembly, and not configured to be axially displaceable or disengageable as described with reference to figure 9A-B. Instead, the impeller 10 or another part is configured to be axially displaceable for accomplishing the desired clutch-functionality of the drive system 9, such that the drive shaft 19 and rotary head assembly 7, is caused to rotate when there is a flow of liquid that passes the impeller 10, and such that the drive shaft 19 and rotary head assembly 7 are configured to remain non-rotating when there is a flow of gas, steam or air that passes the impeller 10.

[0101] With reference to figure 10A-B, an impeller-shaft assembly is illustrated, which largely corresponds to the design described above with reference to figures 6, 7 and 8A-B. In figure 10A, air, gas or steam is supplied to the liquid ejection apparatus, as schematically illustrated by the dashed flow path 11 in figure 10A. The axial fluid force F_F acting on the impeller 10 in a downstream direction is lower than the axial force Fs needed to compress the force generating device 13. Hence, the impeller 10 is located in the first axial position, as illustrated in figure 10A, in which the drive shaft 19 is rotationally disconnected from the impeller 10 due the drive clutch arrangement 12 being in the disengaged state.

[0102] When a flow of pressurized liquid is supplied to the liquid ejection apparatus 1 via the flow pipe 4, as schematically illustrated by the solid flow path 11 in figure 10B, the axial fluid force F_F acting on the impeller 10 in a downstream direction is higher than the axial force Fs needed to compress the force generating device 13. Hence, the impeller 10 becomes displaced a distance 57, such that the locking clutch arrangement 15 becomes disengaged and the drive clutch arrangement 12 becomes engaged, thereby causing rotation of the drive shaft 19 due to rotational connection between impeller 10 and drive shaft 19.

[0103] With reference to figure 11A-B, an impeller-shaft assembly is illustrated that largely corresponds to that described with reference to figures 10A-B, and differing primarily in the location of the drive clutch arrangement 12. In the example embodiment of figured 10A-B, the drive clutch arrangement 12 was located essentially on a downstream side of the impeller 10, but as illustrated in figures 11A-B, the drive clutch arrangement 12 may alternatively be located more on the upstream side of the impeller 10.

[0104] Figures 12A-B shows yet a further example embodiment, in which the impeller 10 is rotationally slidable relative to the drive shaft 19 but axially non-displaceable relative to the drive shaft 19. In other words, here neither the impeller 10 not the drive shaft 19 are displaced axially to perform the necessary operating behaviour. Instead, other parts are used for performing the requested clutch shifting, in particular a drive clutch member 58 configured to provide a selective connection between the drive shaft 19 and the impeller 10, and a locking clutch member 59 configured to provide a selective connection between the stationary support assembly 6 and the impeller 10.

[0105] The impeller 10 includes the first engagement structure 14a and second engagement structure 17, the drive clutch member 58 includes the first corresponding engagement structure 14b and the locking clutch member 59 includes the second corresponding engagement structure 17b. Moreover, the drive clutch member 58 is axially slidable but rotationally locked with the drive shaft 19 via for example shaft splines 60, and the locking clutch member 59 is axially slidable but rotationally locked with the stationary support assembly 6 via for example stationary housing splines 61.

[0106] In figure 12A, air, gas or steam is supplied to the liquid ejection apparatus, as schematically illustrated by the dashed flow path 11 in figure 12A. The axial fluid force F_F acting on driving clutch member 58 in a downstream direction is lower than the axial force F_S needed to compress the force generating device 13. Hence, the driving clutch member 58 is located in a first axial position, as illustrated in figure 12A, in which the drive shaft 19 is rotationally disconnected from the impeller 10 due the driving clutch member 58 being disengaged from the impeller 10. Simultaneously, the axial fluid force F_F acting on the locking clutch member 59 in a downstream direction is lower than the axial force F_S needed to compress an auxiliary force generating device 16. Hence, the locking clutch member 59 is located in a first axial position, as illustrated in figure 12A, in which the impeller 10 is rotationally connected with the stationary support assembly 6 due the locking clutch member 59 being engaged with the impeller 10.

[0107] When a flow of pressurized liquid is supplied to the liquid ejection apparatus 1 via the flow pipe 4, as schematically illustrated by the solid flow path 11 in figure 12B, the axial fluid force F_F acting on the driving clutch member 58 in a downstream direction is higher than the axial force F_S needed to compress the force generating device 13. Hence, the driving clutch member 58 becomes displaced a distance 57, such that the driving clutch member 58 becomes engaged with the impeller 10, thereby causing rotation of the drive shaft 19 due to rotational connection between impeller 10 and drive shaft 19. Simultaneously, the axial fluid force F_F acting on the locking clutch member 59 in a downstream direction is higher than the axial force F_S needed to compress the auxiliary force generating device 16. Hence, the locking clutch member 59 displaced to a second axial position, as illustrated in figure 12B, in which the impeller 10 is rotationally disconnected from the stationary support assembly 6 due the locking clutch member 59 being disengaged with the impeller 10.

[0108] If a freely rotatable impeller 10 is acceptable during supply or release of air, gas or steam to or from the tank 3, the locking clutch arrangement 15 or locking clutch member 59, and associated parts, may be omitted from the described embodiments above. In other words, the example embodiments of the liquid ejection apparatus described above with reference to figures 2 - 12B have primarily either included both a drive clutch arrangement 12 and a locking clutch arrangement 15, or merely a drive clutch arrangement 12. However, in certain example embodiments, the liquid ejection apparatus merely comprises locking clutch arrangement 15 and the drive clutch arrangement 12 is replaced by a continuous rotational connection the impeller 10 the rotary head assembly 7.

[0109] For example, with reference to figures 13A-B, the impeller 10 is axially slidable but rotationally locked with the drive shaft 19 via for example shaft splines 60, and the force generating device 13 is installed for urging the impeller in the upstream direction for setting the locking clutch arrangement 15 in an engaged state. The force generating device 13 may for example be mounted on the drive shaft 19 and abutting the drive shaft 19 on one axial side and abutting a part of the impeller 10 on the other axial side, as illustrated in figure 13A. Alternatively, the force generating device 13 may be mounted in a cavity 20 defined by an axial support surface 21 of the drive shaft 19, an opposite interior axial abutment surface 22 of the impeller 10, and a radial interior surface 23 of the impeller 10 and/or of the drive shaft 19, as described with reference to figures 3 - 4.

[0110] The locking clutch engagement 15 may be designed in a similar manner as described above with reference to figures 3, 4, 6, 7, 10A-B and 11A-B. In other words, the locking clutch arrangement 15 may for example be defined by a second engagement structure 17a located on the impeller 10 and a second corresponding engagement structure 17b located on a part of the stationary support assembly 6, wherein the second engagement structure 17a for example may be provided in form of one or more protrusions or teeth that are arranged on or indirectly connected to the impeller 10, or even the blades 44 of the impeller 10 as such, and the second corresponding engagement structure 17b may be provided in form of one or more corresponding recesses, protrusions or teeth that are arranged on or indirectly connected to the stationary support assembly 6, such as for example on the connection arms 43 or inner bearing portion 42.

[0111] In figure 13A, air, gas or steam is supplied to the liquid ejection apparatus, as schematically illustrated by the dashed flow path 11 in figure 13A. The axial fluid force F_F acting on the impeller 10 in a downstream direction is lower than the axial force F_S needed to compress the force generating device 13. Hence, the impeller remains in a first axial position, as illustrated in figure 13A, in which the drive shaft 19 is rotationally connected with the stationary support assembly 6 due the locking clutch arrangement 15 being in engaged state , such that the impeller 10 and thus also the drive shaft 19 are rotationally immovable.

[0112] When a flow of pressurized liquid is supplied to the liquid ejection apparatus 1 via the flow pipe 4, as schematically illustrated by the solid flow path 11 in figure 13B, the axial fluid force F_F acting on the impeller 10 in a downstream direction is higher than the axial force F_S needed to compress the force generating device 13. Hence, the impeller 10 becomes displaced a distance 57, such that the locking clutch arrangement 15 becomes disengaged, thereby causing rotation of the drive shaft 19 due to the permanent rotational connection between impeller 10 and drive shaft 19.

[0113] In fact, the axial clutch motion may alternatively be performed by another part, such as locking clutch member 59 that is axially slidable but rotationally locked with the drive shaft 19 via for example shaft splines 60, and the force generating device 13 is installed for urging the locking clutch member 59 in the upstream direction for setting the locking clutch arrangement 15 in an engaged state. In this example embodiment, the impeller 10 is permanently rotationally and axially locked with respect to the drive shaft 19, for example by a suitable clamping device and/or a positive mechanical connection, or the like.

[0114] The locking clutch engagement 15 may be designed in a similar manner as described above with reference to figures 3, 4, 6, 7, 10A-B, 11A-B and 13A-B. In other words, the locking clutch arrangement 15 may for example be defined by a second engagement structure 17a located on the locking clutch member 59 and a second corresponding engagement structure 17b located on a part of the stationary support assembly 6, wherein the second engagement structure 17a may for example be provided in form of one or more protrusions or teeth that are arranged on or indirectly connected to the locking clutch member 59, and the second corresponding engagement structure 17b may be provided in form of one or more corresponding recesses, protrusions or teeth that are arranged on or indirectly connected to the stationary support assembly 6, such as for example on the connection arms 43 or inner bearing portion 42.

[0115] In figure 14A, air, gas or steam is supplied to the liquid ejection apparatus, as schematically illustrated by the dashed flow path 11 in figure 14A. The axial fluid force F_F acting on the locking clutch member 59 in a downstream direction is lower than the axial force Fs needed to compress the force generating device 13. Hence, the locking clutch member 59 remains in a first axial position, as illustrated in figure 14A, in which the drive shaft 19 is rotationally connected with the stationary support assembly 6 due the locking clutch arrangement 15 being in engaged state, such that the locking clutch member 59 and thus also the drive shaft 19 are rotationally immovable.

[0116] When a flow of pressurized liquid is supplied to the liquid ejection apparatus 1 via the flow pipe 4, as schematically illustrated by the solid flow path 11 in figure 14B, the axial fluid force F_F acting on the locking clutch member 59 in a downstream direction is higher than the axial force F_S needed to compress the force generating device 13. Hence, the locking clutch member 59 becomes displaced a distance 57, such that the locking clutch arrangement 15 becomes disengaged, thereby causing rotation of the drive shaft 19 due to the permanent rotational connection between impeller 10 and drive shaft 19.

[0117] The basic method steps for cleaning a tank 3 and for supplying or release air, gas or steam to or from the tank 3 is described below. The method is suitable for cleaning an interior surface 2 of a tank 3 by ejecting a liquid by a liquid ejection apparatus 1 located within the tank 3, and for supplying or releasing air, gas or steam to or from an interior of a tank 3 via the liquid ejection apparatus 1. The liquid ejection apparatus 1 is attached to a flow pipe 4 that extends into the tank 3, and the liquid ejection apparatus 1 comprises a stationary support assembly 6 that is configured to be attached to the flow pipe 4 and to a rotary head assembly 7 having at least one liquid ejection outlet 8 for ejecting the liquid on the interior surface 2 of the tank 3.

[0118] The method includes a step of supplying a flow of liquid, in particular a cleaning liquid, to the liquid ejection apparatus 1 via the flow pipe 4, wherein the flow of liquid induces a fluid force that drives an impeller 10 of a drive system 9 of the liquid ejection apparatus 1, and wherein rotation of the impeller 10 results in rotation of the rotary head assembly 7. After a certain time period, the method involves a subsequent stopping of the supply of liquid to the liquid ejection apparatus 1 via the flow pipe 4.

