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(54) Title: HYBRID CHECK VALVE FOR PISTON PUMP, PISTON PUMP PROVIDED WITH SUCH A HYBRID CHECK VALVE, KIT FOR ASSEMBLING THE SAME, AND METHODS OF ASSEMBLING AND OPERATING ASSOCIATED THERETO

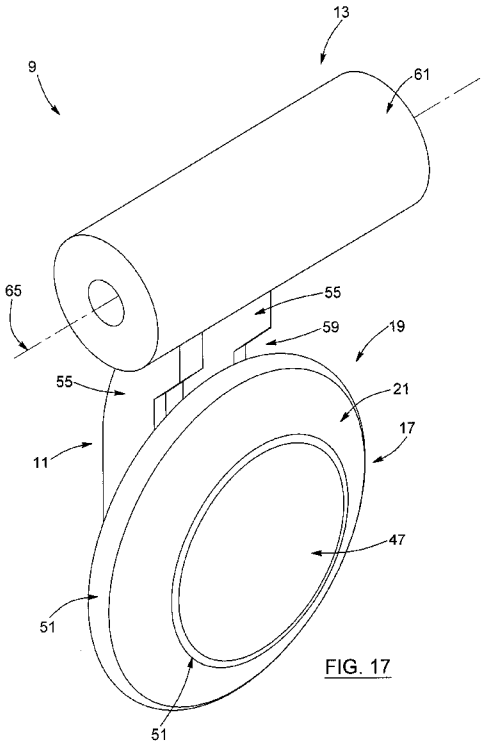

FIG. 17

(57) Abstract: A hybrid check valve (9) for use with a port (7) of a piston pump (1) configured for pumping waste material (3) containing a mixture of at least liquid and solid materials (3a,3b), the hybrid check valve (9) being operable between opened and closed configurations for respectively allowing and preventing the passage of waste material (3) through said port (7). The hybrid check valve (9) includes a supporting component (11), a displacing component (13) for displacing the supporting component (11) between the opened and closed configurations, and an endoskeleton component (15) mountable onto the supporting component (11) and displaceable therewith via the displacing component (13). The hybrid check valve (9) further includes an exoskeleton component (17) mountable about the endoskeleton component (15), the exoskeleton component (17) having a peripheral outer surface (19) being provided with a tapered interface (21) configured for cooperating with a rim (23) of the port (7) for sealing the port (7) when the supporting component (11) is displaced into the closed configuration due to pumping pressure in the chamber (5), the tapered interface (21) being positioned, shaped and sized, and being made of a flexible material with memory, to resiliently deform itself about solid materials (3b) present between the rim (23) of the port (7) and the peripheral outer surface (19) of the exoskeleton component (17), so as to provide a compensatory seal thereinbetween, when the hybrid check valve (9) is operated in the closed configuration. Also disclosed is a piston pump (1) provided with such a hybrid check valve (9).

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HYBRID CHECK VALVE FOR PISTON PUMP, PISTON PUMP PROVIDED WITH SUCH A HYDRID CHECK VALVE, KIT FOR ASSEMBLING THE SAME, AND METHODS OF ASSEMBLING AND OPERATING ASSOCIATED THERETO

Field of the invention:

The present invention relates to a check valve. More particularly, the present invention relates to a hybrid check valve for a piston pump, to a piston pump provided with such a hybrid check valve, to a kit for assembling the same, to a fluid circuit provided with such a hybrid check valve or piston pump, and to corresponding methods of assembling and operating associated thereto. The present patent application claims the priorities of US provisional applications Nos. 61/371,859 and 61/371,895 both filed on August 9th, 2010, the contents of which are both incorporated herein by reference.

Background of the invention:

Piston pumps and the check valves used therewith are well known in the art.

For example, known to the Applicant are the following US patents: 274,204; 305,722; 629,449; 1,060,160; 1,399,684; 3,363,645; 3,613,720; 3,809,119; 3,933,173; and 5,794,655.

It is known that the operating principle of a piston pump is typically based on the action and the tightness of two check valves that open and close in synchronization with the suction and compression cycles of the piston. The liquid and gas tightness quality of the outlet check valve during the filling phase of the piston is essential to create a vacuum and a strong suction, forcing the liquid to be pumped into the pumping tube. The liquid and gas tightness of the intake check valve during the compression phase is essential to create a pressure that will push the liquid to be pumped to the evacuation.

The biggest challenge for conventional check valves is tightness for both liquids as thin as pure water and/or for waste mixtures containing liquids and solids, such as manure containing fibres, for example. These different scenarios normally require different check valve designs, thereby causing usage restrictions of the pump for a particular purpose, in that conventional pumps are generally only adapted for a single situation.

Pumping pure liquid or liquid mixtures containing fibres and solids of different content and size (ex. manure) presents a challenge for a conventional piston pump because of its dependence on the water tightness of its check valves. The loss of water tightness of these valves directly affects the performance of the pump. Transferring and pumping liquid demands a great pressure depending of the complete installation. Composition and viscosity of the pumped liquid, the length of the transfer pipe, the difference in elevation between the beginning and the ends of the transfer pipe, are different factors that influence the required pressure for a proper liquid transfer. Furthermore, check valves of piston pumps must mechanically resist to that pressure while maintaining it sealed. Check valves seals of piston pumps currently on the market cannot be both resistant to high pressure and be sealed upon closure for thin liquids or liquids containing fibres or solids. This makes it impossible to use this type of transfer mode for liquids containing solids of inconsistent thickness, etc.

Hence, in light of the aforementioned, there is a need for an improved system which, by virtue of its design and components, would be able to overcome or at least minimize some of the aforementioned prior art problems.

Summary of the invention:

The object of the present invention is to provide a check valve which satisfies some of the above-mentioned needs and which is thus an improvement over other related check valves and/or sealing methods known in the prior art.

In accordance with the present invention, the above object is achieved, as will be easily understood, with a hybrid check valve (hereinafter referred to also simply as "check valve") such as the one briefly described herein and such as the one exemplified in the accompanying drawings.

In accordance with a preferred aspect of the present invention, there is provided a hybrid check valve for use with a gate of a piston pump for opening and closing said gate, the hybrid check valve comprising:

a support frame movable about the gate of the piston pump between opened and closed configurations, the support frame being made of a substantially solid material;

a first component mounted onto the support frame, the first component being positioned, shaped and sized for having a portion configured for operatively abutting against an outer surface of the gate when the support frame is in the closed configuration, the first component being made of a substantially semi-soft material; and

a second component operatively mounted onto the support frame, against the first component, the second component being positioned, shaped and sized for having a portion configured for plugging the gate when the support frame is in the closed configuration, the second component being made of a substantially tight-soft material.

Preferably, the first component is resistant to high pressure and provides water tightness on the check valve seating surface, whereas the second component preferably comprises a soft and flexible conical surface with memory insertable into the opening of the gate for molding the surface of the check valve seating surface without permanent deformation.

Preferably also, the first and second components are operatively secured against the support frame by means of at least one securing plate mountable against a front face of the second component, each securing plate having at least one fastener extending through both components and being lockable about a rear face of the support frame.

According to another aspect of the present invention, there is also provided a hybrid check valve for use with a port of a piston pump configured for pumping waste material containing a mixture of at least liquid and solid materials, the hybrid check valve being operable between opened and closed configurations for respectively allowing and preventing the passage of waste material through said port, the hybrid check valve comprising:

a supporting component displaceable with respect to the port between opened and closed configurations;

a displacing component for displacing the supporting component between the opened and closed configurations;

a mounting component mountable onto the supporting component and displaceable therewith via the displacing component; and

a sealing component mountable about the mounting component, the sealing component having a peripheral outer surface being provided with a tapered interface configured for cooperating with a rim of the port for sealing the port when the supporting component is displaced into the closed configuration due to pumping pressure in the chamber, the tapered surface being positioned, shaped and sized, and being made of a flexible material with memory, to resiliently deform itself about solid materials present between the rim of the port and the peripheral outer surface of the sealing component, so as to provide a compensatory seal thereinbetween, when the hybrid check valve is operated in the closed configuration.

According to yet another aspect of the present invention, there is also provided a hybrid check valve for use with a port of a piston pump configured for pumping waste material containing a mixture of at least liquid and solid materials, the hybrid check valve being operable between opened and closed configurations for respectively allowing and preventing the passage of waste material through said port, the hybrid check valve comprising:

a supporting component displaceable with respect to the port between opened and closed configurations;

a displacing component for displacing the supporting component between the opened and closed configurations;

an endoskeleton component mountable onto the supporting component and displaceable therewith via the displacing component; and

an exoskeleton component mountable about the endoskeleton component, the exoskeleton component having a peripheral outer surface being provided with a tapered interface configured for cooperating with a rim of the port for sealing the port when the supporting component is displaced into the closed configuration due to pumping pressure in the chamber, the tapered surface being positioned, shaped and sized, and being made of a flexible material with memory, to resiliently deform itself about solid materials present between the rim of the port and the peripheral outer surface of the exoskeleton component, so as to provide a compensatory seal thereinbetween, when the hybrid check valve is operated in the closed configuration.

According to another aspect of the present invention, there is provided a piston pump provided with the above-mentioned check valve(s) and/or components thereof.

More particularly, according to the present invention, there is provided a piston pump for pumping waste material containing a mixture of at least liquid and solid materials, the piston pump comprising a chamber having at least one port through which the waste material to be pumped is allowed to pass, each port being provided with a hybrid check valve operable between opened and closed configurations for respectively allowing and preventing the passage of waste material through said port, each hybrid check valve comprising:

a supporting component displaceable with respect to the port between opened and closed configurations;

a displacing component for displacing the supporting component between the opened and closed configurations;

an endoskeleton component mountable onto the supporting component and displaceable therewith via the displacing component; and

an exoskeleton component mountable about the endoskeleton component, the exoskeleton component having a peripheral outer surface being provided with a tapered interface configured for cooperating with a rim of the port for sealing the port when the supporting component is displaced into the closed configuration due to pumping pressure in the chamber, the tapered surface being positioned, shaped and sized, and being made of a flexible material with memory, to resiliently deform itself about solid materials present between the rim of the port and the peripheral outer surface of the exoskeleton component, so as to provide a compensatory seal thereinbetween, when the hybrid check valve is operated in the closed configuration.

According to another aspect of the present invention, there is provided a fluid circuit provided with the above-mentioned check valve(s), piston pump(s) and/or components thereof.

According to another aspect of the present invention, there is provided a method of installing (i.e. assembling) the above-mentioned check valve(s), piston pump(s) and/or fluid circuit.

According to another aspect of the present invention, there is provided a method of operating the above-mentioned check valve(s), piston pump(s) and/or fluid circuit.

According to another aspect of the present invention, there is provided a kit with corresponding components for assembling the above-mentioned check valve(s), piston pump(s) and/or fluid circuit.

According to yet another aspect of the present invention, there is also provided a method of assembling components of the above-mentioned kit.

According to yet another aspect of the present invention, there is also provided a method of doing business with the above-mentioned kit, check valve(s), piston pump(s), fluid circuit and/or method(s).

According to yet another aspect of the present invention, there is also provided a fluid having been treated with the above-mentioned kit, check valve(s), piston pump(s), fluid circuit and/or method(s).

The objects, advantages and other features of the present invention will become more apparent upon reading of the following non-restrictive description of preferred embodiments thereof, given for the purpose of exemplification only, with reference to the accompanying drawings.

Brief description of the drawings:

Figure 1 is a perspective view of a twin vertical piston pump provided with hybrid check valves according to a preferred embodiment of the present invention.

Figure 2 is a schematic cross-sectional view of a vertical piston pump provided with hybrid check valves according to a preferred embodiment of the present invention.

Figure 2a is an enlarged view of a portion of what is shown in Figure 2.

Figure 3 is a schematic cross-sectional view of another vertical piston pump provided with hybrid check valves according to a preferred embodiment of the present invention, the vertical piston pump being shown in a first suction mode to load the pumping tube.

Figure 3a is an enlarged view of a portion of what is shown in Figure 3.

Figure 4 is another schematic cross-sectional view of what is shown in Figure 3, the vertical piston pump being now shown just before a first pumping cycle.

Figure 4a is an enlarged view of a portion of what is shown in Figure 4.

Figure 5 is another schematic cross-sectional view of what is shown in Figure 4, the vertical piston pump being now shown in a pumping and gas evacuation cycle.

Figure 5a is an enlarged view of a portion of what is shown in Figure 5.

Figure 6 is another schematic cross-sectional view of what is shown in Figure 5, the vertical piston pump being now shown in a pumping and liquid evacuation cycle.

Figure 6a is an enlarged view of a portion of what is shown in Figure 6.

Figure 7 is another schematic cross-sectional view of what is shown in Figure 6, the vertical piston pump being now shown in a liquid admission cycle with a full pumping tube.

Figure 7a is an enlarged view of a portion of what is shown in Figure 7.