[0119] The method further includes a step of supplying a flow of air, gas or steam to the liquid ejection apparatus 1 via the flow pipe 4 or releasing a flow of gas from the interior of the tank 3 via the liquid ejection apparatus 1 and the flow pipe 4, wherein the drive system 9 prevents rotation of the rotary head assembly 7 when there is a flow of gas, steam or air that passes the impeller 10.

[0120] The term "prevents rotation of the rotary head assembly 7" herein refers to either rotational locking of the rotary head assembly 7, or simply disconnecting the rotary head assembly 7 from the impeller 10, such that the rotary head assembly 7 can come to stillstand by itself due to lack of rotational driving torque being supplied to the rotary head assembly 7. Both solutions solves the problem of avoiding rotational motion of the rotary head assembly 7 in the absence of liquid.

[0121] A tank cleaning process may include both repetition of a certain cleaning process step, as well as consecutively performing at least two different cleaning process steps, wherein the specific order of the cleaning process steps may be changed and modified according to the specific implementation and product. Hence, the order of the steps of the method described above is not limiting but may be altered, such that the step of supplying a flow of liquid, in particular a cleaning liquid, to the liquid ejection apparatus 1 via the flow pipe 4, may be performed after the step of supplying a flow of air, gas or steam to the liquid ejection apparatus 1 via the flow pipe 4 or releasing a flow of gas from the interior of the tank 3 via the liquid ejection apparatus 1.

[0122] In some example embodiments of the method for cleaning the tank 3 and for supplying or releasing air, gas or steam to or from the tank 3, the flow of liquid sets a drive clutch arrangement 12 in an engaged state against a counter force provided by a force generating device 13 of the liquid ejection apparatus 1, such that the impeller 10 becomes rotationally connected with a rotary head assembly 7 and rotation of the impeller 10 results in rotation of a part of the rotary head assembly 1, wherein the force generating device 13 in the absence of liquid supply to the liquid ejection apparatus 1 sets the drive clutch arrangement 12 in a disengaged state, such that the impeller 10 becomes rotationally disconnected from the rotary head assembly 7. Furthermore, a fluid force induced by the flow of air, gas or steam and acting for setting the drive clutch arrangement 12 in the engaged state is lower than a counter force provided by the force generating device 13 acting for setting the drive clutch arrangement 12 in the disengaged state, such that the drive clutch arrangement 12 is maintained in the disengaged state.

[0123] In some example embodiments of the method for cleaning the tank 3 and for supplying or releasing air, gas or steam to or from the tank 3, the flow of liquid sets a drive clutch arrangement 12 in an engaged state against a counter force provided by a force generating device 13 of the liquid ejection apparatus 1, such that the impeller 10 becomes rotationally connected with a rotary head assembly 7 and rotation of the impeller 10 results in rotation of a part of the rotary head assembly 1, wherein the force generating device 13 in the absence of liquid supply to the liquid ejection apparatus 1 sets the drive clutch arrangement 12 in a disengaged state, such that the impeller 10 becomes rotationally disconnected from the rotary head assembly 7. Furthermore, a fluid force induced when releasing gas acts for setting the drive clutch arrangement 12 in the disengaged state together with the force generating device 13, such that the drive clutch arrangement 12 is maintained in the disengaged state.

[0124] The term "acts together" herein means that the fluid force induced when releasing gas works together with the force generating device 13 for setting the drive clutch arrangement 12 in the disengaged state.

[0125] In some example embodiments of the method for cleaning the tank 3 and for supplying or releasing air, gas or steam to or from the tank 3, that may either be used and implemented in combination with the method described above, or as an alternative solution, the flow of liquid sets an locking clutch arrangement 15 in a disengaged state against a counter force provided by a force generating device 13 of the liquid ejection apparatus 1, such that the impeller 10 becomes rotationally disconnected from the stationary support assembly 6 and rotation of the impeller 10 results in rotation of a part of the rotary head assembly 1, wherein the force generating device 13 in the absence of liquid supply to the liquid ejection apparatus 1 sets the locking clutch arrangement 15 in an engaged state, such that the impeller 10 becomes rotationally connected with the stationary support assembly 6. Furthermore, a fluid force induced by the flow of air, gas or steam and acting for setting the locking clutch arrangement 15 in the disengaged state is lower than a counter force provided by the force generating device 13 acting for setting the locking clutch arrangement 15 in the engaged state, such that the locking clutch arrangement is maintained in engaged state.

[0126] In some example embodiments of the method for cleaning the tank 3 and for supplying or releasing air, gas or steam to or from the tank 3, that may either be used and implemented in combination with the method described above, or as an alternative solution, the flow of liquid sets an locking clutch arrangement 15 in a disengaged state against a counter force provided by a force generating device 13 of the liquid ejection apparatus 1, such that the impeller 10 becomes rotationally disconnected from the stationary support assembly 6 and rotation of the impeller 10 results in rotation of a part of the rotary head assembly 1, wherein the force generating device 13 in the absence of liquid supply to the liquid ejection apparatus 1 sets the locking clutch arrangement 15 in an engaged state, such that the impeller 10 becomes rotationally connected with the stationary support assembly 6. Furthermore, a fluid force induced when releasing gas acts for setting the locking clutch arrangement 15 in the engaged state, together with the force generating device 13, such that the locking clutch arrangement 15 is maintained in the engaged state.

[0127] It will be appreciated that the above description is merely exemplary in nature and is not intended to limit the present disclosure, its application or uses. While specific examples have been described in the specification and illustrated in the drawings, it will be understood by those of ordinary skill in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure as defined in the claims. Furthermore, modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof.

[0128] The liquid ejection apparatus 1 has been described with reference to various example embodiments and specific features of any of the embodiments may be combined with features of any of the other embodiments. For example, aspect relating to the impeller-shaft assembly design, gearbox design, rotatory head assembly design, force generating device design, engagement structure design of the drive and/or locking clutch arrangements, etc. of any example embodiment may be combined with other aspects taken from another example embodiment.

[0129] Therefore, it is intended that the present disclosure not be limited to the particular examples illustrated by the drawings and described in the specification as the best mode presently contemplated for carrying out the teachings of the present disclosure, but that the scope of the present disclosure will include any embodiments falling within the foregoing description and the appended claims. Reference signs mentioned in the claims should not be seen as limiting the extent of the matter protected by the claims, and their sole function is to make claims easier to understand.

References

1:	Liquid ejection apparatus	25:	Second rotational axis
2:	Interior surface	26:	Flange connection
3:	Tank	27:	Flow of liquid

(continued)

4:	Flow pipe	28:	Rotation of rotary head assembly
5:	Housing		
6:	Stationary support assembly	29:	Rotation of rotary outlet hub
7:	Rotary head assembly	30:	Flow of released gas
7a:	Rotary head	31:	Toothed surface
7b.	Rotary outlet hub	32:	Sun gear
8:	Liquid ejection outlet	33:	Planetary gears
9:	Drive system	34:	Ring gear
10:	Impeller	35:	Planetary gear carrier
11:	Flow path	36:	First roller bearing
12:	Drive clutch arrangement	37:	Second roller bearing
13:	Force generating device	38:	Toothed surface
14a:	First engagement structure	39:	Stem
14b:	First corresponding engagement structure	40:	Guide member
		41:	Cylindrical outer portion
15:	Locking clutch arrangement	42:	Inner bearing portion
16:	Auxiliary force generating device	43:	Connection arm
		44:	Impeller blade
17a:	Second engagement structure	45:	Stem nut
17b:	Second corresponding engagement structure	46:	Upstream facing surface area
		47:	Dashed rectangle
18:	Liquid flow direction	48:	Upstream side of impeller
19:	Drive shaft	49:	Downstream side of impeller
20:	Cavity	50:	Radial interior surface of impeller
21:	Axial support surface		
22:	Interior axial abutment surface	51	Sliding bushing
		52:	Central opening
23:	Radial interior surface	53:	flange
24:	First rotational axis	54:	Weep hole
55:	first part	61:	Stationary housing splines
56:	second part	62:	Threads
57:	Axial displacement	A:	Axial direction
58:	drive clutch member	R:	Radial direction
59:	locking clutch member	FF:	Fluid force
60:	Shaft splines	FS:	Spring force

Claims

1. A liquid ejection apparatus (1) for cleaning an interior surface (2) of a tank (3), the liquid ejection apparatus (1) being configured to be attached to a flow pipe (4) that extends into the tank (3), and to receive a liquid from the flow pipe (4), the liquid ejection apparatus (1) comprising:

a stationary support assembly (6) configured to be attached to the flow pipe (4) that extends into the tank (3), and to receive a liquid from the flow pipe (4),
a rotary head assembly (7) having at least one liquid ejection outlet (8) for ejecting the liquid on the interior surface (2) of the tank (3), and
a drive system (9) for rotating the rotary head assembly (7), wherein the drive system (9) includes an impeller (10) arranged in a flow path (11) of the liquid and being configured to be rotated by the flow of liquid that passes the impeller (10), wherein the drive system (9) is configured to cause rotation of the rotary head assembly (7) when there is a flow of liquid that passes the impeller (10), and wherein the drive system (9) is configured to prevent rotation of the rotary head assembly (7) when there is a flow of gas, steam or air that passes the impeller (10).

2. The liquid ejection apparatus according to claim 1, wherein the drive system (9) further includes:

- a drive clutch arrangement (12) that when set in an engaged state rotationally connects the impeller (10) with the rotary head assembly (7), and when set in a disengaged state rotationally disconnects the impeller (10) from the rotary head assembly (7), and/or
- an locking clutch arrangement (15) that when set in an engaged state rotationally connects the impeller (10) with the stationary support assembly (6), and when set in a disengaged state rotationally disconnects the impeller (10) from the stationary support assembly (6).

3. The liquid ejection apparatus according to claim 2, wherein the drive clutch arrangement (12) is configured to automatically shift from disengaged to engaged state when affected, directly or indirectly, by a fluid force induced by the liquid flowing through the flow path (11).

4. The liquid ejection apparatus according to any of the preceding claims 2 - 3, wherein the liquid ejection apparatus (1) includes a force generating device (13) that urges the drive clutch arrangement (12) towards the disengaged state, such that the drive clutch arrangement (12) is automatically shifted from engaged to disengaged state in absence of liquid flowing through the flow path (11).

5. The liquid ejection apparatus according to any of the preceding claims 2 - 4, wherein the drive clutch arrangement (12) is defined by a first engagement structure (14a) located on the impeller (10) or on a part rotationally secured to the impeller (10), and a first corresponding engagement structure (14b) located on a part of the rotary head assembly (7), and the engaged state of the drive clutch arrangement (12) corresponds to the first engagement structure (14a) being rotationally engaged with the first corresponding engagement structure (14b), and the disengaged state of the drive clutch arrangement (12) corresponds to the first engagement structure (14a) being rotationally disengaged from the first corresponding engagement structure (14b).

6. The liquid ejection apparatus according to any of the preceding claims 2 - 5, wherein the drive system (9) further includes a locking clutch arrangement (15) that when set in an engaged state rotationally connects the impeller (10) with the stationary support assembly (6), and when set in a disengaged state rotationally disconnects the impeller (10) from the stationary support assembly (6).

7. The liquid ejection apparatus according to claim 6, wherein the locking clutch arrangement (15) is configured to automatically shift from engaged to disengaged state when affected, directly or indirectly, by a fluid force induced by liquid flowing through the flow path (11).

8. The liquid ejection apparatus according to any of claims 6 - 7, wherein the locking clutch arrangement (15) is urged towards the engaged state by means of the force generating device (13) or an auxiliary force generating device (16), such that the locking clutch arrangement (15) is automatically shifted from disengaged to engaged state in absence of liquid flowing through the flow path (11).

9. The liquid ejection apparatus according to any of the preceding claims 6 - 8, wherein the locking clutch arrangement (15) is defined by a second engagement structure (17a) located on the impeller (10) or on a part rotationally and axially secured to the impeller (10), and a second corresponding engagement structure (17b) located on a part of the stationary support assembly (6), and the engaged state of the locking clutch arrangement (15) corresponds to the second engagement structure (17a) being rotationally engaged with the second corresponding engagement structure (17b), and the disengaged state of the locking clutch arrangement (15) corresponds to the second engagement structure (17a) being rotationally disengaged from the second corresponding engagement structure (17b).

10. The liquid ejection apparatus according to any of the preceding claims 4 - 9, wherein the impeller (10) is axially displaceable between a first axial position and a second axial position, wherein the first axial position of the impeller (10) corresponds to the disengaged state of the drive clutch arrangement (12), wherein the second axial position of the impeller (10) corresponds to the engaged state of the drive clutch arrangement (12), wherein the impeller (10) is pushed towards the first axial position by the force generating device (13), and wherein the impeller (10) is configured to be pushed to the second axial position by an axial force induced by the flow of liquid passing the impeller (10).

11. The liquid ejection apparatus according to claim 10, wherein the first axial position of the impeller (10) corresponds to the engaged state of the locking clutch arrangement (15), wherein the second axial position of the impeller (10)

corresponds to the disengaged state of the locking clutch arrangement (15).

12. The liquid ejection apparatus according to any of the preceding claims 10 - 11, wherein the liquid ejection apparatus (1) has an axial direction (A) that is parallel with the rotational axis of the impeller (10), and wherein the force generating device (13) pushes the impeller (10) in the axial direction (A) substantially opposite to a liquid flow direction (18).

13. The liquid ejection apparatus according to any of the preceding claims 10 - 12, wherein the liquid ejection apparatus (1) has an axial direction (A) that is parallel with the rotational axis of the impeller (10) and a radial direction (R) perpendicular to the axial direction (A), wherein the liquid ejection apparatus (1) comprises an elongated drive shaft (19) carrying the impeller (10) and extending in the axial direction (A), and wherein the force generating device (13) is:

mounted on the drive shaft (19) and abutting the drive shaft (19) on one axial side and the impeller (10) on the other axial side, or
mounted in a cavity (20) defined by an axial support surface (21) of the drive shaft (19), an opposite interior axial abutment surface (22) of the impeller (10), and a radial interior surface (23) of the impeller (10) and/or of the drive shaft (19).

14. A method for cleaning an interior surface (2) of a tank (3) by ejecting a liquid by a liquid ejection apparatus (1) located within the tank (3), and for supplying or releasing air, gas or steam to or from an interior of a tank (3) via the liquid ejection apparatus (1), wherein the liquid ejection apparatus (1) is attached to a flow pipe (4) that extends into the tank (3), and wherein liquid ejection apparatus (1) comprises a stationary support assembly (6) configured to be attached to the flow pipe (4) that extends into the tank (3) and a rotary head assembly (7) having at least one liquid ejection outlet (8) for ejecting the liquid on the interior surface (2) of the tank (3), the method comprises:

supplying a flow of liquid to the liquid ejection apparatus (1) via the flow pipe (4), wherein the flow of liquid induces a fluid force that drives an impeller (10) of a drive system (9) of the liquid ejection apparatus (1), and wherein rotation of the impeller (10) results in rotation of the rotary head assembly (7), and subsequently stopping the supply of liquid to the liquid ejection apparatus (1) via the flow pipe (4); and
supplying a flow of air, gas or steam to the liquid ejection apparatus (1) via the flow pipe (4) or releasing a flow of gas from the interior of the tank (3) via the liquid ejection apparatus (1) and the flow pipe (4), wherein the drive system (9) prevents rotation of the rotary head assembly (7) when there is a flow of gas, steam or air that passes the impeller (10).

15. The method according to claim 14,

wherein the flow of liquid sets a drive clutch arrangement (12) in an engaged state against a counter force provided by a force generating device (13) of the liquid ejection apparatus (1), such that the impeller (10) becomes rotationally connected with a rotary head assembly (7) and rotation of the impeller (10) results in rotation of a part of the rotary head assembly (1), and wherein the force generating device (13), in the absence of liquid supply to the liquid ejection apparatus (1), sets the drive clutch arrangement (12) in a disengaged state, such that the impeller (10) becomes rotationally disconnected from the rotary head assembly (7); and

- wherein a fluid force induced by the flow of air, gas or steam and acting for setting the drive clutch arrangement (12) in the engaged state is lower than a counter force provided by the force generating device (13) acting for setting the drive clutch arrangement (12) in the disengaged state, such that the drive clutch arrangement (12) is maintained in the disengaged state; or
- wherein a fluid force induced when releasing gas acts for setting the drive clutch arrangement (12) in the disengaged state together with the force generating device (13), such that the drive clutch arrangement (12) is maintained in the disengaged state; and/or

wherein the flow of liquid sets an locking clutch arrangement (15) in a disengaged state against a counter force provided by a force generating device (13) of the liquid ejection apparatus (1), such that the impeller (10) becomes rotationally disconnected from the stationary support assembly (6) and rotation of the impeller (10) results in rotation of a part of the rotary head assembly (7), and wherein the force generating device (13), in the absence of liquid supply to the liquid ejection apparatus (1), sets the locking clutch arrangement (12) in an engaged state, such that the impeller (10) becomes rotationally connected with the stationary support assembly (6); and

- wherein a fluid force induced by the flow of air, gas or steam and acting for setting the locking clutch arrangement (15) in the disengaged state is lower than a counter force provided by the force generating device (13) acting for setting the locking clutch arrangement (15) in the engaged state, such that the locking clutch arrangement is maintained in engaged state; or
- wherein a fluid force induced when releasing gas acts for setting the locking clutch arrangement (15) in the engaged state, together with the force generating device (13), such that the locking clutch arrangement (15) is maintained in the engaged state.