Figure 8 is a perspective view of one of the check valves shown in Figure 1, according to a preferred embodiment of the present invention.

Figure 9 is a schematic representation of a check valve being operated within a piston pump along an open configuration according to a preferred embodiment of the present invention.

Figure 10 is another schematic representation of what is shown in Figure 9, the check valve being now shown operated in a closed configuration, according to a preferred embodiment of the present invention.

Figures 11a-11h are schematic comparative views of the various aspects, components and features of a check valve according to a preferred embodiment of the present invention, as shown in Figure 11a, when contrasted to those of conventional check valves according to the prior art, as better shown in Figures 11b-11h.

Figure 12 is a perspective view of a hybrid check valve according to a preferred embodiment of the present invention.

Figure 13 is a schematic representation of a hybrid check valve being operated within a piston pump along an open configuration according to a preferred embodiment of the present invention.

Figure 14 is another schematic representation of what is shown in Figure 13, the check valve being now shown operated in a closed configuration, according to a preferred embodiment of the present invention.

Figure 15 is a schematic cross-sectional view of a fluid circuit provided with a pair of inlet and outlet hybrid check valves according to a preferred embodiment of the present invention.

Figure 16 is a side elevational view of one of the hybrid check valves shown in Figure 15, so as to better illustrate an angle of slant of the tapered surface with respect to a corresponding end surface of the endoskeleton component.

Figure 17 is a front perspective view of a hybrid check valve according to yet another preferred embodiment of the present invention.

Figure 18 is another front perspective view of a hybrid check valve according to yet another preferred embodiment of the present invention.

Figure 19 is a rear perspective view of what is shown in Figure 18.

Figure 20 is a front plan view of what is shown in Figure 18.

Figure 21 is a rear plan view of what is shown in Figure 18.

Figure 22 is a left side elevational view of what is shown in Figure 18.

Figure 23 is a right side elevational view of what is shown in Figure 18.

Figure 24 is a top plan view of what is shown in Figure 18.

Figure 25 is a bottom plan view of what is shown in Figure 18.

Figure 26 is a front exploded view of what is shown in Figure 18.

Figure 27 is a rear exploded view of what is shown in Figure 18.

Figure 28 is a schematic cross-sectional view taken along line XXV-XXV of Figure 18, the hybrid check valve being shown cooperating with a rim of a port of a fluid circuit according to a preferred embodiment of the present invention.

Figure 28a is an enlarged view of a portion of what is shown in Figure 25.

Detailed description of preferred embodiments of the invention:

In the following description, the same numerical references refer to similar elements. The embodiments, geometrical configurations, materials mentioned and/or dimensions shown in the figures or described in the present description are preferred embodiments only, given for exemplification purposes only.

Moreover, although the present invention was primarily designed as a check valve for a piston pump intended for transferring a fluid flow, it may be used with other

types of pumps and objects, and in other fields, as apparent to a person skilled in the art. For this reason, expressions such as "piston", "pump", "fluid", "flow", etc., used herein should not be taken as to limit the scope of the present invention and includes all other kinds of objects or fields with which the present invention could be used and may be useful.

Moreover, in the context of the present invention, the expressions "valve", "device", "unit", "piston", "kit", "assembly", "system", "pump", "circuit" and "product", as well as any other equivalent expressions and/or compounds word thereof known in the art will be used interchangeably, as apparent to a person skilled in the art. This applies also for any other mutually equivalent expressions, such as, for example: a) "extracting", "suction", "vacuum", "drawing", "pumping", "processing", "transferring", etc.; b) "mixture", "fluid", "liquid", "air", "solid", "flow", "stream", etc.; c) "port", "gate", "opening", "rim", "seating surface", etc.; d) "rotating", "driving", "displacing", "moving", "supporting", "gliding", "conveying" etc.; e) "mode", "configuration", "cycle", "state", etc.; f) "fastening", "securing", "attaching", "anchoring", "adjusting", "positioning", etc.; g) "rotating", "pivoting", "turning", "rolling", etc.; h) "fastener", "pin", "projection", etc.; i) "arms", "flange", "plate", etc.; j) "seating", "sealing", "plugging", "covering", "closing", etc.; k) "chamber", "tube", "cylinder", "pump", etc.; l) "interface", "seating surface", etc.; as well as for any other mutually equivalent expressions, pertaining to the aforementioned expressions and/or to any other structural and/or functional aspects of the present invention, as also apparent to a person skilled in the art.

Furthermore, in the context of the present description, it will be considered that expressions such as "connected" and "connectable", or "mounted" and "mountable", may be interchangeable, in that the present invention also relates to a kit with corresponding components for assembling a resulting fully assembled hybrid check valve and corresponding piston pump.

In addition, although the preferred embodiment of the present invention as illustrated in the accompanying drawings may comprise various components, and

although the preferred embodiment of the check valve as shown consists of certain geometrical configurations as explained and illustrated herein, not all of these components and geometries are essential to the invention and thus should not be taken in their restrictive sense, i.e. should not be taken as to limit the scope of the present invention. It is to be understood, as also apparent to a person skilled in the art, that other suitable components and cooperation thereinbetween, as well as other suitable geometrical configurations may be used for the check valve, resulting piston pump and corresponding parts according to the present invention, as will be briefly explained hereinafter and as can be easily inferred herefrom by a person skilled in the art, without departing from the scope of the invention.

Broadly described, the present invention, as illustrated in the accompanying drawings, relates to a check valve for used with a piston pump intended to transfer waste liquid mixtures (ex. manure, etc.) provided with or without solids (ex. fibres, etc.), in applications including pumping or transferring mixtures that could contain solids, adjustable flow, with high stability on short or long distances. The present check valve is preferably of simple design and inexpensive to manufacture. As will be shown hereinbelow, the present check valve and resulting piston pump possess several advantages when compared to conventional systems known in the art.

List of numerical references for some of the corresponding preferred components illustrated in the accompanying drawings:

1. piston pump
3. waste material
3a. liquid material
3b. solid material
5. chamber
7. port
7a. inlet port

7b. outlet port
9. hybrid check valve
9a. inlet hybrid check valve
9b. outlet hybrid check valve
11. supporting component
13. displacing component
15. endoskeleton component
17. exoskeleton component
19. peripheral outer surface
21. tapered interface
23. rim
25. tilting assembly
27. adjustment assembly
29. slot
31. compressible sleeve
33. fastener
35. shouldering portion
37. front end
39. tightening component
41. grommet
43. threaded portion
45. nut
47. front end surface
49. rear end surface
51. intersection
53. inner plate
55. supporting arm
57. mounting plate
59. recessed segment
61. hinge

63. fixed component
65. pivot axis
101. compressible gaseous area
102. pumping tube
103. piston
104. compression chamber
105. hydraulic cylinder
108. automatic air relief valve
109. check valve seating surface
110. liquid to be transferred
111. suction pipe
112. evacuation pipe
113. check valve of the automatic air relief valve
114. floating component (ex. ball) of the automatic air relief valve
115. floating component (ex. ball) seating surface in the automatic air relief valve

Broadly described, the present invention, as illustrated in the accompanying drawings, relates to a check valve (9), and to a corresponding piston pump (1) provided with such check valve (9), intended for pumping mixture materials (3), such as those found in sewers, waste conduits and in manure. Indeed, these types of mixture materials (3) may be very "liquid" (3a), and/or may also contain different solid materials (3b). Indeed, it is well known that a manure mixture to be pumped and processed generally contains a mixture of solid fibres, liquid and fatty materials, with specific fluid properties and behaviour that are unique to manure. Because these various mixture waste materials vary in viscosity, and may contain different types of solid materials (3b) therein, and represent very harsh environments for conventional check valves, these conventional check valves generally do not resist such harsh environments, and are very often prone to "jamming", and thus, improper operation and/or efficiency of the resulting piston pump (1), because of the inherent design flaws of such conventional check valves. The present hybrid check valve (9) thus offers a substantial solution to

these conventional check valves, and as will be explained hereinbelow, it is preferably of a simple design and inexpensive to manufacture and use. Indeed, the present hybrid check valve (9) presents several advantages when compared to conventional check valves known in the art.

According to a preferred embodiment of the present invention, the resulting piston pump (1) is one used for pumping waste material (3) containing a mixture of at least liquid and solid materials (3a,3b), the piston pump (1) comprising a chamber (5) having at least one port (7) through which the waste material (3) to be pumped is allowed to pass; each port (7) being provided with a hybrid check valve (9) operable between opened and closed configurations for respectively allowing and preventing the passage of waste material (3) through said port (7), as is well known in the art.

As can be easily and understood by a person skilled in the art when referring to the accompanying drawings, the hybrid check valve (9) according to the present invention preferably comprises a supporting component (11) displaceable with respect to the port (7) between opened and closed configurations, as well as a displacing component (13) for displacing the supporting component (11) between the opened and closed configurations. The supporting and displacing components (11,13) may take on various shapes and forms, as will be explained in greater detail hereinbelow.

According to a given preferred embodiment of the present invention, the hybrid check valve (9) comprises an endoskeleton component (15) mountable onto the supporting component (11) and displaceable therewith via the displacing component (13), as well as an exoskeleton component (17) mountable about the endoskeleton component (15). The exoskeleton component (17) preferably comprises a peripheral outer surface (19) being provided with a tapered interface (21) configured for cooperating with a rim (23) of the port (7) for sealing the port (7) when the supporting component (11) is displaced into the closed configuration due to pumping pressure in the chamber (5) (i.e. about 115 psi in a conventional piston pump for use with manure),

the tapered interface (21) being positioned, shaped and sized, and being made of a flexible material with memory, to resiliently deform itself about solid materials (3b) present between the rim (23) of the port (7) and the peripheral outer surface (19) of the exoskeleton component (17), so as to provide a compensatory seal thereinbetween, when the hybrid check valve (9) is operated in the closed configuration. This is particularly advantageous when solid materials (3b), such as fibres present in manure, are present between the exoskeleton component (17) and the rim (23) of the corresponding port (7), because the geometrical configuration of the tapered interface (21) and the flexible nature of the exoskeleton component (17) will cover and seal both such fibres and corresponding rim (23), so as to provide a proper seal in order to allow the resulting piston pump (1) to be properly operated, that is, to be operated along up to different modes, without any loss of suction pressure, pumping pressure, etc.

According to a preferred embodiment of the present invention, and as can be easily understood when referring to Figures 12-28a, the endoskeleton component (17) is operatively mountable onto the supporting component (11) of the hybrid check valve (9) via a tilting assembly (25) for allowing the endoskeleton component (15) to be "tilteable" (i.e. to move, to tilt, to pivot, to swirl, to rotate, etc.) with respect to the supporting component (11), and in turn allowing the corresponding tapered interface (21) of the exoskeleton component (17) to be "tilteable" with respect to the rim (23) of the port (7).

This is particularly advantageous in that not only does the flexible material of the exoskeleton component (17) mounted about the endoskeleton component (15) provides some "slack" or flexibilty in order to compensate for any solid materials (3b) that might be present between the tapered interface (21) and the rim (23) of the port (7) to be opened and closed, but also, the provision of such a tilting assembly (25) further provides a suitable "play" to the check valve (9) so as to ensure a proper seal when in the closed configuration, irrespectively of whether the supporting component (11) is completely in the "closed" configuration, or not. Indeed, the nature and the disposition of

the endoskeleton and the exoskeleton components (15,17), in addition to the tilting assembly (25), provide the present check valve (9) with "compensation" features that enable a certain compensatory "play" or "slack", and thus ensure a proper seal when the hybrid check valve (9) is triggered into a closed configuration, so as to ensure a proper seal of the port (7), as can be understood by a person skilled in the art from the accompanying drawings.

Preferably also, the tilting assembly (25) may comprise an adjustment assembly (27) for selectively adjusting the range of "tilt" (i.e. play, slack, etc.) of the hybrid check valve (9) with respect to the supporting component (11). Indeed, the tilting assembly (25) not only enables the exoskeleton component (17) to be tiltable or pivotable with respect to its corresponding supporting component (11), but also, in accordance with a preferred embodiment of the present invention, there is also provided an adjustment assembly (27) which enables to selectively adjust the "range" or the "extent" (ex. "stiffness", etc.) of such tilt or pivoting of the exoskeleton component (17) with respect to its corresponding supporting arm (55).

A person skilled in the art will understand that various suitable adjustment assemblies (27) may be used according to the present invention, such as, for example, anything that provides a suitable "tilting" or "pivoting" joint, but according to a preferred and simplified embodiment of the present invention, as better exemplified in Figures 18-28a, and more particularly Figures 28 and 28a, the tilting assembly (25) comprises: a) a slot (29) extending through the supporting component (11); b) a compressible sleeve (31) mountable about the slot (29); c) a fastener (33) projecting from the endoskeleton component (15) and insertable into the compressible sleeve (31), the fastener (33) being provided with a shouldering portion (35) for abutting against a front end (37) of the compressible sleeve (31); and d) a tightening component (39) cooperable with the fastener (33) for selectively tightening the shouldering portion (35) thereof against the compressible sleeve (31).