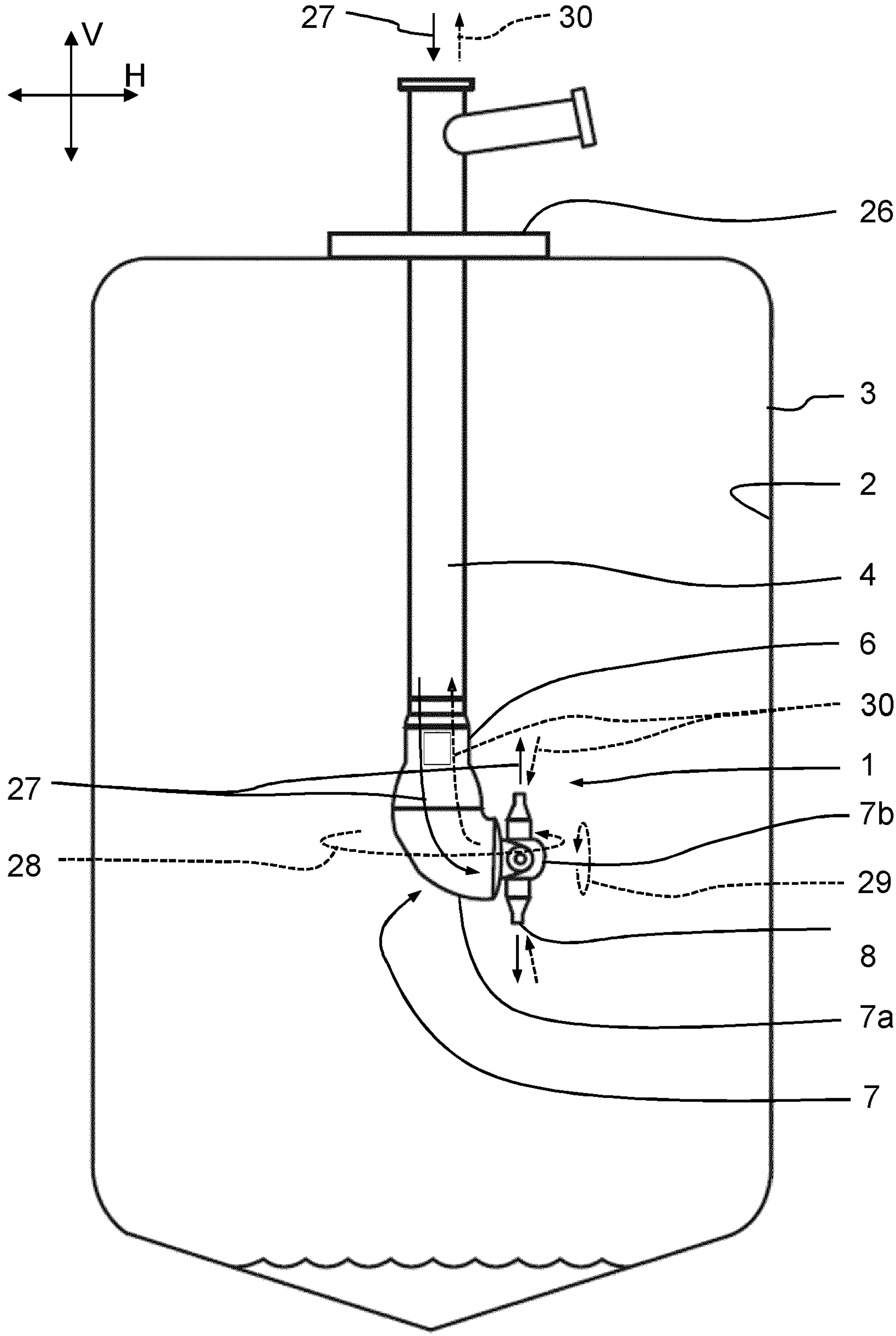


FIG.1

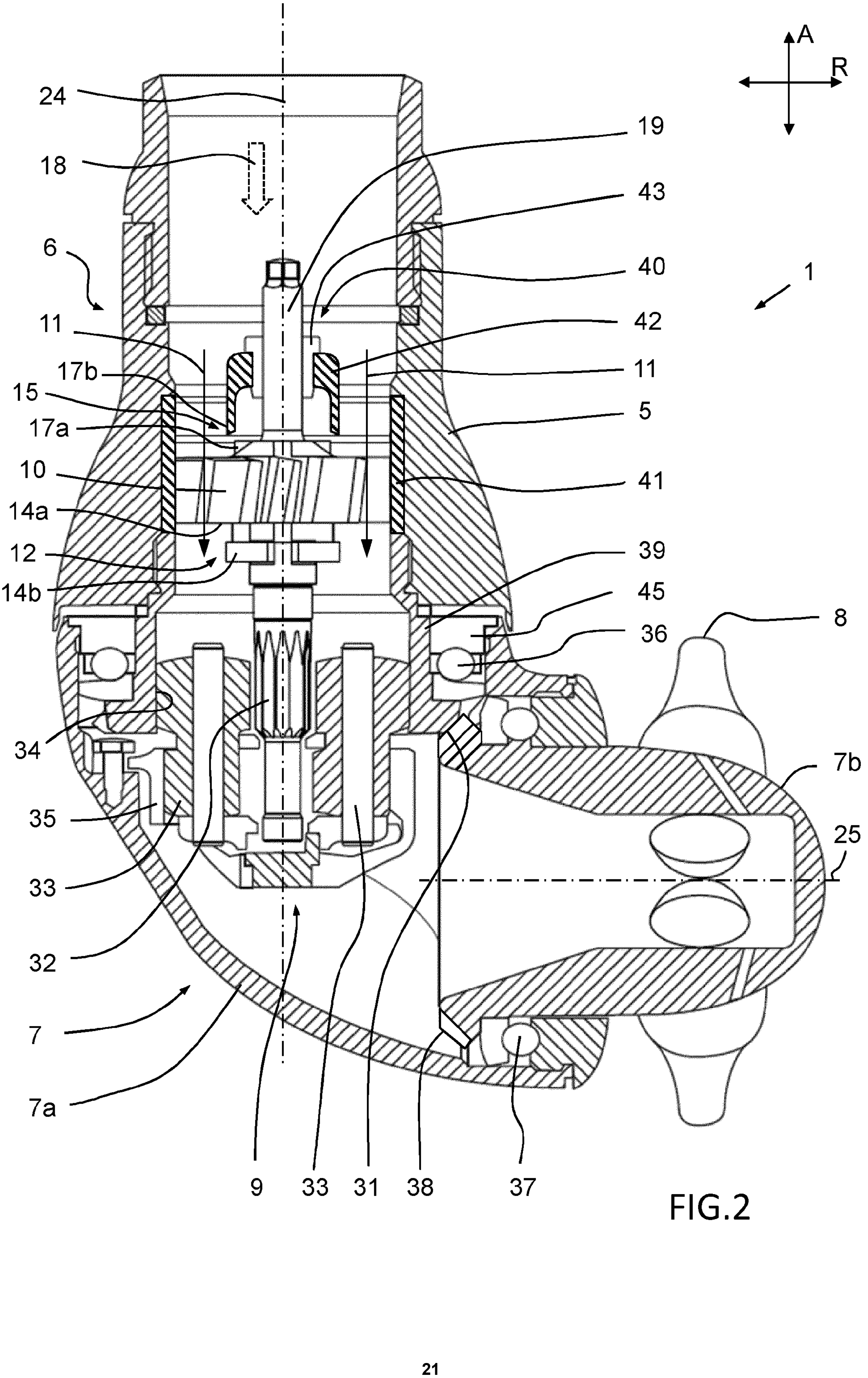
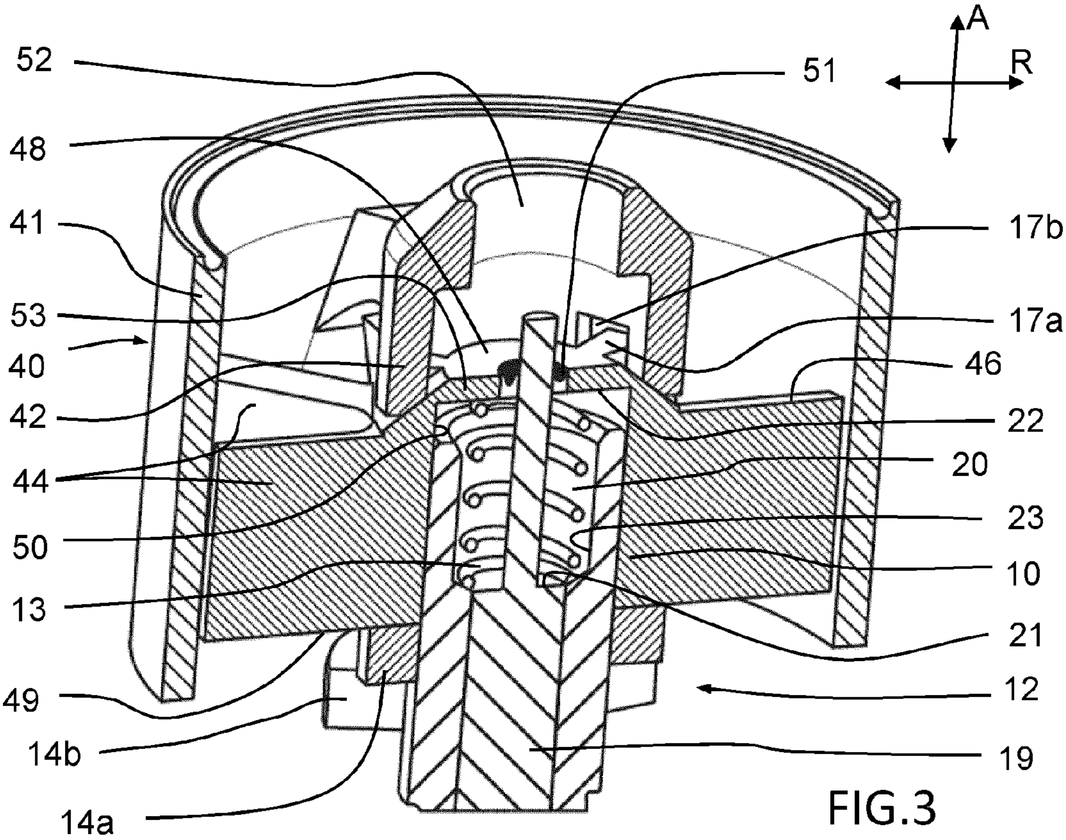

A
R
24
19
18
43
6
40
1
11
42
17b
11
15
5
17a
10
41
14a
39
12
14b
45
8
36
34
7b
35
25
33
32
7
7a
9
33
31
38
37

FIG.2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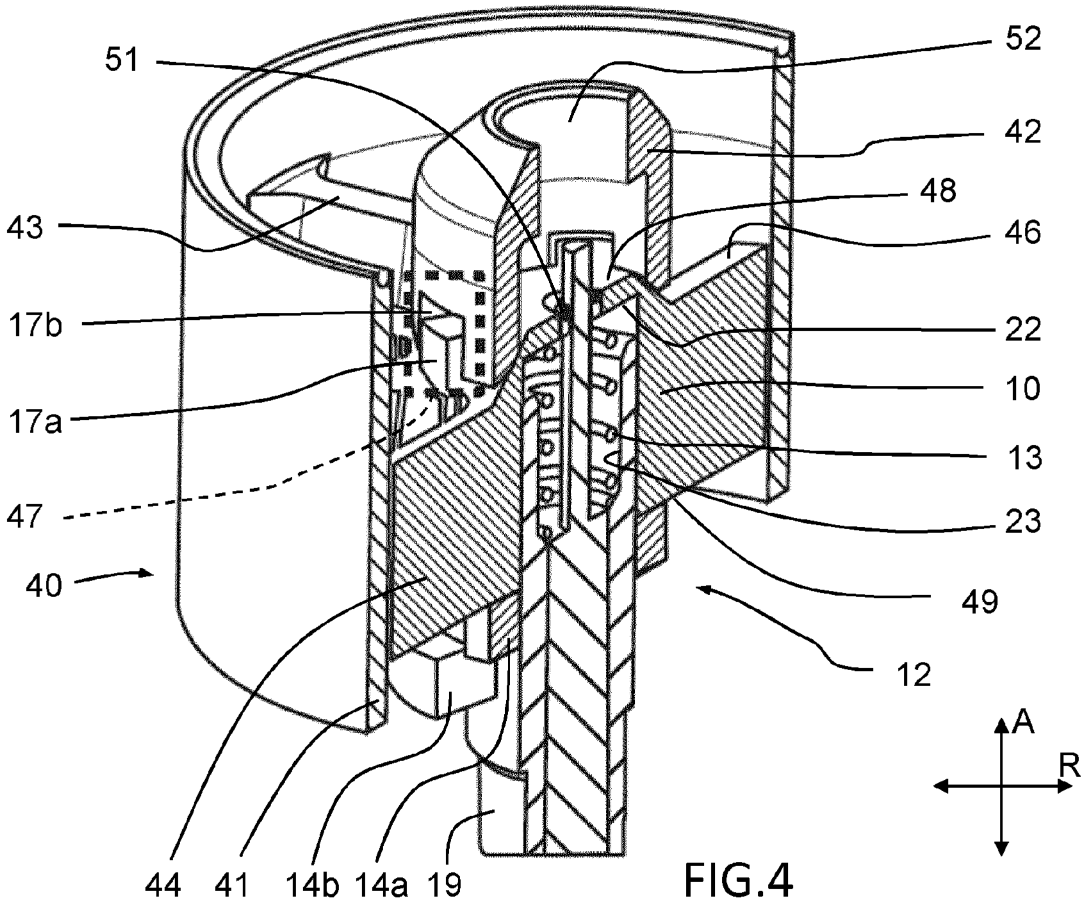
14b
19
14a
FIG.3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17a
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23
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49
12
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R
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14b
14a
19
FIG.4