According to yet another preferred embodiment of the present invention, and as exemplified in Figures 25-28a, the compressible sleeve (31) is made of an elastic material, and may simply consist of a grommet (41), for example, and the fastener (33) is preferably provided with a threaded portion (43). As a result, the tightening component (39) can simply be a nut (45) mountable and adjustably displaceable along the threaded portion (43) of the fastener (33) for selectively compressing the grommet (41) against the fastener (33), and in turn adjusting the freedom of motion of the fastener (33) of the endoskeleton component (15) with respect to the supporting component (11), as can be easily understood by a person skilled in the art when referring to Figures 28 and 28a. Indeed, as the grommet (41) is compressed, that is, as both distal ends of the grommet (41) are urged towards one another, it will in turn force a bulging of the grommet (41), thereby pressing against the fastener (33), and thereby restricting the range or the extent of tilt of said fastener (33), which in turn restricts the freedom of motion of the fastener (33) of the endoskeleton component (15), and thus, of the exoskeleton component (17), with respect to the supporting component (11).

According to a preferred embodiment of the present invention, and as better exemplified in Figures 16, 22 and 23, the exoskeleton component (17) comprises a frustoconical shape, with opposite front and rear end surfaces (47,49), and the peripheral outer surface (19) with tapered interface (21) extends between said front and rear end surfaces (47,49). It is worth mentioned that although the preferred embodiment of the tapered interface (21) exemplified in the accompanying drawings is essentially a "rectilinear" and "slanted" slope, the tapered interface (21) of the check valve (9) according to the present invention may take on other suitable geometric configurations, such as, for example, a curved (i.e. curvilinear) configuration, that would be complementary in shape to that of its corresponding rim (23) with which it is intended to cooperate, as can be easily understood by a person skilled in the art.

Preferably and also, and as shown in Figures 16, 22 and 23, intersections (51) between the peripheral outer surface (19) with tapered interface (21) and the

corresponding front and rear end surfaces (47,49) of the exoskeleton component (17) are rounded. Once again, it is worth mentioning that other suitable transitions between the peripheral outer surface (19) with tapered interface (21) and the corresponding front and rear end surfaces of (47,49) of the exoskeleton component (17) may be used according to the present invention, as can be easily understood by a person skilled in the art.

As better shown in Figure 16, and according to a preferred embodiment of the present invention, the angle (Θ) of slant of the tapered interface (21) with respect to a rear end surface (49) of the exoskeleton component (17) is of about 30 degrees. Once again, it is worth mentioning also that other suitable ranges of angles of slant for the tapered surfaces (21) with respect to a rear end surface (49) of the exoskeleton component (17), and/or with respect to corresponding front end surfaces (47) of such exoskeleton component (17), may be used according to the present invention. Typically, because the present hybrid check valve (9) is intended to be used with a curvilinear rim (23), as better exemplified in Figure 28, for example, the smaller the radius of curvature of said rim (23), then it is preferable to use a smaller angle (Θ) of slant for the tapered interface (21), as can be easily understood by a person skilled in the art. Conversely, the greater the radius of curvature of said curvilinear rim (23), then it will be preferable to use a greater angle (Θ) of slant for the tapered interface (21), as can also be easily understood by a person skilled in the art. Once again, various other suitable geometric configurations and cooperations between the tapered interface (21) and/or the angle (Θ) of slant thereof, with the corresponding rim (23) to be sealed off, may be used according to the present invention.

According to another preferred embodiment of the present invention, and as better shown in Figures 28 and 28a, the exoskeleton component (17) is preferably molded about the endoskeleton component (15), and the endoskeleton component (15) preferably comprises a T-shaped configuration, in that, the endoskeleton component (15) comprises an inner plate (53) lodged inside the exoskeleton component (17) and

also comprises a fastener (33) projecting outwardly from said inner plate (53). Preferably also, the inner plate (53) is a circular inner plate (53), and has a shape complementary to that of the exoskeleton component (17).

Preferably also, the endoskeleton component (15) is made of a metallic material, such as steel for example, and the exoskeleton component (15) is made of an elastomeric material, such as natural rubber Duro 50 for example, although various other suitable components may be used respectively for the endoskeleton and exoskeleton components (15,17).

Similarly to the other components and features of the present hybrid check valve (9) which may take on various different shapes and forms, the supporting component (11) may simply consist of a rigid supported plate, as exemplified in Figures 8-10 for example, or may comprise a pair of supporting arms (55) and a mounting plate (57) extending between said supporting arms (55), as better shown in Figures 12-14, and in such a case, the tilting assembly (25), which may take on various suitable embodiments, as briefly described hereinabove, is preferably provided about the cross-member mounting plate (57).

In the case where the supporting component (11) preferably comprises a pair of supporting arms (55), such supporting arms (55) preferably comprise recessed segments (59) for accommodating the exoskeleton component (17), as better exemplified in Figures 16, 22, 23 and 28a.

Similar to the supporting component (11) which may take on various suitable shapes and sizes, the displacing component (13) according to the present may also take on various suitable embodiments, but according to a preferred embodiment of the present invention, as exemplified in Figures 8-28a, the displacement component (13) comprises a hinge (61) removably mountable onto a fixed component (63) of the piston pump (1) and rotatable about a pivot axis (65), the supporting component (11) being in

turn rotatable about the pivot axis (65) between the opened and closed configurations of the hybrid check valve (9). Once again, it is worth mentioning that the displacement component (13) may take on various other suitable embodiments so long as they enable the check valve (9) to be removably operated between opened and closed configurations, so as to respectively allow and prevent the passage of flow material (3) through the given port (7). For example, the displacement component (13) may consist of a sliding assembly enabling the corresponding hybrid check valve (9) to be operated between a drawn-away mode (i.e. open configuration) and sealed-against mode (i.e. closed configuration), as can be easily understood by a person skilled in the art.

As can also be easily understood by a person skilled in the art when referring to the accompanying drawings, the piston pump (1) according to the present invention preferably comprises at least first and second ports (7), that is, at least inlet and outlet ports (7a,7b), each port (7) being provided with a corresponding hybrid check valve (9a,9b). The piston pump (1) may be a vertical piston pump (1), such as a twin piston pump, as better shown in Figure1 for example, for pumping manure, as it is generally required in agricultural environments and the like, and preferably also, for sake of simplicity and for other obvious reasons, each port (7) is preferably circular, in which case, according to the present invention, the rim (23) of each port (7) is preferably curvilinear and adapted to cooperate with the tapered interface (23) of the peripheral outer surface (19) of the exoskeleton component (17), in the manner briefly described hereinabove.

In accordance with another aspect of the present invention, there is also preferably provided a kit with corresponding components, such as the ones detailed herein, for assembling a corresponding check valve (9) and a resulting piston pump (1), and there is also preferably provided a fluid circuit provided with such a check valve (9) and/or a resulting piston pump (1) according to the present invention.

Referring now to the preferred embodiment illustrated in Figures 8-10, there is shown how various other modifications could be made to the present hybrid check valve (9) without departing from the scope of the present invention. Indeed, in these figures, the embodiments shown illustrate how there is a core body of the check valves (9a,9b) which is made of a substantially rigid material covered with a semi-rigid or elastic material resistant to high pressure - while providing water tightness on the check valve seating surface (11) - and a soft and flexible conical surface (21) with memory inserted in the opening to be sealed that moulds perfectly into the contour of the check valve seating surface (11) without permanent deformation.

In accordance with a preferred embodiment of the present invention, the check valves (9) for piston pumps (1) according to the present invention are preferably liquid and gas tight. In addition, they preferably allow long fibres through as well as some solids without permanent deformation while maintaining essential water tightness for a piston pump (1). The solids (3b) temporarily impregnate into the flexible section (i.e. exoskeleton 17 with tapered interface 21) of the check valve (9) and contribute to the seal during this stage of a cycle and then continue its movement.

Thus, the present check valve piston pumps are completely sealed for the transfer of very fluid liquids as well as for the transfer of liquids containing solids. As may now be better appreciated by a person skilled in the art in view of the present description, and the accompanying drawings, the present piston pump (1) can transfer various alternating liquids of variable composition during the transfer, because of the innovative design of its hybrid check valves.

It is understood that the concept of using a combination of rigid, semi-rigid and/or flexible material, constitute an important aspect of the present invention permitting the use of a piston pump (1) for the transfer and pumping of liquids of variable consistency including solids (3b). It also includes any structure based on this concept aimed at

obtaining the tightness of piston pump check valves (9), as can also be easily understood by a person skilled in the art.

It is also to be understood that the choice of material, the shape of the valves (9) and seating surface, the position of the different types of material can take on various variants according to the present invention, other than those exemplified in the accompanying drawings, as apparent to a person skilled in the art. The concept covered by the present invention allows to adapt the shape and size depending on the project and the choice of material that meet the qualifications listed above for the chemical, thermal and mechanical compatibility.

It is also understood that the vertical position of the check valves (9) is not a limitation of the present invention and that variations are part of the adjustments to the project, as can also be easily understood by a person skilled in the art.

Finally, and according to the present invention, the check valve (9), resulting piston pump (1) and corresponding parts are preferably made of substantially rigid materials, such as metallic materials, hardened polymers, composite materials, and/or the like, as well as possible combinations thereof, whereas other components of the present invention, in order to achieve the resulting advantages briefly discussed herein (ex. seal), can be made of a polymeric material (plastic, rubber, etc.), and/or the like, depending on the particular applications for which the check valve (9) and resulting piston pump (1) are intended for and the different parameters in cause, as also apparent to a person skilled in the art.

Furthermore, the present invention is a substantial improvement over the prior art in that, by virtue of its design and components, the check valve (9) and resulting piston pump (1) are simple and easy to use, as well as is simple and easy to manufacture and/or assemble, without compromising the reliability of its functions. Hence, it may now be appreciated that the present invention represents important advantages over other

piston pumps known in the prior art, in that, when referring to Figure 11 for example, there is presented the different ways to produce check valves (flapper style), each one being a limited application for a given specific situation, some being very good for liquids, others for solids only, but the only one that can do both at the same time is the hybrid check valve (9) according to the present invention with corresponding components, features and resulting advantages, as explained hereinabove, and as exemplified in the accompanying drawings.

Of course, numerous modifications could be made to the above-described embodiments without departing from the scope of the invention, as defined in the appended claims.

CLAIMS:

1. A piston pump (1) for pumping waste material (3) containing a mixture of at least liquid and solid materials (3a,3b), the piston pump (1) comprising a chamber (5) having at least one port (7) through which the waste material (3) to be pumped is allowed to pass, each port (7) being provided with a hybrid check valve (9) operable between opened and closed configurations for respectively allowing and preventing the passage of waste material (3) through said port (7), each hybrid check valve (9) comprising:

a supporting component (11) displaceable with respect to the port (7) between opened and closed configurations;

a displacing component (13) for displacing the supporting component (11) between the opened and closed configurations;

an endoskeleton component (15) mountable onto the supporting component (11) and displaceable therewith via the displacing component (13); and

an exoskeleton component (17) mountable about the endoskeleton component (15), the exoskeleton component (17) having a peripheral outer surface (19) being provided with a tapered interface (21) configured for cooperating with a rim (23) of the port (7) for sealing the port (7) when the supporting component (11) is displaced into the closed configuration due to pumping pressure in the chamber (5), the tapered interface (21) being positioned, shaped and sized, and being made of a flexible material with memory, to resiliently deform itself about solid materials (3b) present between the rim (23) of the port (7) and the peripheral outer surface (19) of the exoskeleton component (17), so as to provide a compensatory seal thereinbetween, when the hybrid check valve (9) is operated in the closed configuration.

2. A piston pump (1) according to claim 1, where the endoskeleton component (17) is operatively mountable onto the supporting component (11) of the hybrid check valve (9) via a tilting assembly (25) for allowing the endoskeleton component (15) to be tilteable with respect to the supporting component (11), and in

turn allowing the corresponding tapered interface (21) of the exoskeleton component (17) to be tilteable with respect to the rim (23) of the port (7).

3. A piston pump (1) according to claim 2, wherein the tilting assembly (25) comprises an adjustment assembly (27) for selectively adjusting the range of tilt of the hybrid check valve (9) with respect to the supporting component (11).

4. A piston pump (1) according to claim 2 or 3, wherein the tilting assembly (25) comprises:

- a slot (29) extending through the supporting component (11);
- a compressible sleeve (31) mountable about the slot (29);
- a fastener (33) projecting from the endoskeleton component (15) and insertable into the compressible sleeve (31), the fastener (33) being provided with a shouldering portion (35) for abutting against a front end (37) of the compressible sleeve (31); and
- a tightening component (39) cooperable with the fastener (33) for selectively tightening the shouldering portion (35) thereof against the compressible sleeve (31).

5. A piston pump (1) according to claim 4, wherein the compressible sleeve (31) is made of an elastomeric material.

6. A piston pump (1) according to claim 4 or 5, wherein the compressible sleeve (31) is a grommet (41), wherein the fastener (33) is provided with a threaded portion (43), and wherein the tightening component (39) is a nut (45) mountable and adjustably displaceable along the threaded portion (43) of the fastener (33) for selectively compressing the grommet (41) against the fastener (33), and in turn adjusting the freedom of motion of the fastener (33) of the endoskeleton component (15) with respect to the supporting component (11).

7. A piston pump (1) according to any one of claims 1-6, wherein the exoskeleton component (17) comprises a frustoconical shape, with opposite front and rear end surfaces (47,49), and wherein the peripheral outer surface (19) with tapered interface (21) extends between said front and rear end surfaces (47,49).

8. A piston pump (1) according to claim 7, wherein intersections (51) between the peripheral outer surface (19) with tapered interface (21) and the corresponding front and rear end surfaces (47,49) of the exoskeleton component (17) are rounded.

9. A piston pump (1) according to any one of claims 1-8, wherein the angle (Θ) of slant of the tapered interface (21) with respect to a rear end surface (49) of the exoskeleton component (17) is of about 30 degrees.

10. A piston pump (1) according to any one of claims 1-9, wherein the exoskeleton component (17) is molded about the endoskeleton component (15).

11. A piston pump (1) according to any one of claims 1-10, wherein the endoskeleton component (15) comprises a T-shaped configuration.

12. A piston pump (1) according to any one of claims 1-11, wherein the endoskeleton component (15) comprises an inner plate (53) lodged inside the exoskeleton component (17) and also comprises a fastener (33) projecting outwardly from said inner plate (53).

13. A piston pump (1) according to claim 12, wherein the inner plate (53) is a circular inner plate (53).

14. A piston pump (1) according to any one of claims 1-13, wherein the endoskeleton component (15) is made of a metallic material.

15. A piston pump (1) according to claim 14, wherein the metallic material is steel.

16. A piston pump (1) according to any one of claims 1-15, wherein the exoskeleton component (15) is made of an elastomeric material.

17. A piston pump (1) according to claim 16, wherein the elastomeric material is natural rubber Duro 50.

18. A piston pump (1) according to any one of claims 1-17, wherein the supporting component (11) comprises a pair of supporting arms (55) and a mounting plate (57) extending between said supporting arms (55).

19. A piston pump (1) according to claim 18, wherein the supporting arms (55) comprise recessed segments (59) for accommodating the exoskeleton component (17).

20. A piston pump (1) according to claim 18 or 19, wherein a tilting assembly (25) is provided about the mounting plate (57).

21. A piston pump (1) according to any one of claims 1-20, wherein the displacing component (13) comprises a hinge (61) removably mountable onto a fixed component (63) of the piston pump (1) and rotatable about a pivot axis (65), the supporting component (11) being in turn rotatable about the pivot axis (65) between the opened and closed configurations of the hybrid check valve (9).

22. A piston pump (1) according to any one of claims 1-21, wherein the at least one port (7) comprises at least inlet and outlet ports (7a,7b), each port (7) being provided with a corresponding hybrid check valve (9a,9b).

23. A piston pump (1) according to any one of claims 1-22, wherein each port (7) is circular and wherein the rim (23) of each port (7) is curvilinear.

24. A piston pump (1) according to any one of claims 1-23, wherein the piston pump (1) is a vertical piston pump (1) for pumping manure.

25. A piston pump (1) according to any one of claims 1-24, wherein the piston pump (1) is a twin piston pump (1) for pumping manure.

26. A kit with components including at least check valve (9) for assembling a piston pump (1) according to any one of claims 1-25.

27. A fluid circuit (67) provided with a piston pump (1) according to any one of claims 1-25.

28. A hybrid check valve (9) for use with a port (7) of a piston pump (1) configured for pumping waste material (3) containing a mixture of at least liquid and solid materials (3a,3b), the hybrid check valve (9) being operable between opened and closed configurations for respectively allowing and preventing the passage of waste material (3) through said port (7), the hybrid check valve (9) comprising:

a supporting component (11) displaceable with respect to the port (7) between opened and closed configurations;

a displacing component (13) for displacing the supporting component (11) between the opened and closed configurations;

an endoskeleton component (15) mountable onto the supporting component (11) and displaceable therewith via the displacing component (13); and

an exoskeleton component (17) mountable about the endoskeleton component (15), the exoskeleton component (17) having a peripheral outer surface (19) being provided with a tapered interface (21) configured for cooperating with a rim (23) of the port (7) for sealing the port (7) when the supporting component (11) is displaced into the

closed configuration due to pumping pressure in the chamber (5), the tapered interface (21) being positioned, shaped and sized, and being made of a flexible material with memory, to resiliently deform itself about solid materials (3b) present between the rim (23) of the port (7) and the peripheral outer surface (19) of the exoskeleton component (17), so as to provide a compensatory seal thereinbetween, when the hybrid check valve (9) is operated in the closed configuration.

29. A hybrid check valve (9) according to claim 28, where the endoskeleton component (17) is operatively mountable onto the supporting component (11) of the hybrid check valve (9) via a tilting assembly (25) for allowing the endoskeleton component (15) to be tilteable with respect to the supporting component (11), and in turn allowing the corresponding tapered interface (21) of the exoskeleton component (17) to be tilteable with respect to the rim (23) of the port (7).

30. A hybrid check valve (9) according to claim 29, wherein the tilting assembly (25) comprises an adjustment assembly (27) for selectively adjusting the range of tilt of the hybrid check valve (9) with respect to the supporting component (11).

31. A hybrid check valve (9) according to claim 29 or 30, wherein the tilting assembly (25) comprises:

- a slot (29) extending through the supporting component (11);
- a compressible sleeve (31) mountable about the slot (29);
- a fastener (33) projecting from the endoskeleton component (15) and insertable into the compressible sleeve (31), the fastener (33) being provided with a shouldering portion (35) for abutting against a front end (37) of the compressible sleeve (31); and
- a tightening component (39) cooperable with the fastener (33) for selectively tightening the shouldering portion (35) thereof against the compressible sleeve (31).

32. A hybrid check valve (9) according to claim 31, wherein the compressible sleeve (31) is made of an elastomeric material.

33. A hybrid check valve (9) according to claim 31 or 32, wherein the compressible sleeve (31) is a grommet (41), wherein the fastener (33) is provided with a threaded portion (43), and wherein the tightening component (39) is a nut (45) mountable and adjustably displaceable along the threaded portion (43) of the fastener (33) for selectively compressing the grommet (41) against the fastener (33), and in turn adjusting the freedom of motion of the fastener (33) of the endoskeleton component (15) with respect to the supporting component (11).

34. A hybrid check valve (9) according to any one of claims 28-33, wherein the exoskeleton component (17) comprises a frustoconical shape, with opposite front and rear end surfaces (47,49), and wherein the peripheral outer surface (19) with tapered interface (21) extends between said front and rear end surfaces (47,49).

35. A hybrid check valve (9) according to claim 34, wherein intersections (51) between the peripheral outer surface (19) with tapered interface (21) and the corresponding front and rear end surfaces (47,49) of the exoskeleton component (17) are rounded.

36. A hybrid check valve (9) according to any one of claims 28-35, wherein the angle (Θ) of slant of the tapered interface (21) with respect to a rear end surface (49) of the exoskeleton component (17) is of about 30 degrees.

37. A hybrid check valve (9) according to any one of claims 28-36, wherein exoskeleton component (17) is molded about the endoskeleton component (15).

38. A hybrid check valve (9) according to any one of claims 28-37, wherein the endoskeleton component (15) comprises a T-shaped configuration.

39. A hybrid check valve (9) according to any one of claims 28-38, wherein the endoskeleton component (15) comprises an inner plate (53) lodged inside the exoskeleton component (17) and also comprises a fastener (33) projecting outwardly from said inner plate (53).

40. A hybrid check valve (9) according to claim 39, wherein the inner plate (53) is a circular inner plate (53).

41. A hybrid check valve (9) according to any one of claims 28-40, wherein the endoskeleton component (15) is made of a metallic material.

42. A hybrid check valve (9) according to claim 41, wherein the metallic material is steel.

43. A hybrid check valve (9) according to any one of claims 28-42, wherein the exoskeleton component (15) is made of an elastomeric material.

44. A hybrid check valve (9) according to claim 43, wherein the elastomeric material is natural rubber Duro 50.

45. A hybrid check valve (9) according to any one of claims 28-44, wherein the supporting component (11) comprises a pair of supporting arms (55) and a mounting plate (57) extending between said supporting arms (55).

46. A hybrid check valve (9) according to claim 45, wherein the supporting arms (55) comprise recessed segments (59) for accommodating the exoskeleton component (17).

47. A hybrid check valve (9) according to claim 45 or 46, wherein a tilting assembly (25) is provided about the mounting plate (57).

48. A hybrid check valve (9) according to any one of claims 28-47, wherein the displacing component (13) comprises a hinge (61) removably mountable onto a fixed component (63) of the piston pump (1) and rotatable about a pivot axis (65), the supporting component (11) being in turn rotatable about the pivot axis (65) between the opened and closed configurations of the hybrid check valve (9).