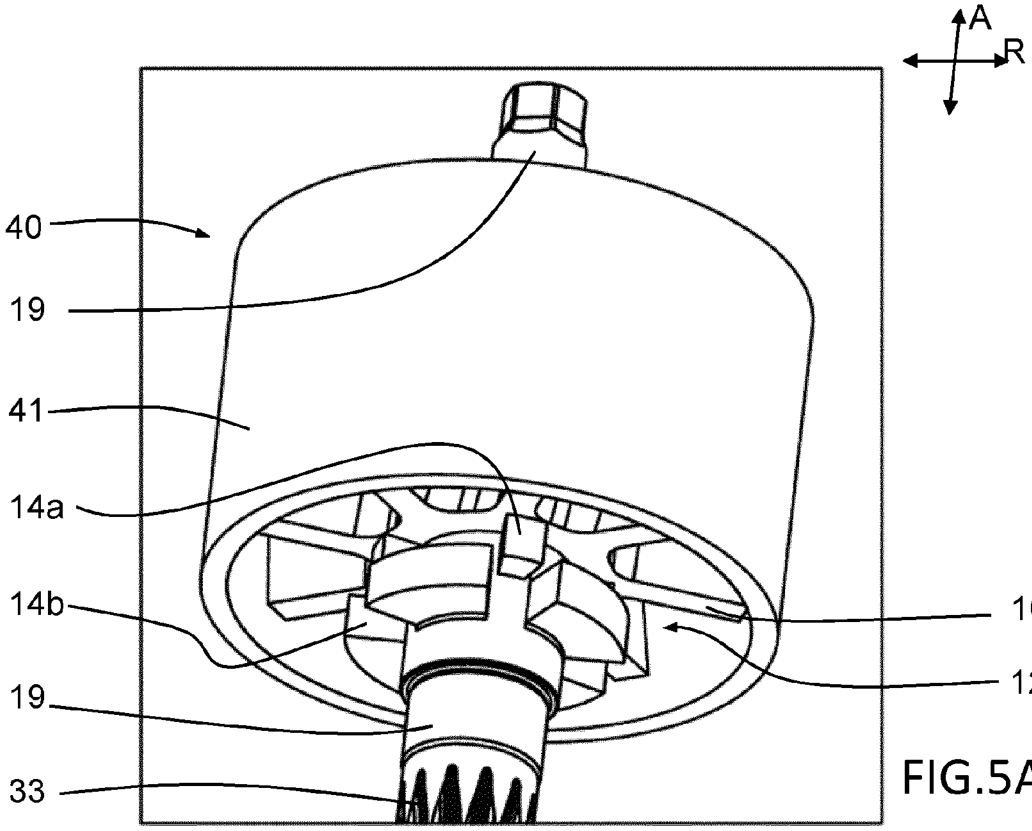


FIG.5A

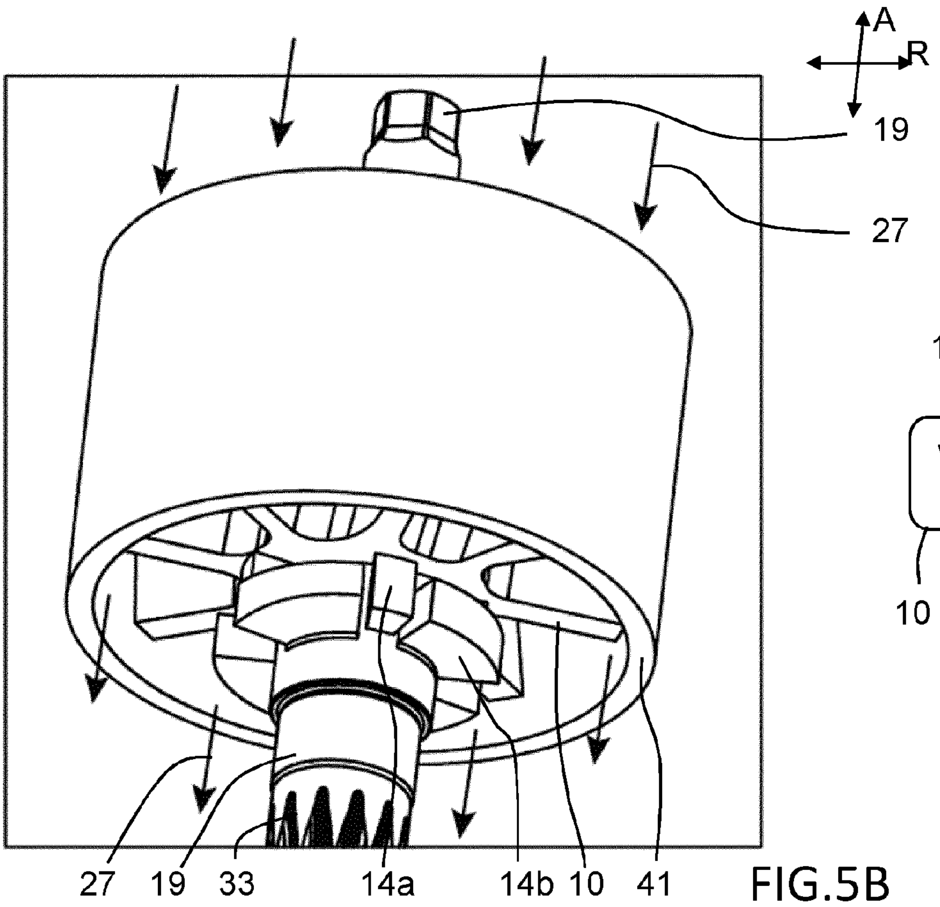


FIG.5B

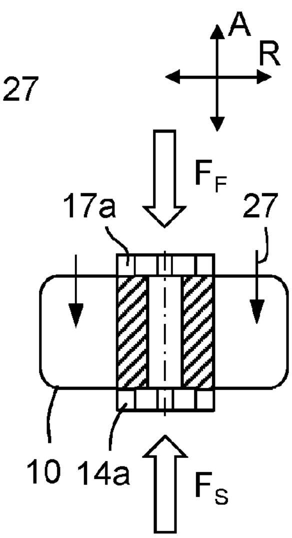
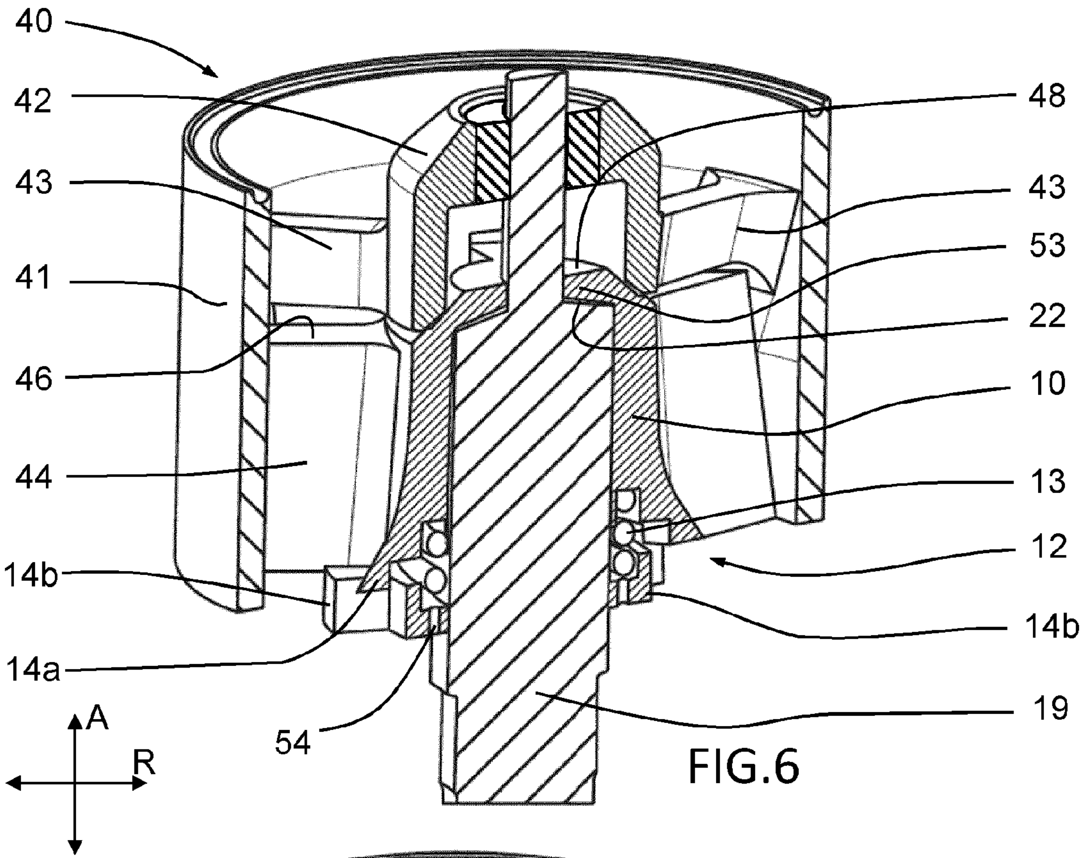


FIG.5C


40
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46
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14b
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53
22
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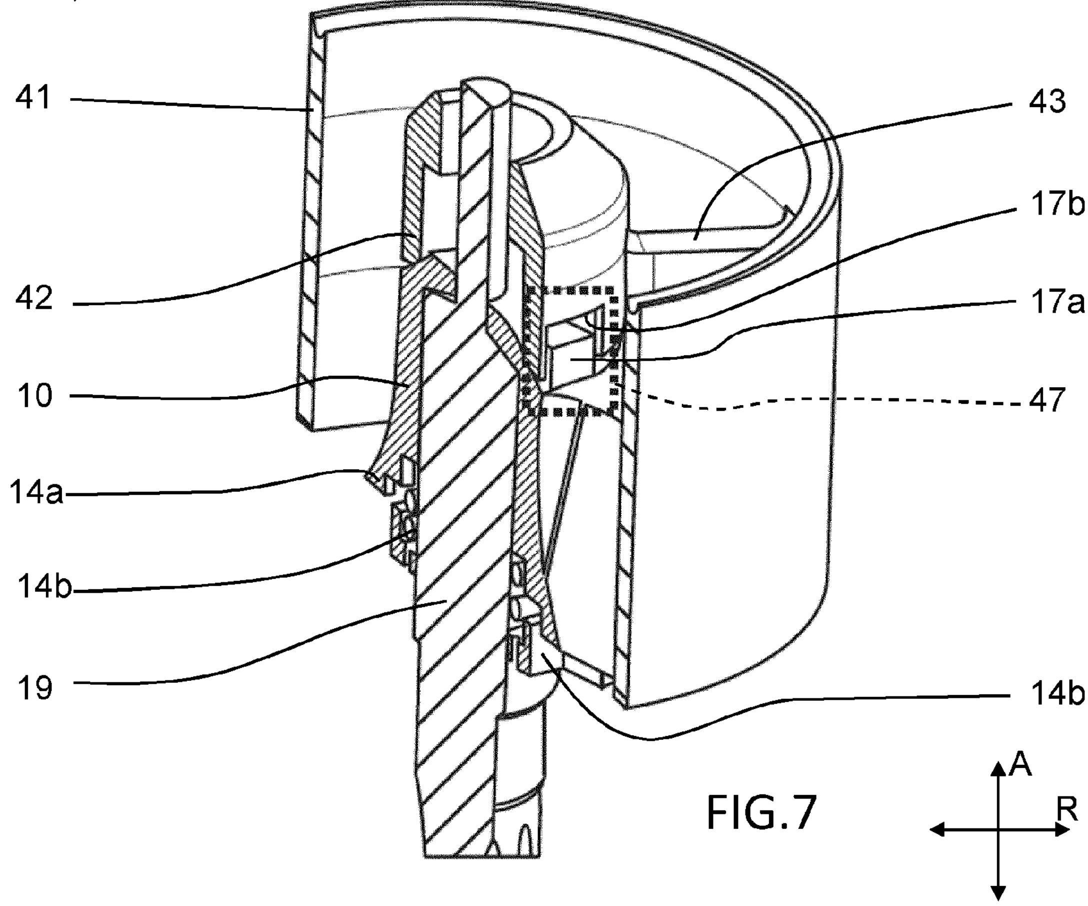
13
12
14b
19
A
R

FIG.6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14a
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19
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17b
17a
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14b
A
R