49. A kit with components for assembling a hybrid check valve (9) according to any one of claims 28-48.

50. A fluid circuit (67) provided with a check valve (9) according to any one of claims 28-48.

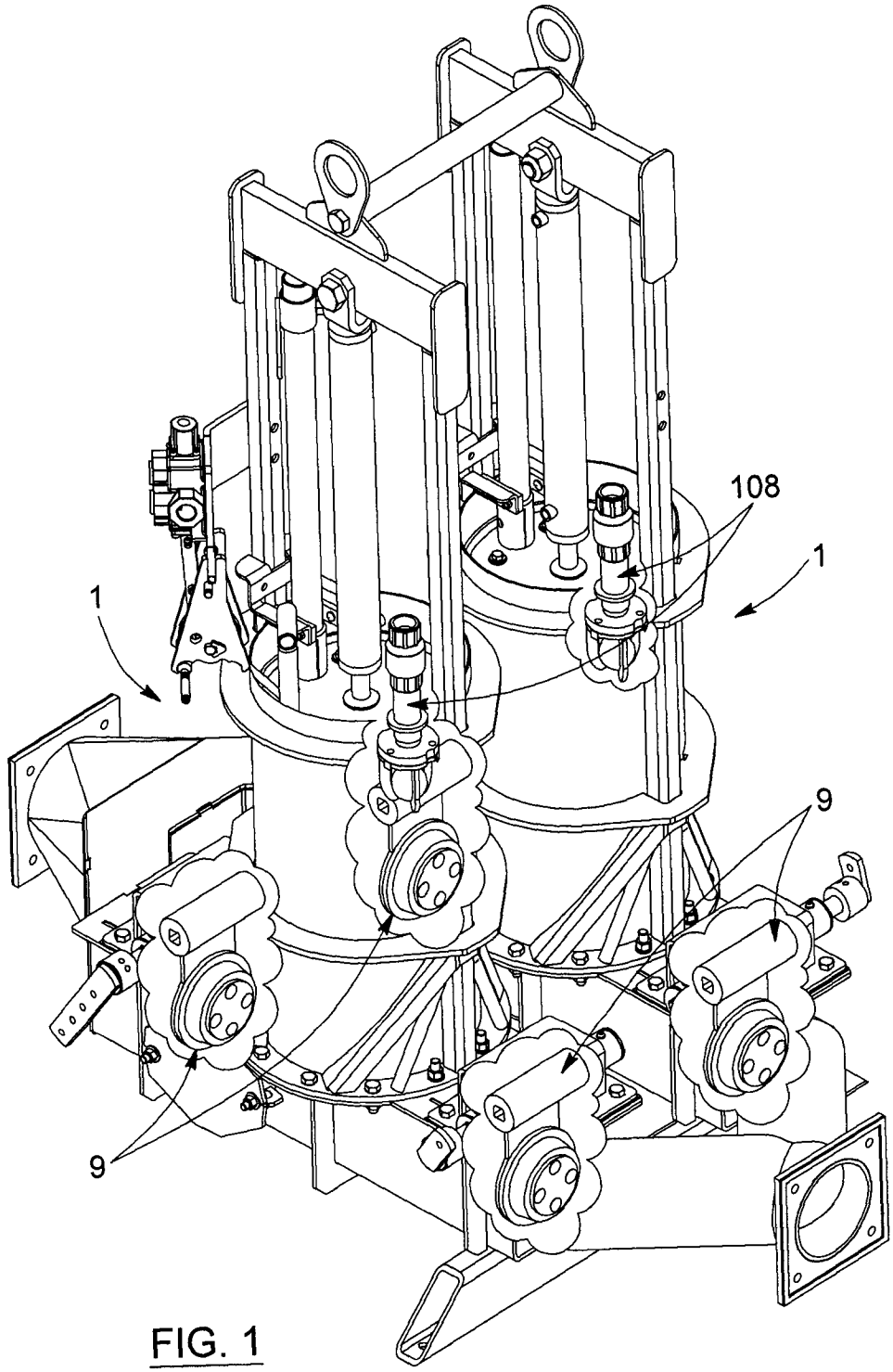

FIG. 1

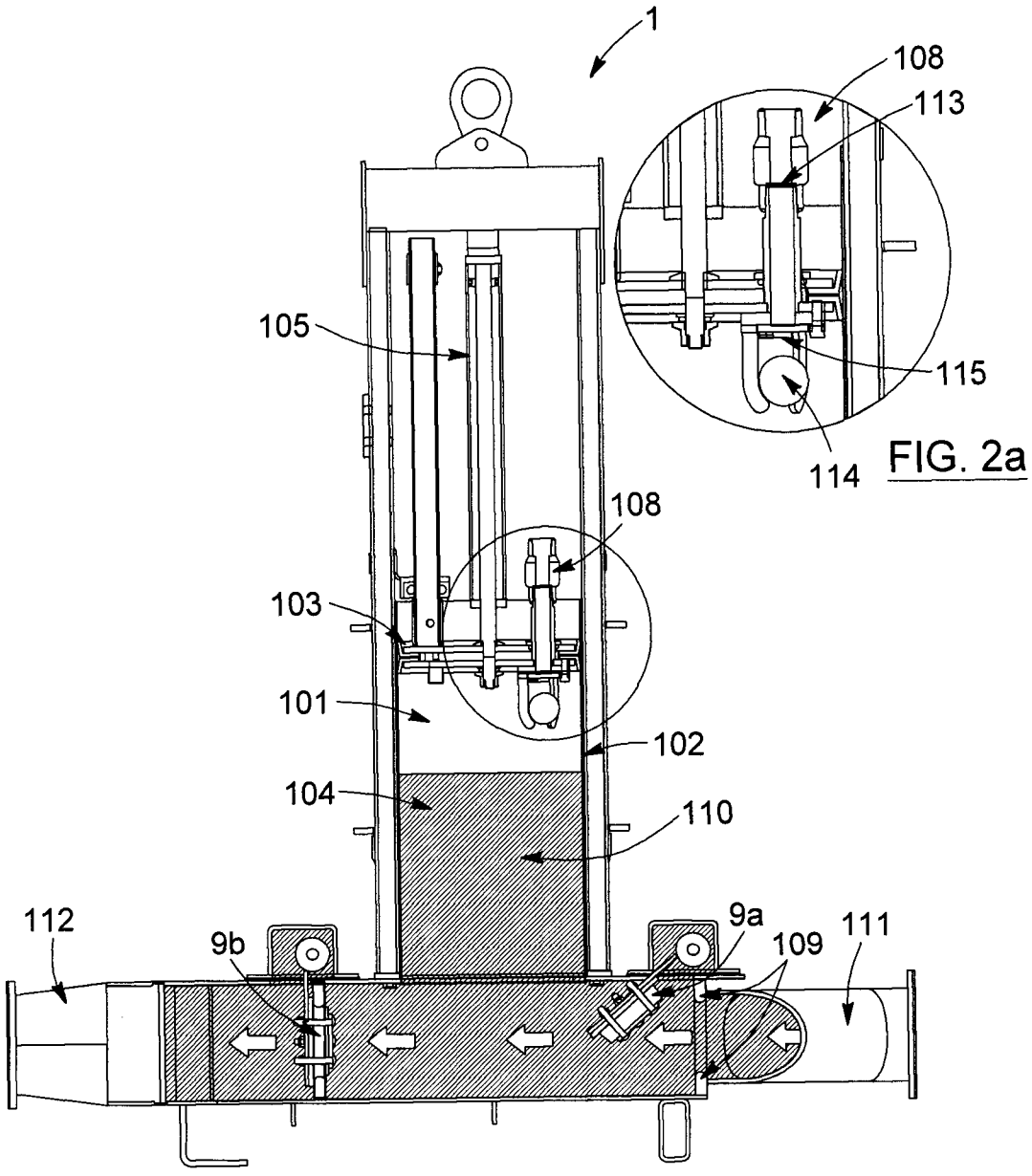

FIG. 2a

FIG. 2

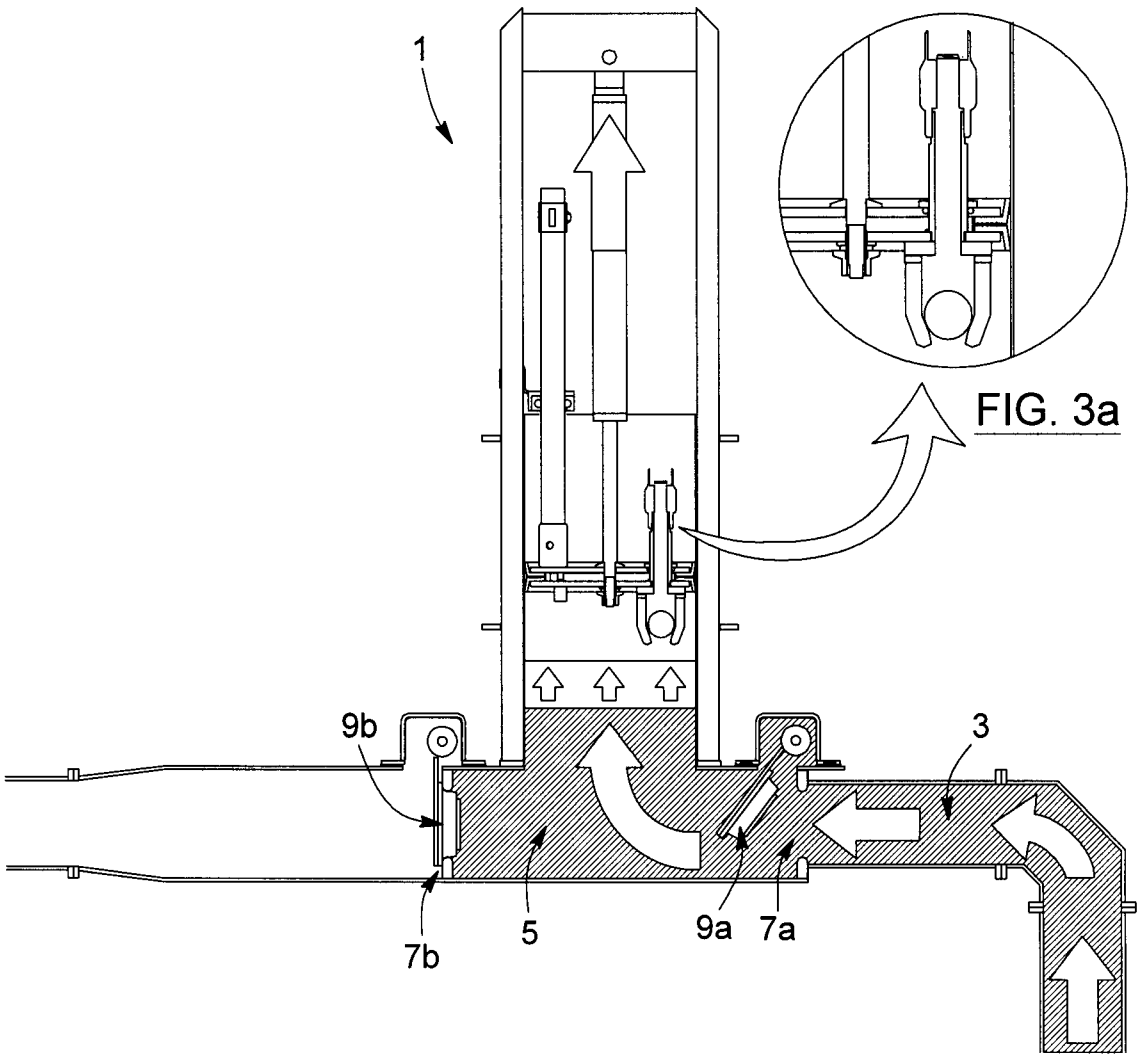

FIG. 3
(part 1 - start the machine: first suction action to load the pumping tube)

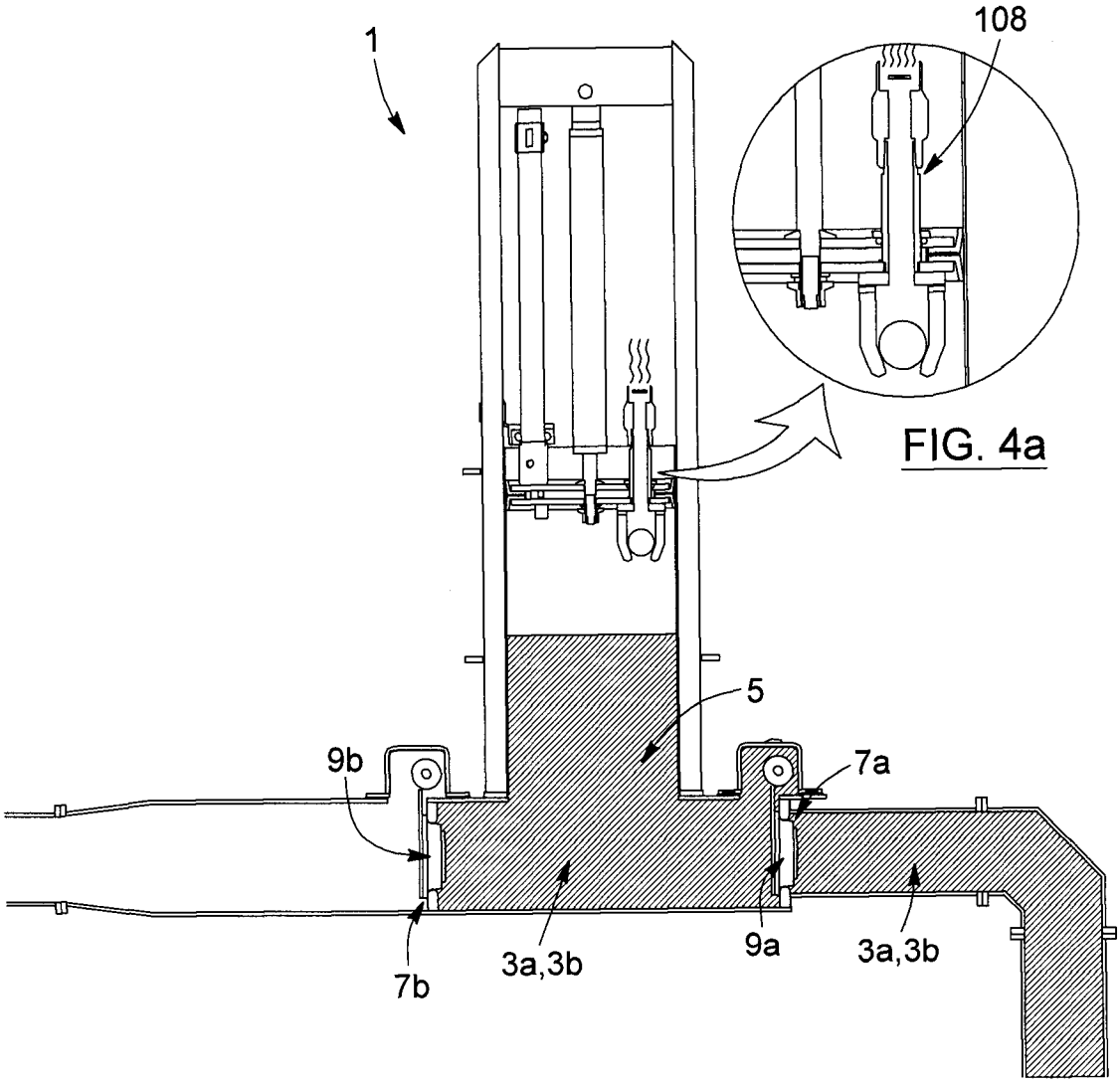

FIG. 4a

FIG. 4
(part 2 - just before the first pumping cycle)