FIG.7

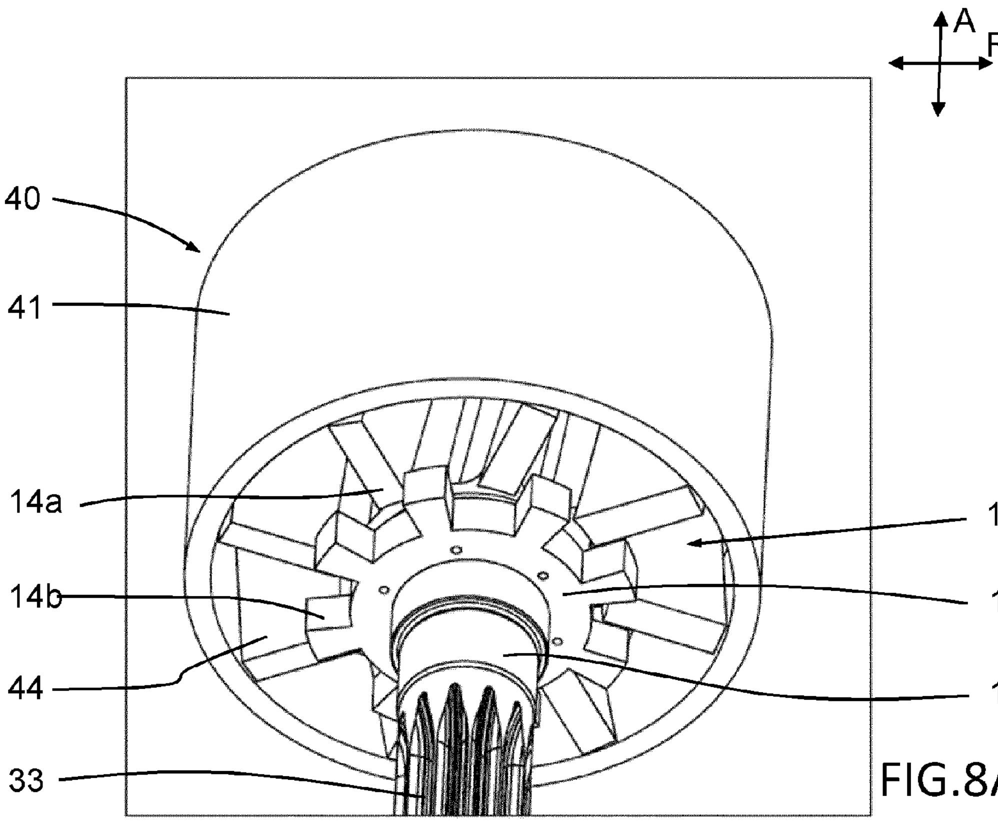


FIG.8A

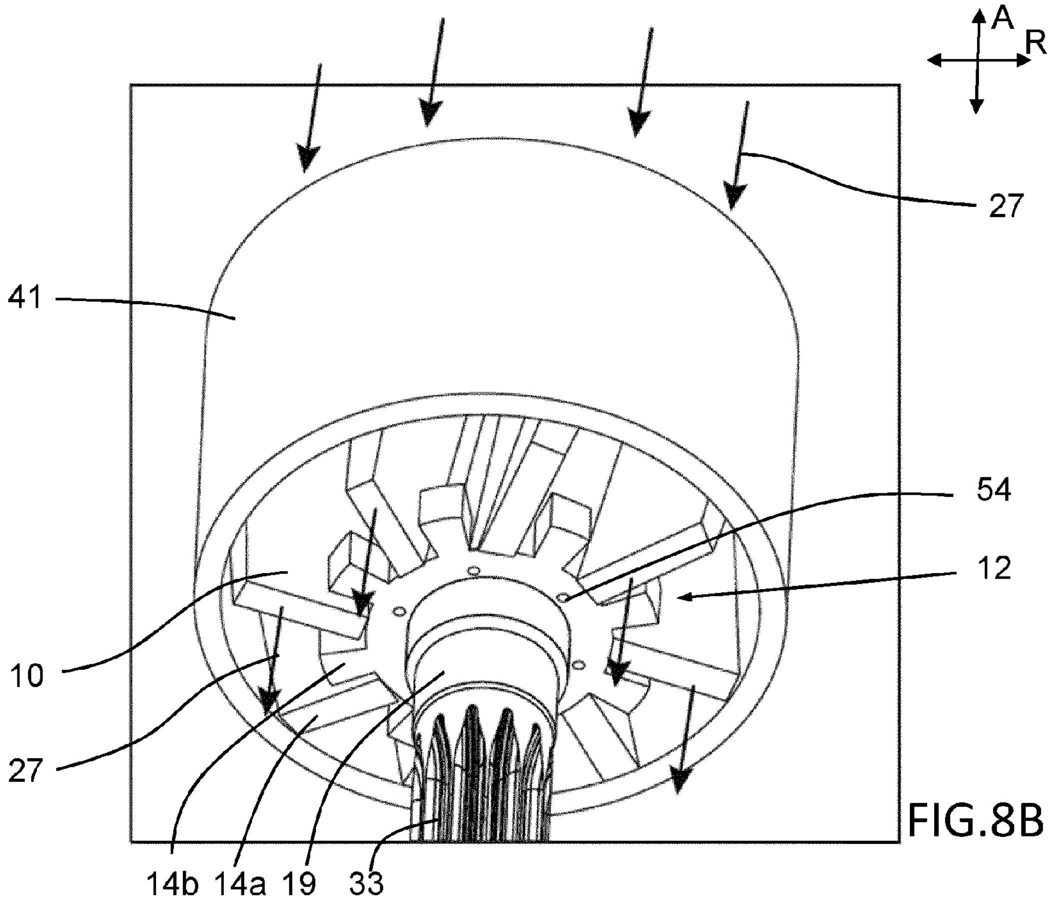
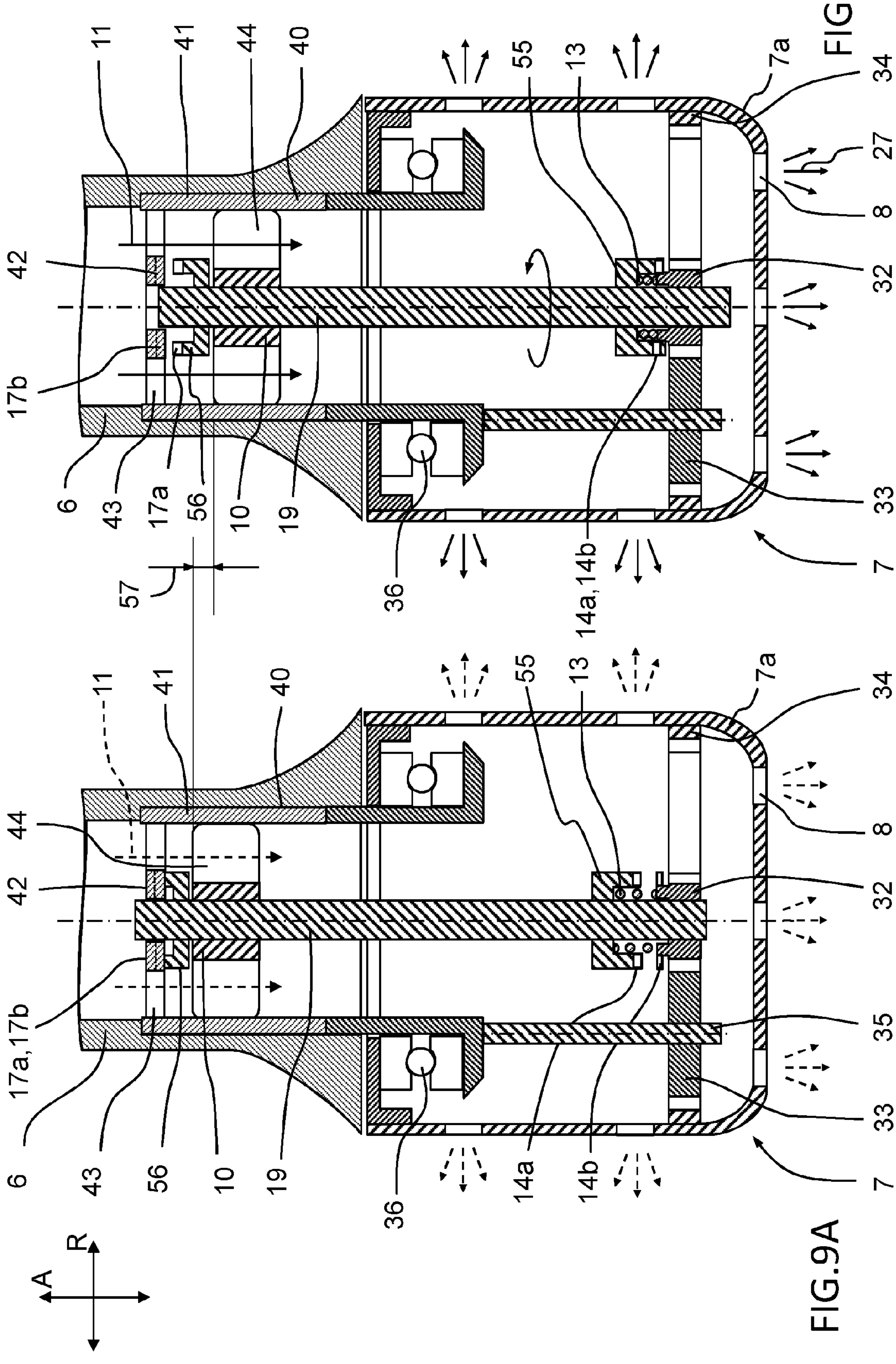


FIG.8B


11
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44
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13
7a
34
27
8
32
33
7
42
17b
6
43
17a
56
10
19
57
36
14a,14b
A
R
17a,17b
14a
14b
35