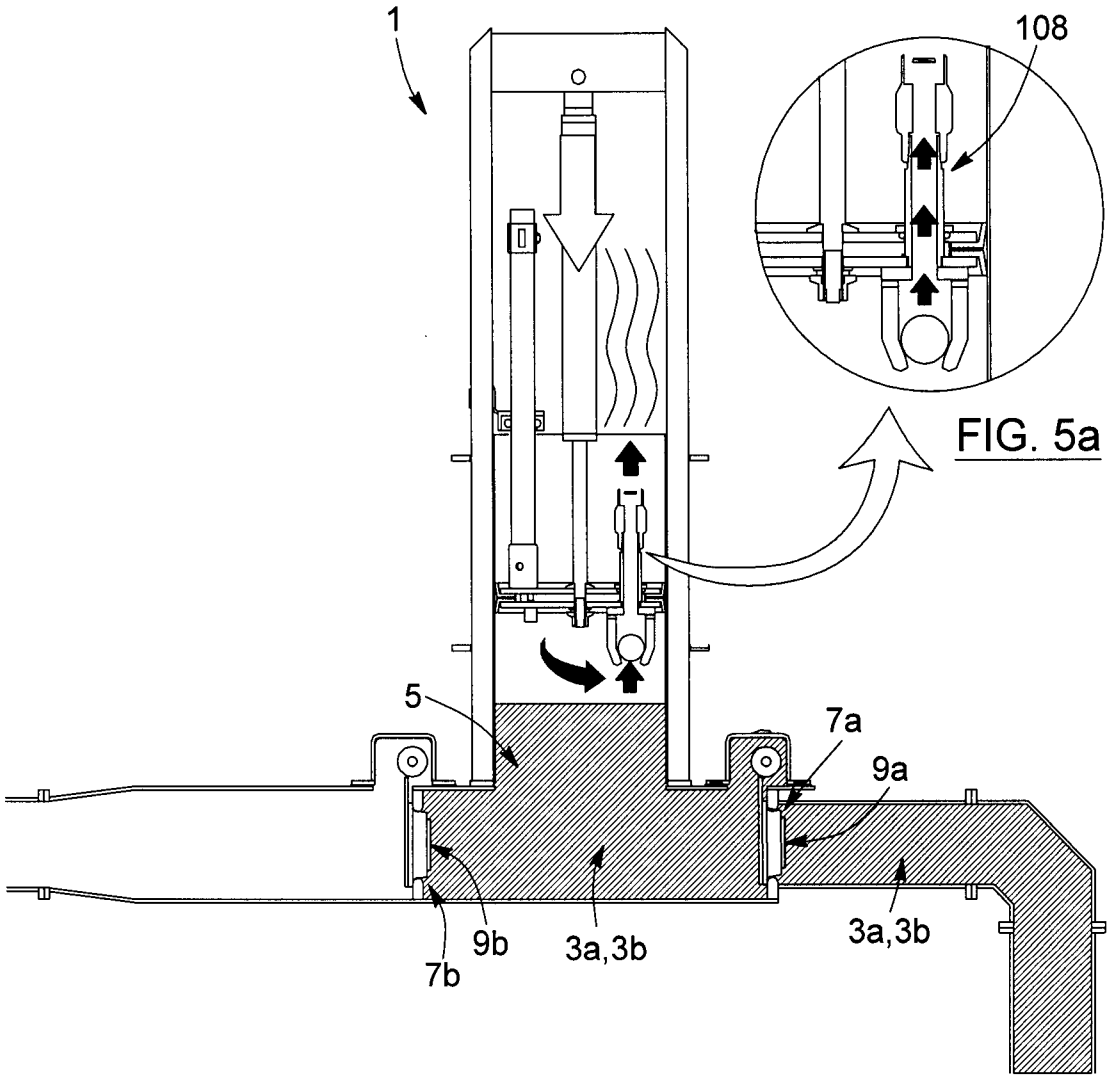

FIG. 5a

FIG. 5
(part 3 - first part of pumping cycle: gas evacuation)

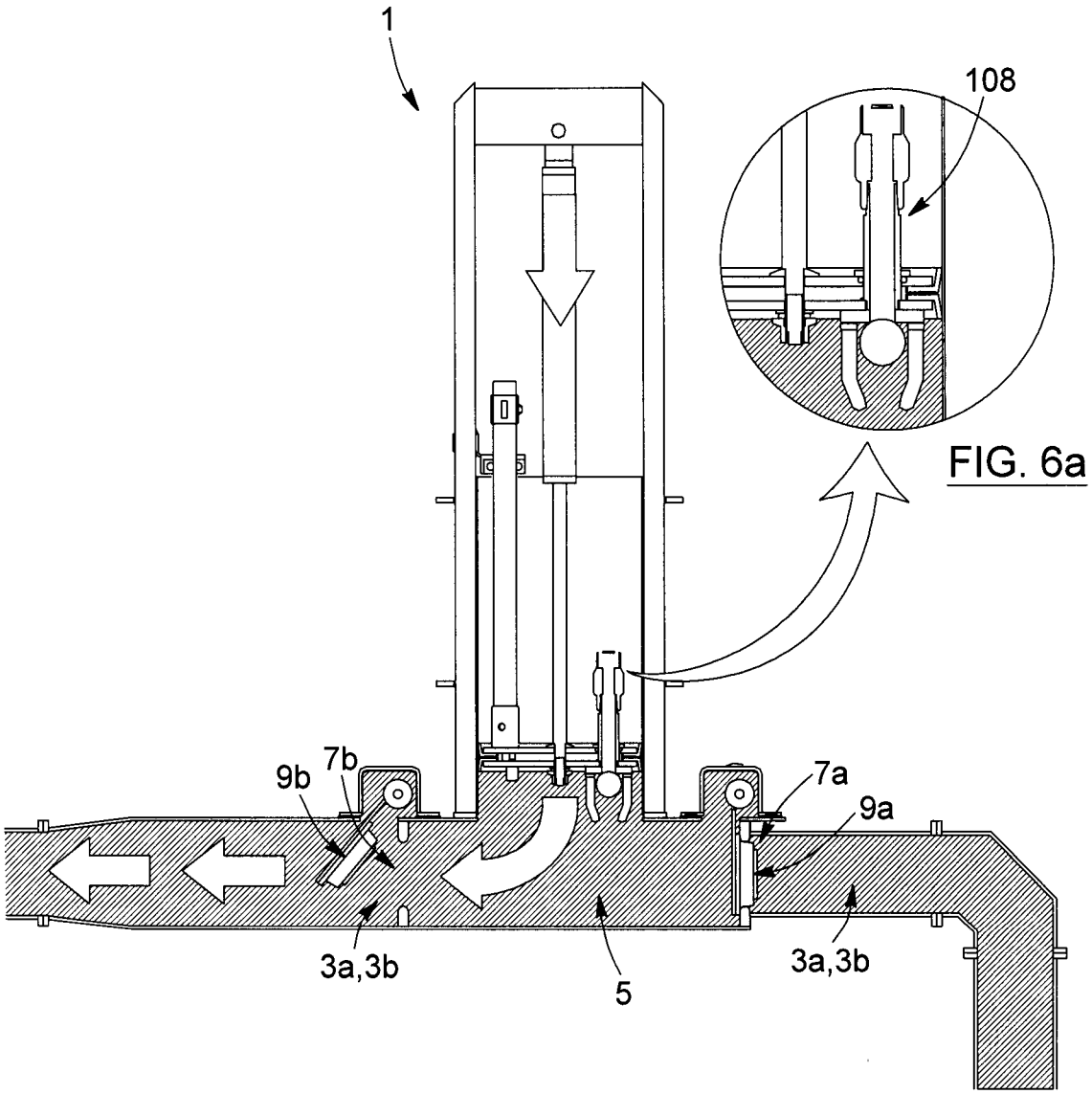

FIG. 6a

FIG. 6

(part 4 - end of the first pumping action: liquid evacuation)

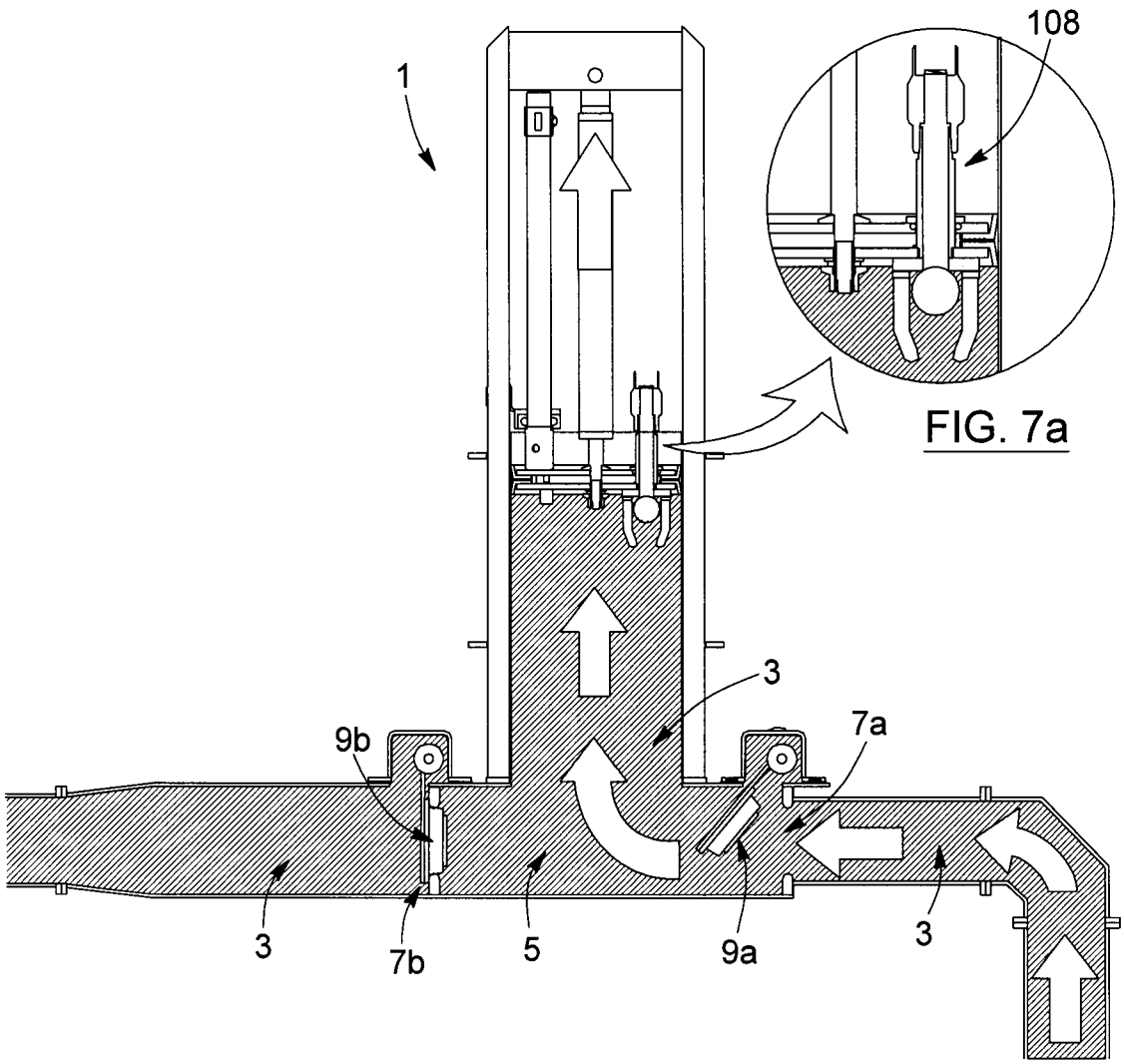

FIG. 7a

FIG. 7

(part 5 - start the second cycle: liquid admission with a full pumping tube)