FIG.9B

FIG.9A

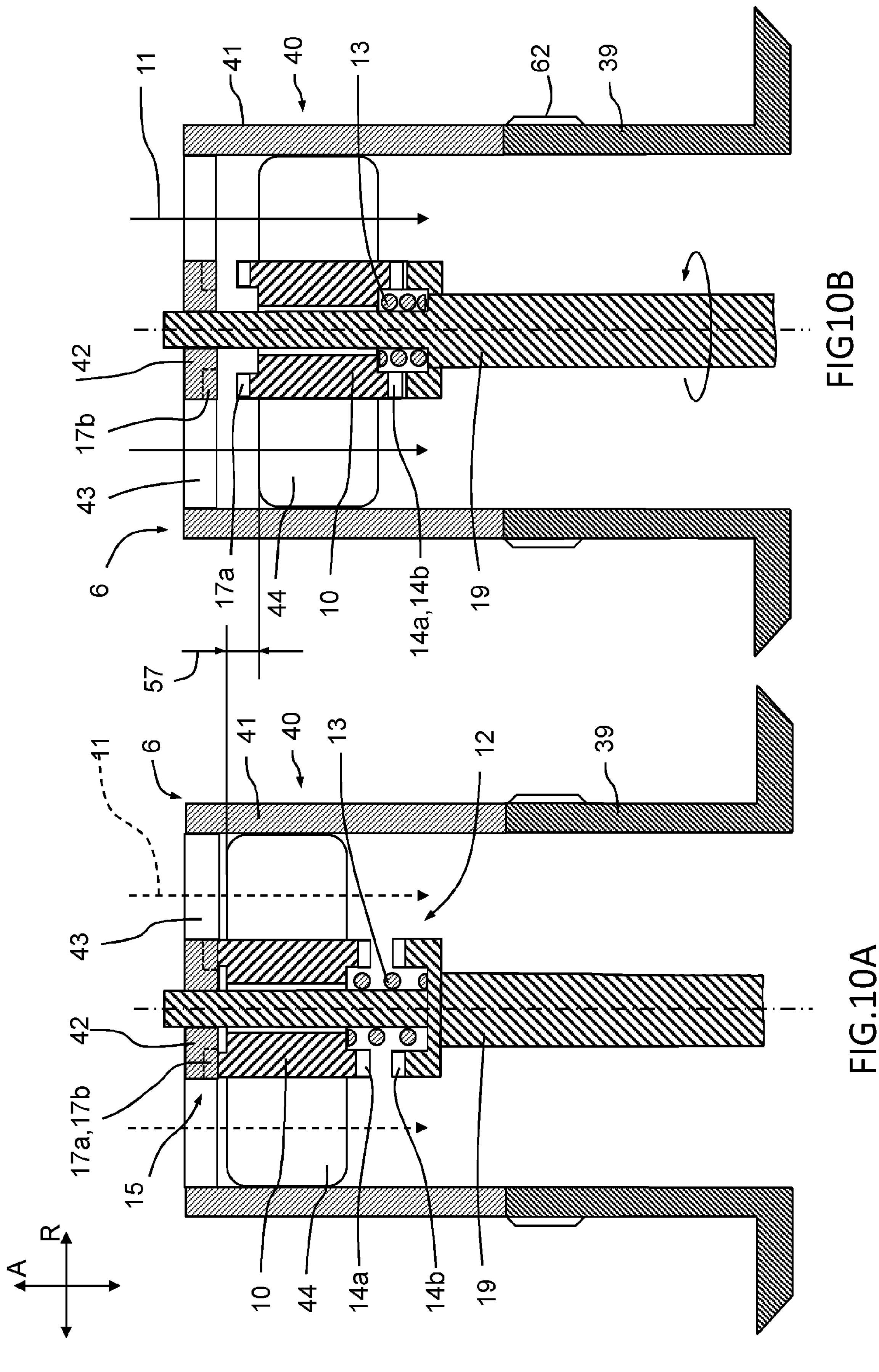

FIG10B

FIG.10A

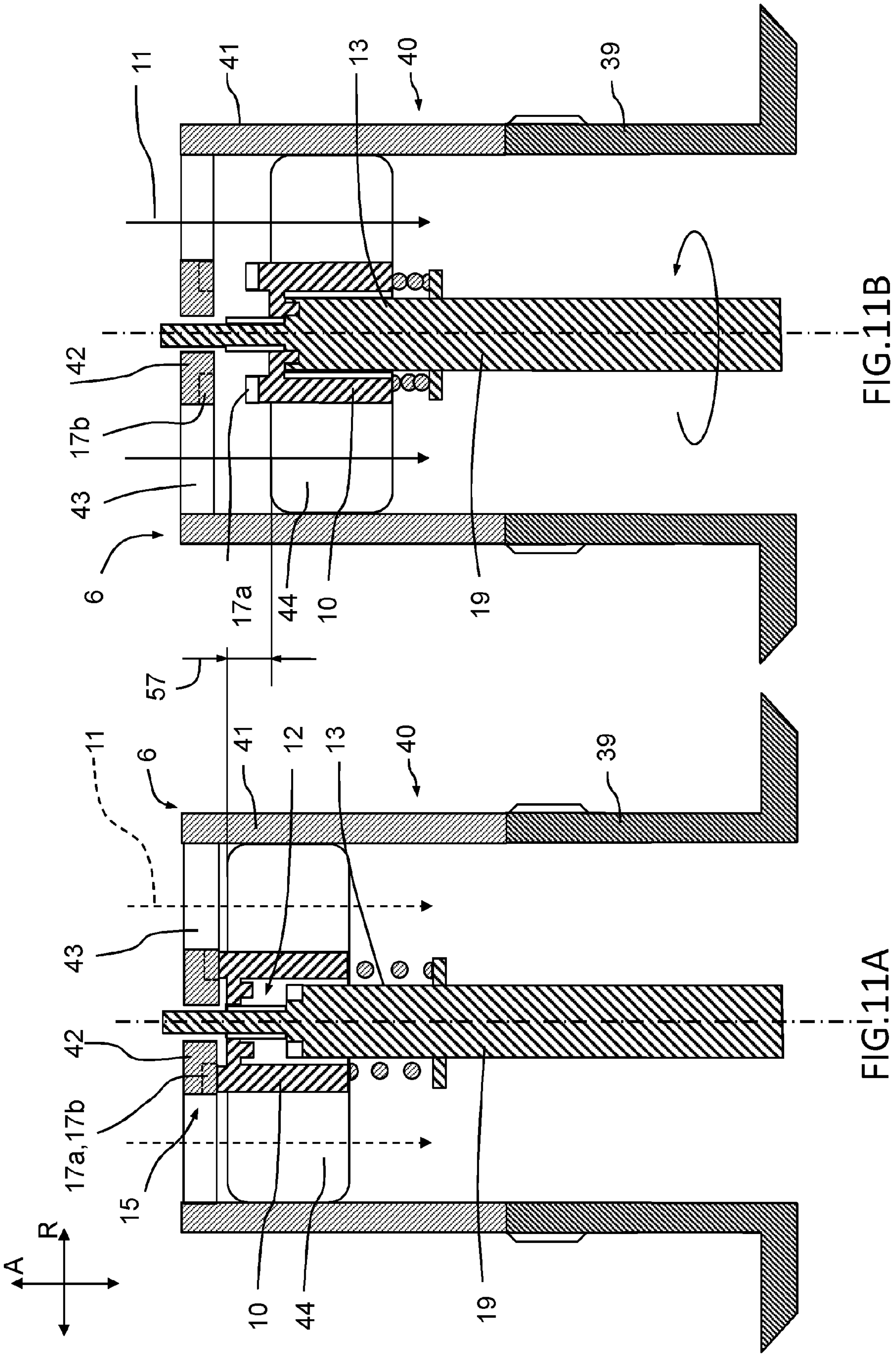

FIG.11B

FIG.11A

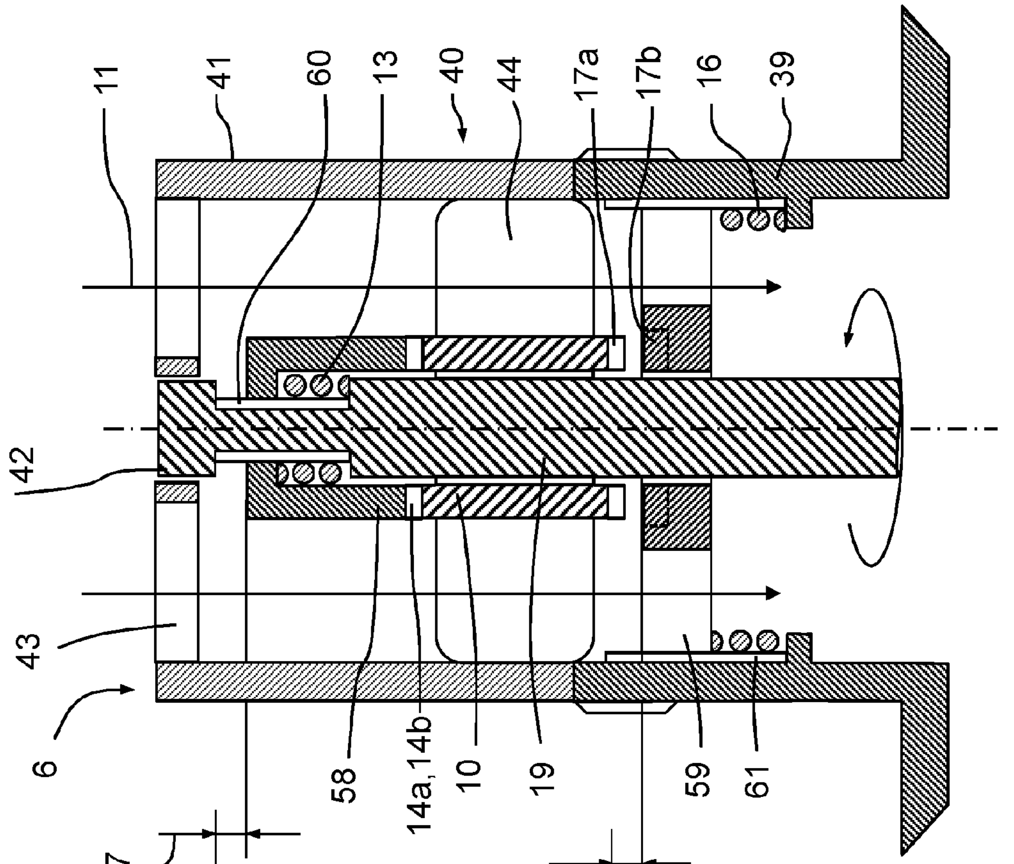

FIG.12B

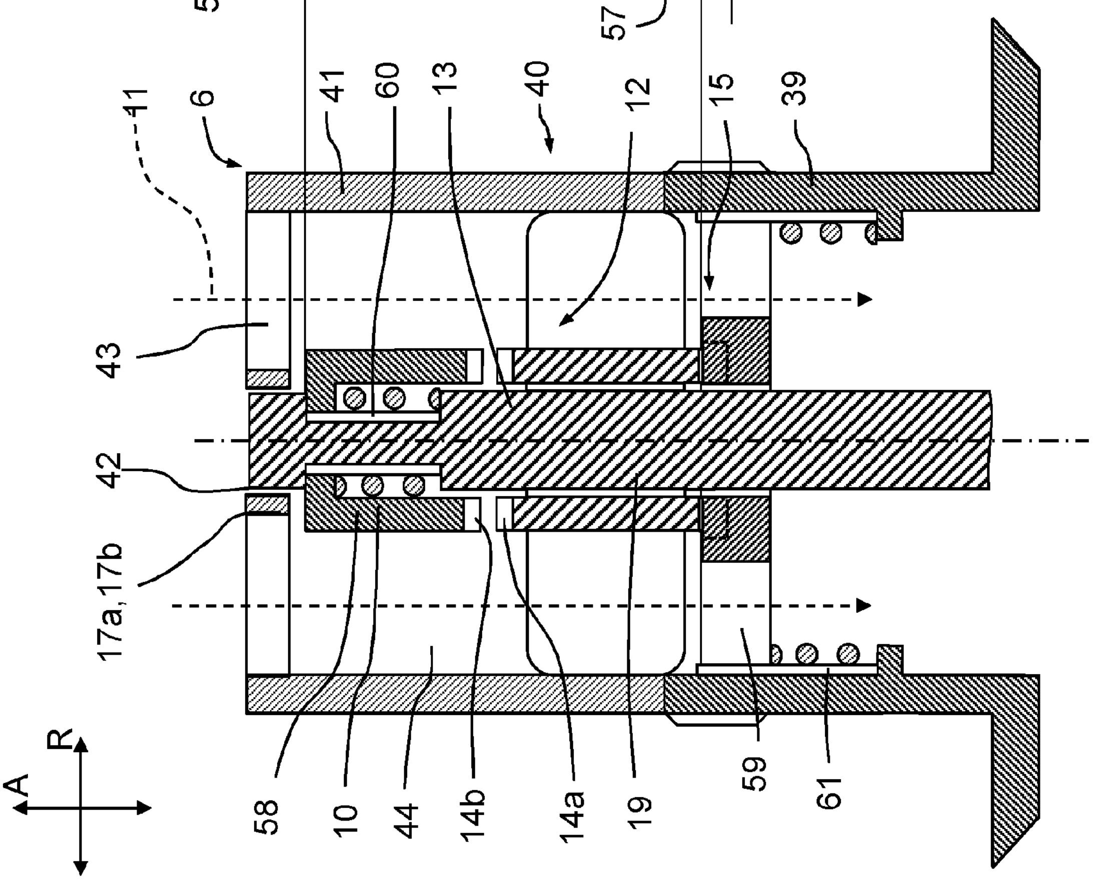

FIG.12A

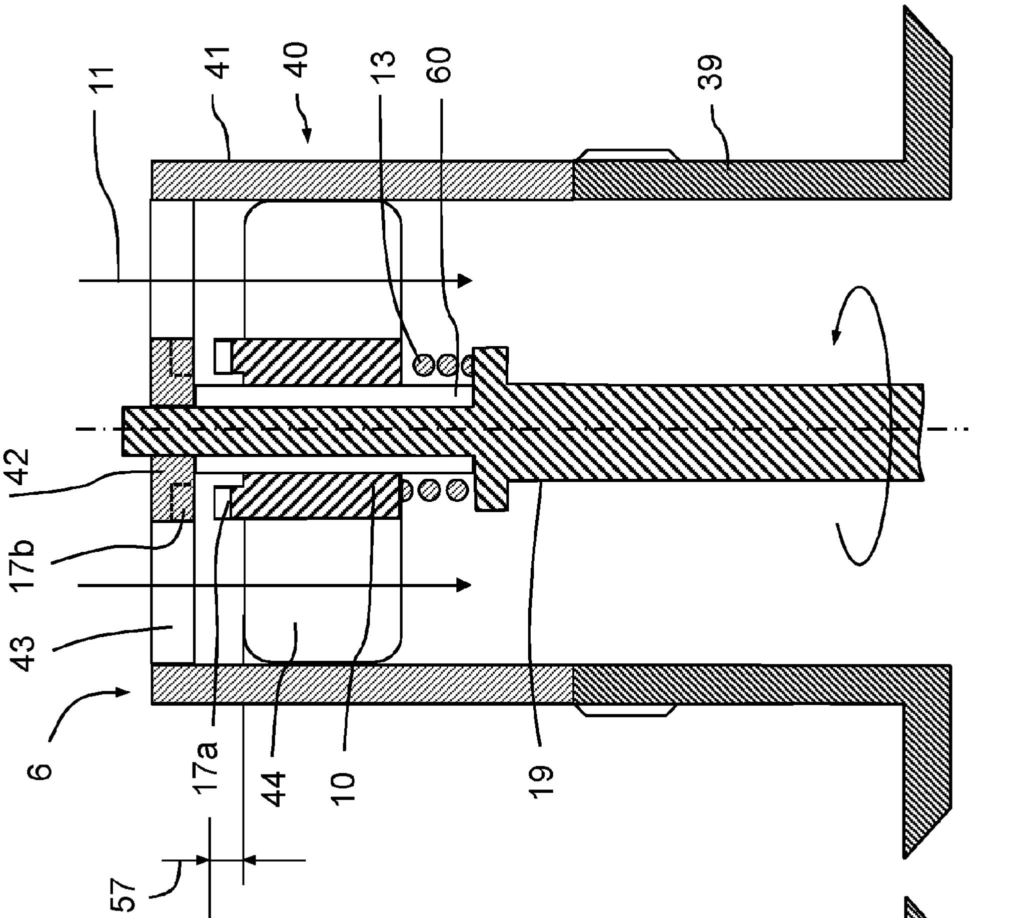

FIG.13B

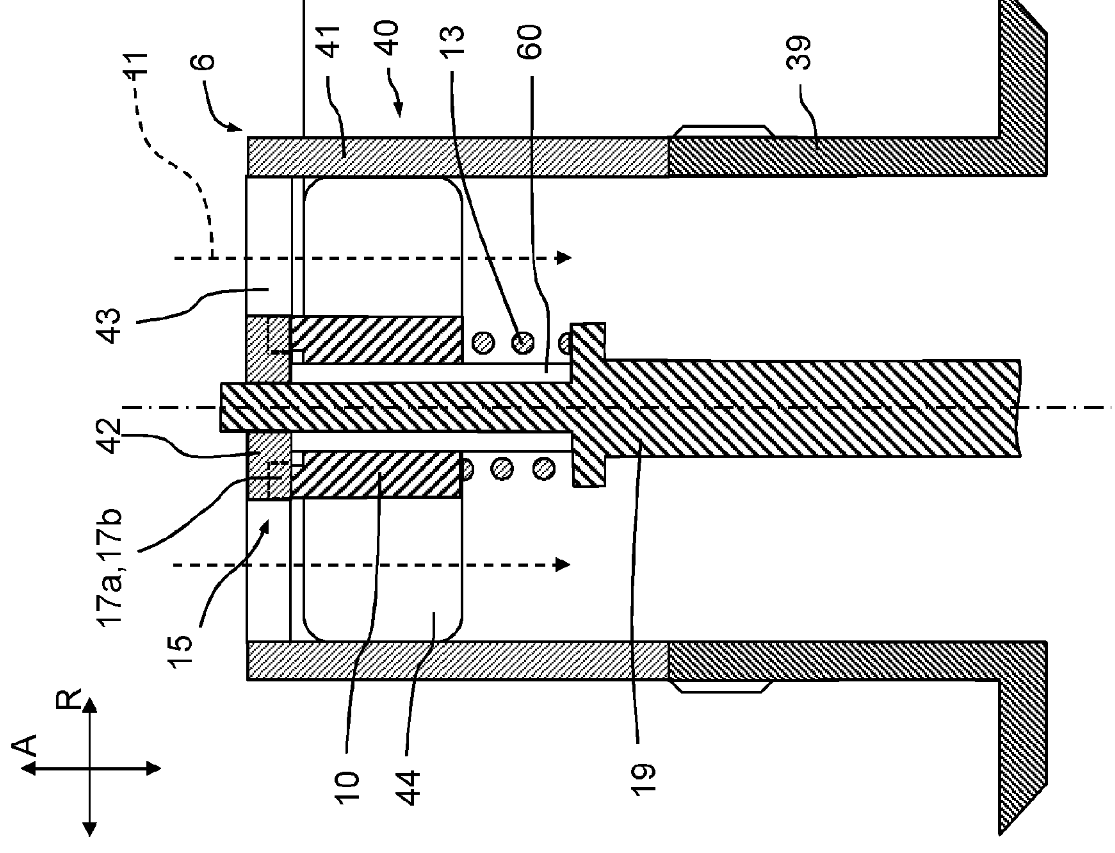

FIG.13A

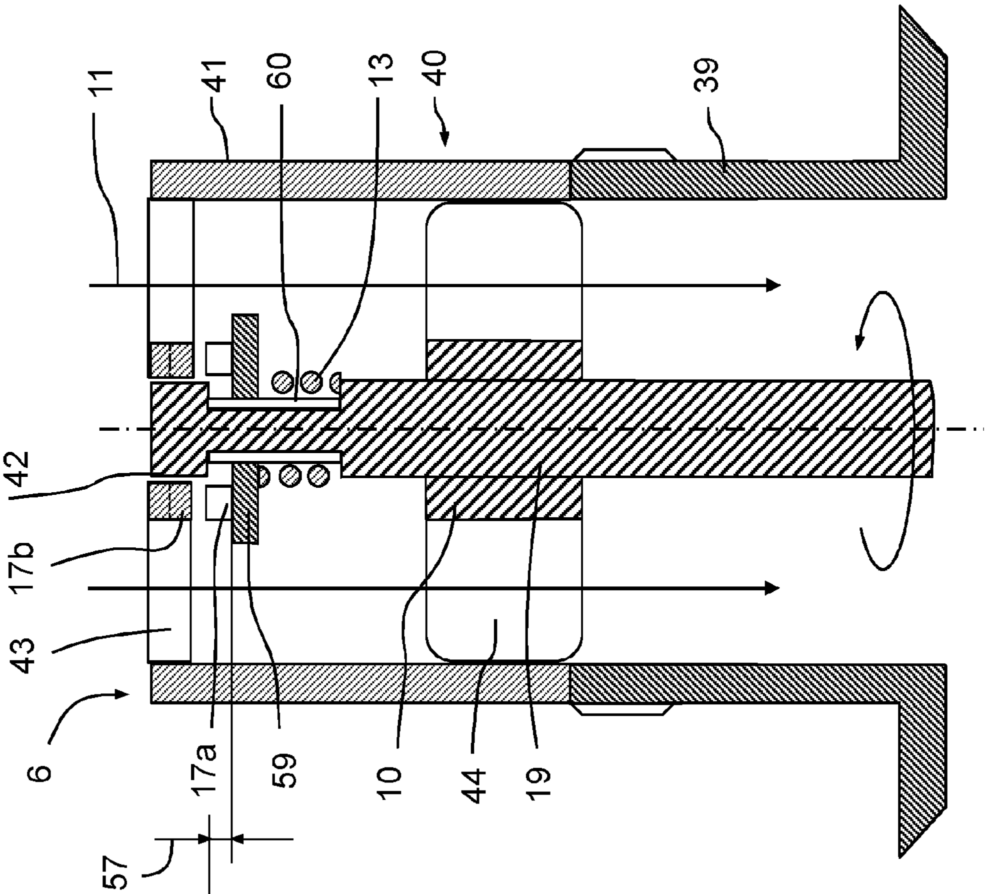

FIG.14B

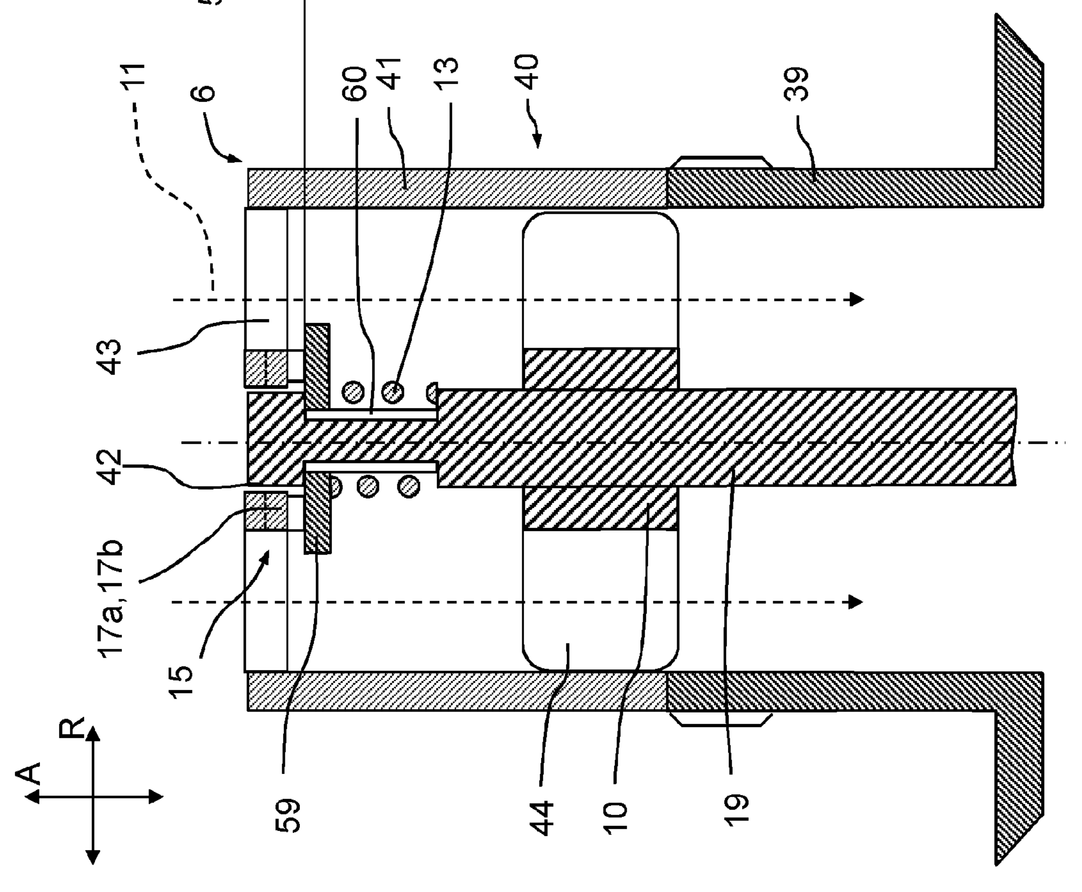

FIG.14A

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 6900

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	16 October 2021	Neiller, Frédéric

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