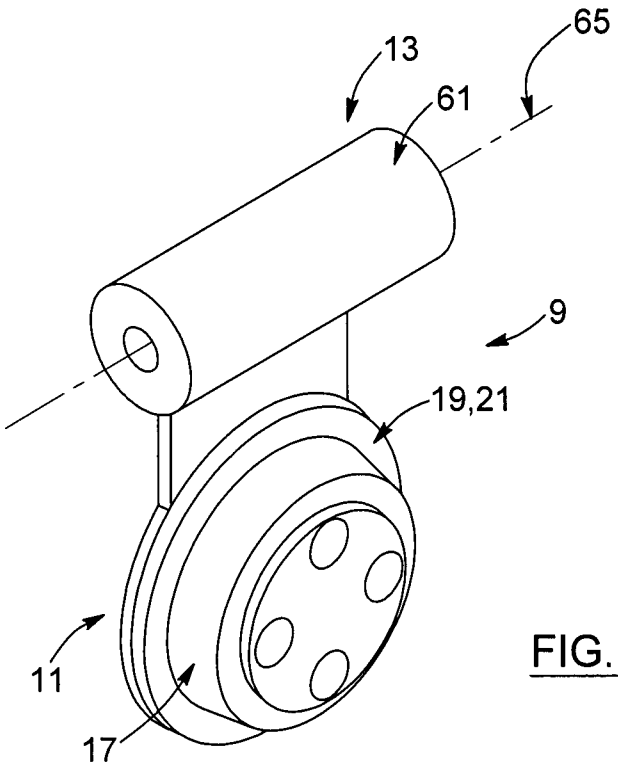

FIG. 8

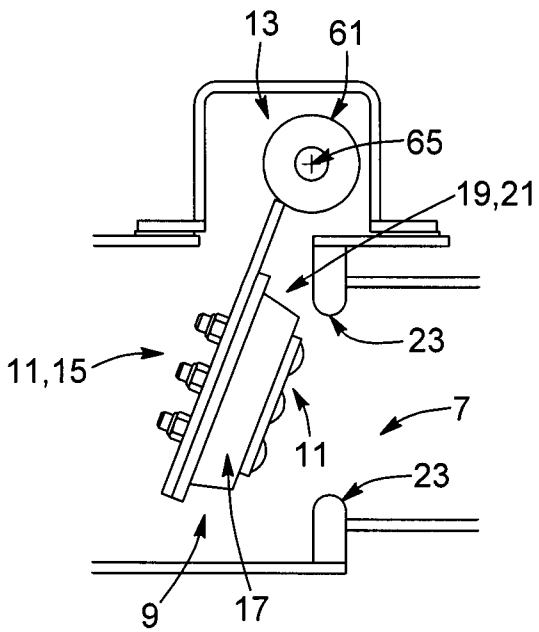

FIG. 9

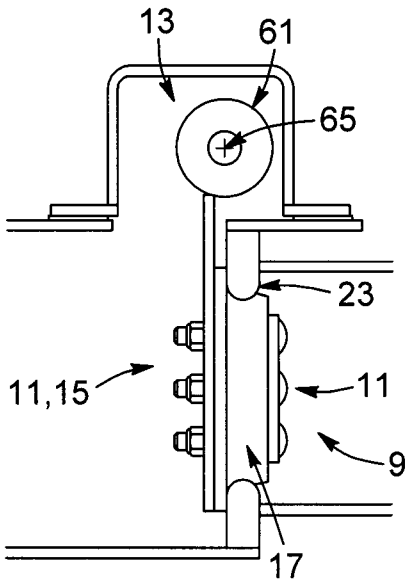

FIG. 10

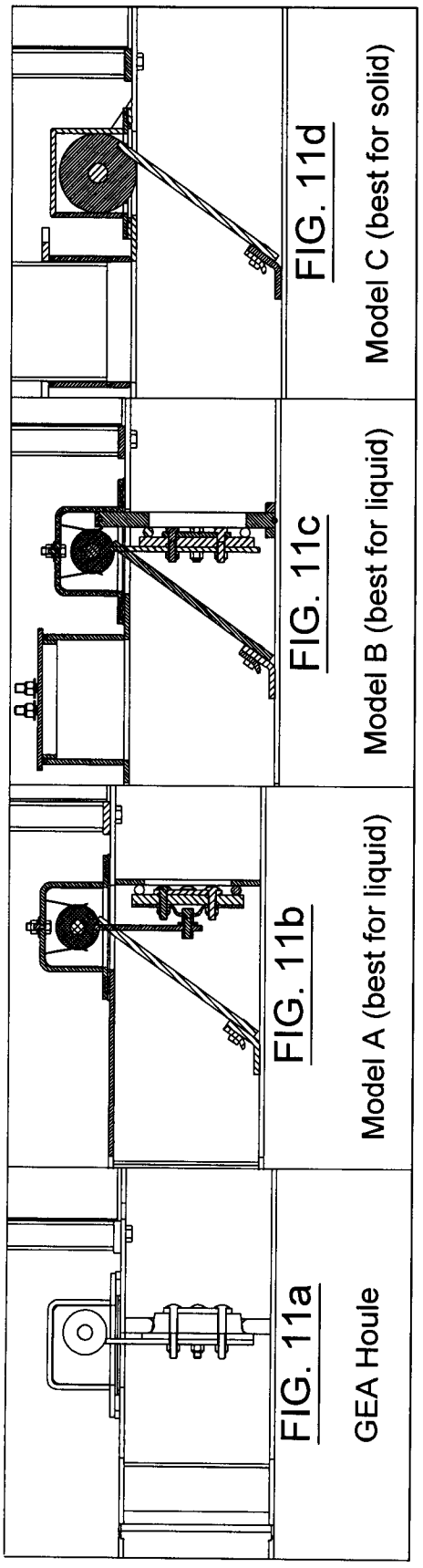

FIG. 11a
GEA Houle

FIG. 11b
Model A (best for liquid)

FIG. 11c
Model B (best for liquid)

FIG. 11d
Model C (best for solid)

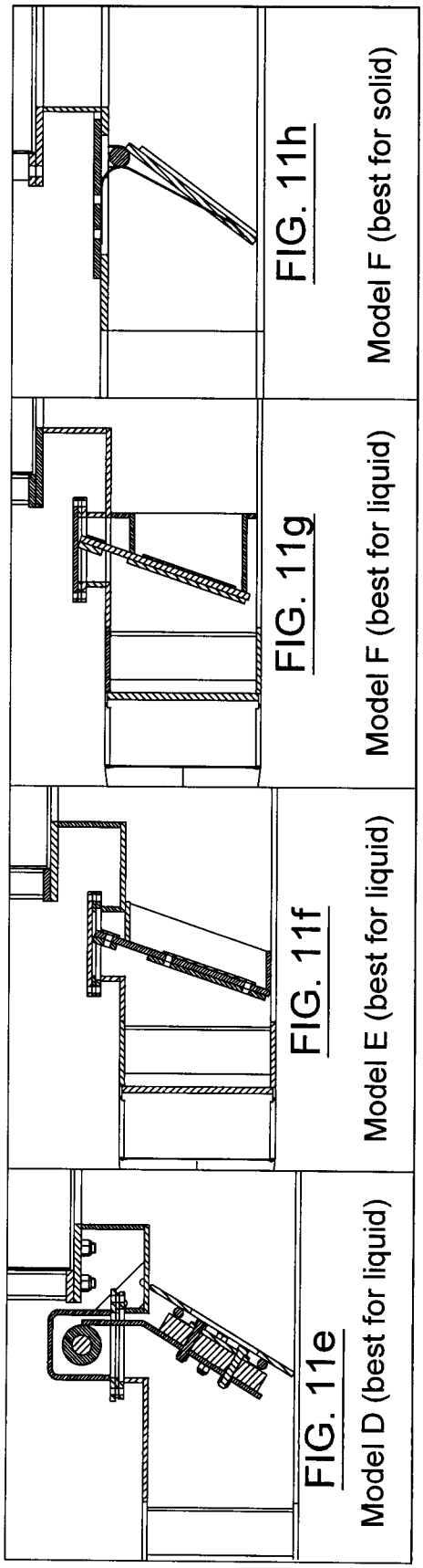

FIG. 11e
Model D (best for liquid)

FIG. 11f
Model E (best for liquid)

FIG. 11g
Model F (best for liquid)

FIG. 11h
Model F (best for solid)

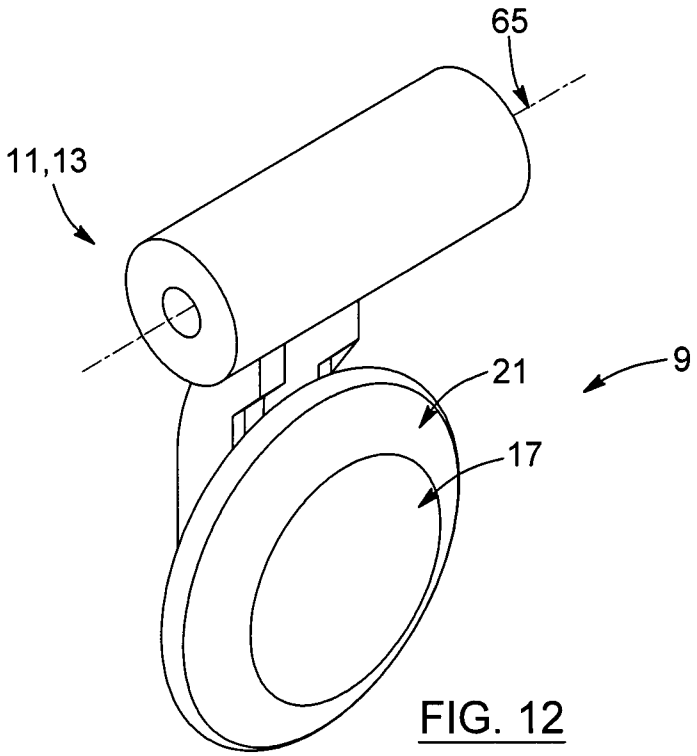

FIG. 12

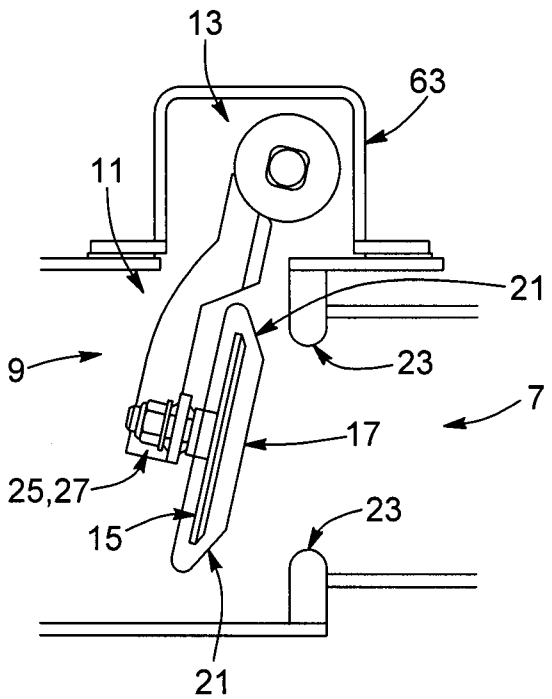

FIG. 13

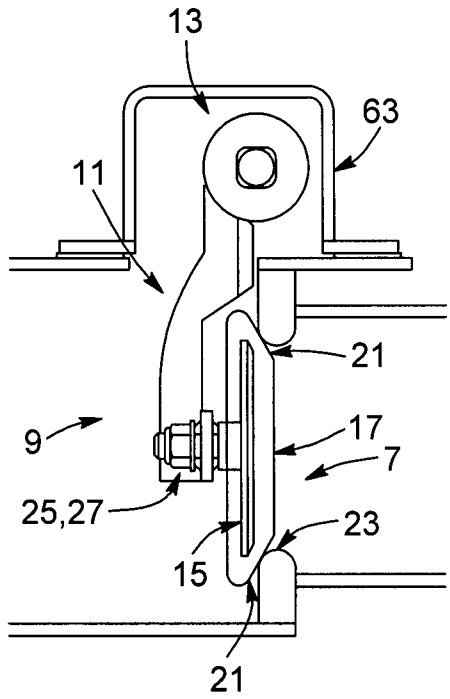

FIG. 14

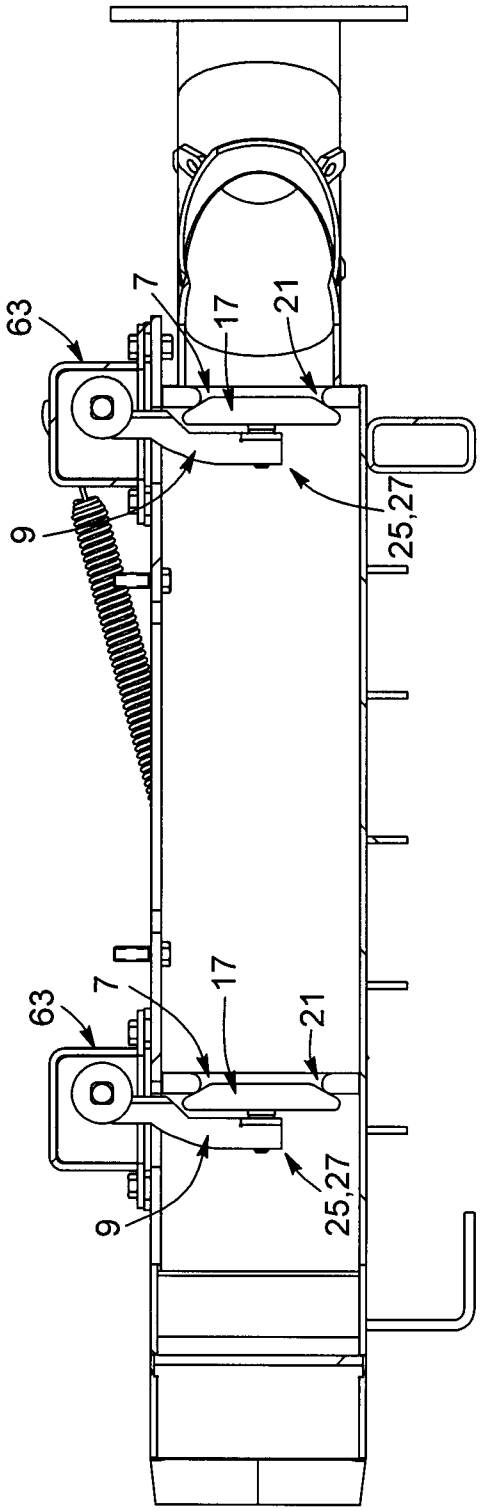

FIG. 15

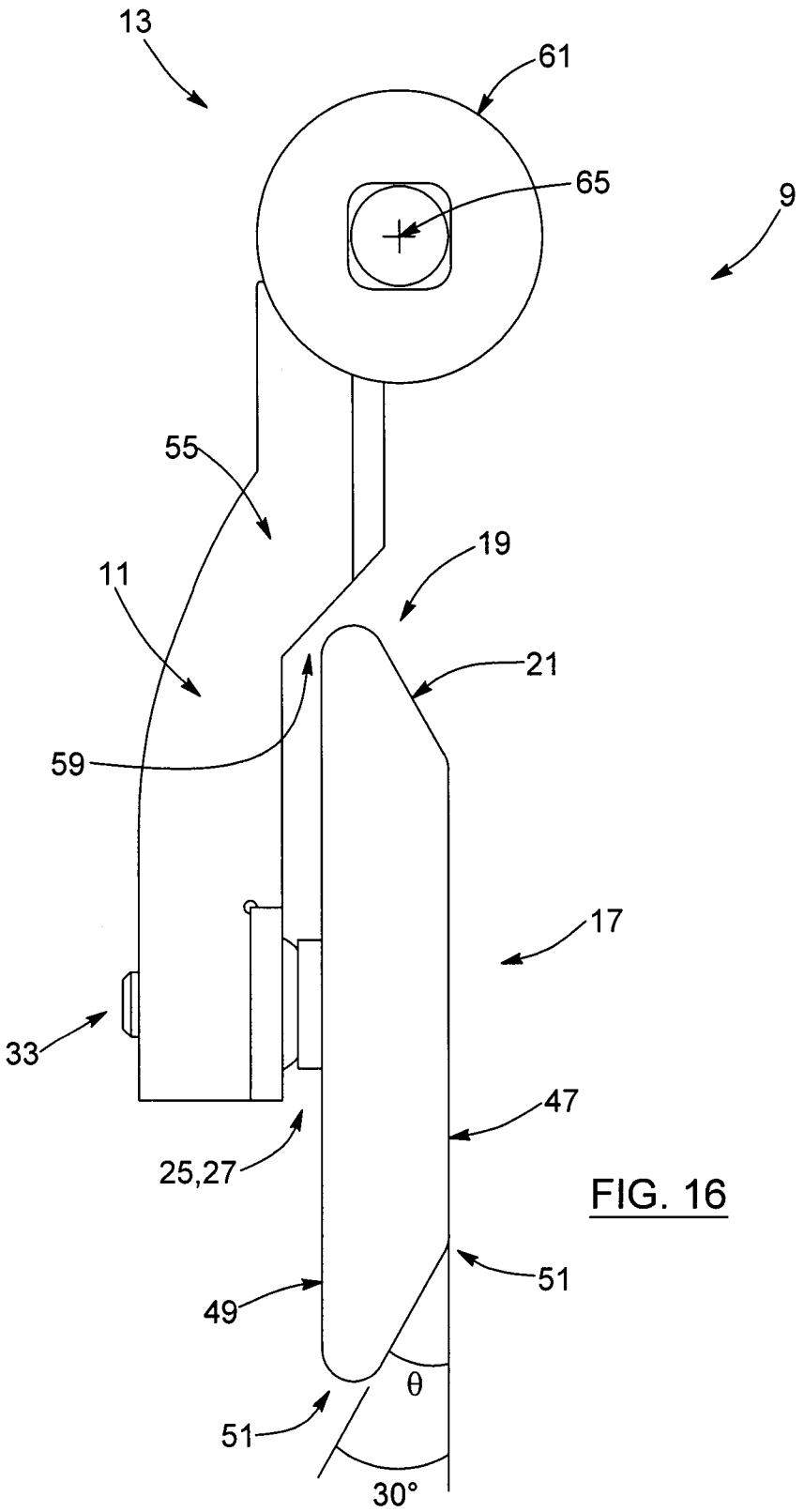

FIG. 16

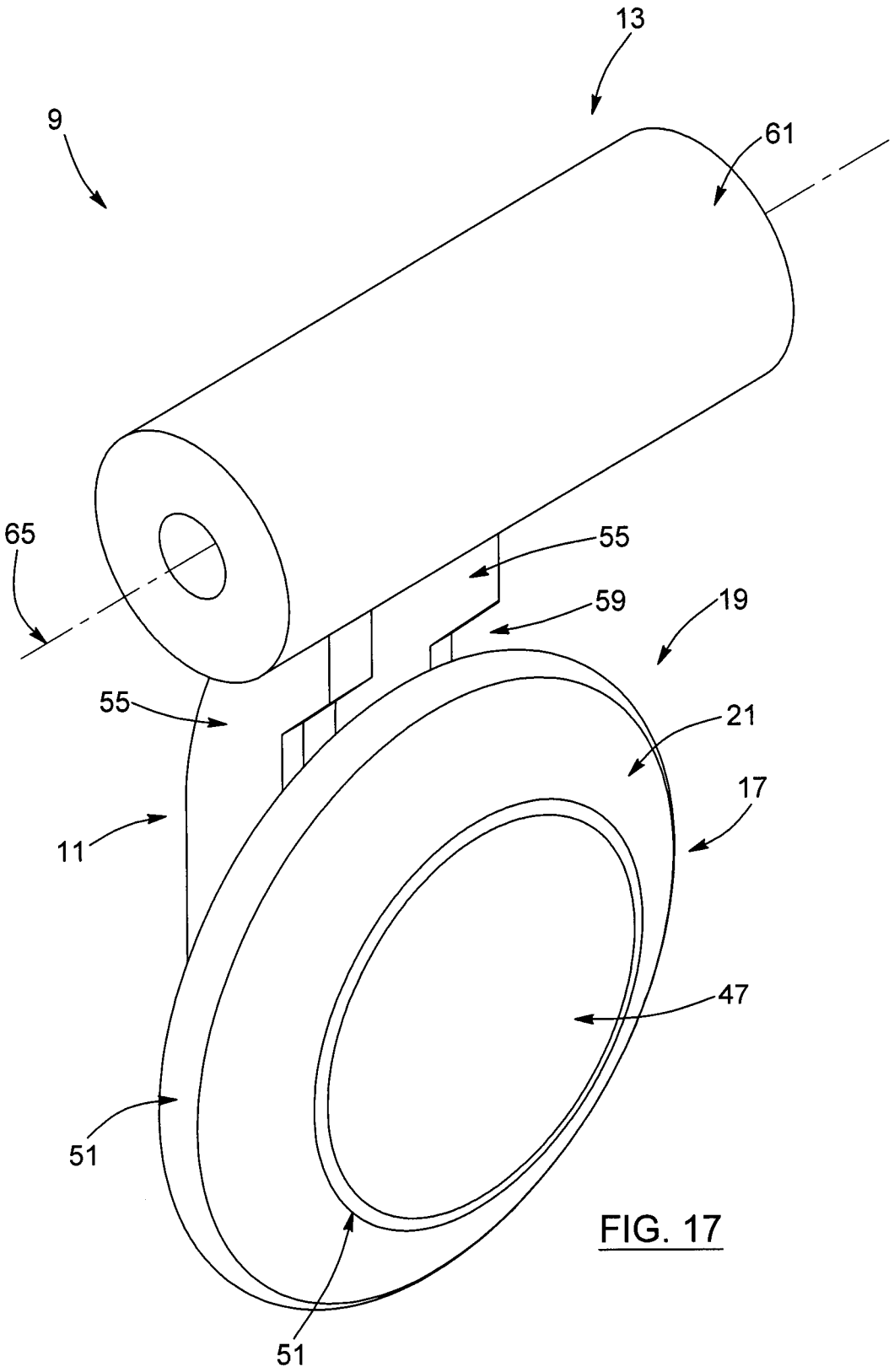

FIG. 17

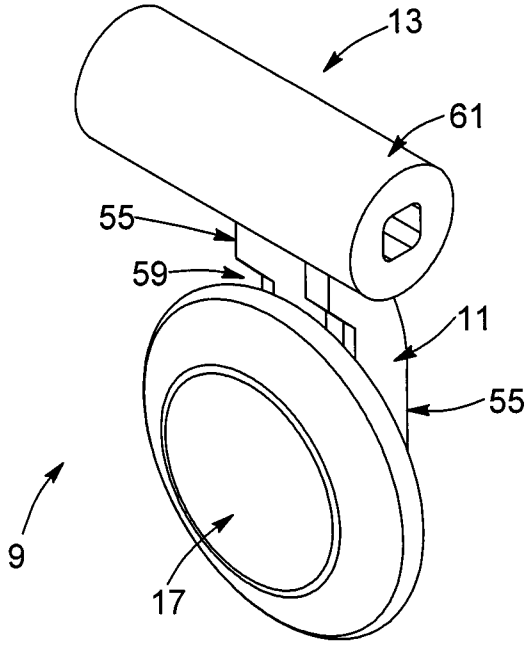

FIG. 18

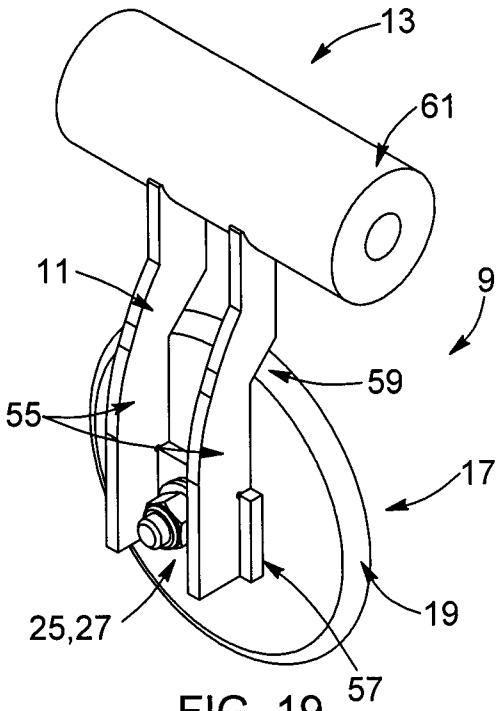

FIG. 19

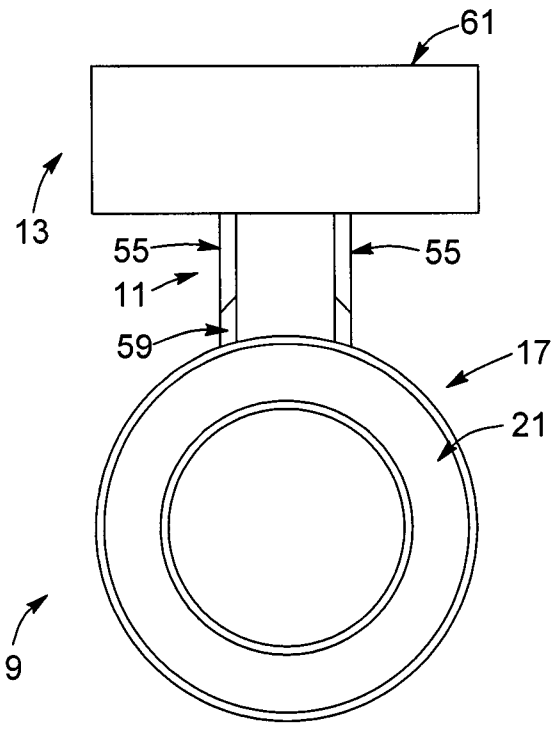

FIG. 20

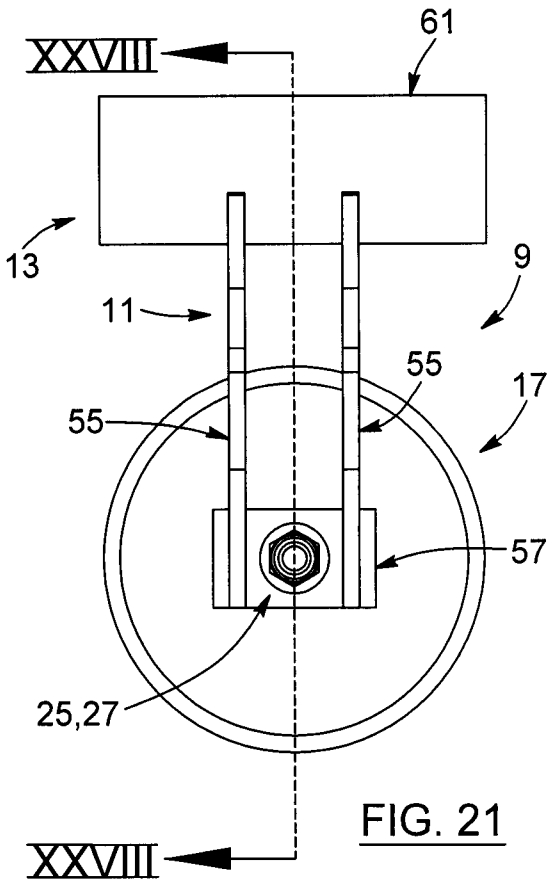

FIG. 21

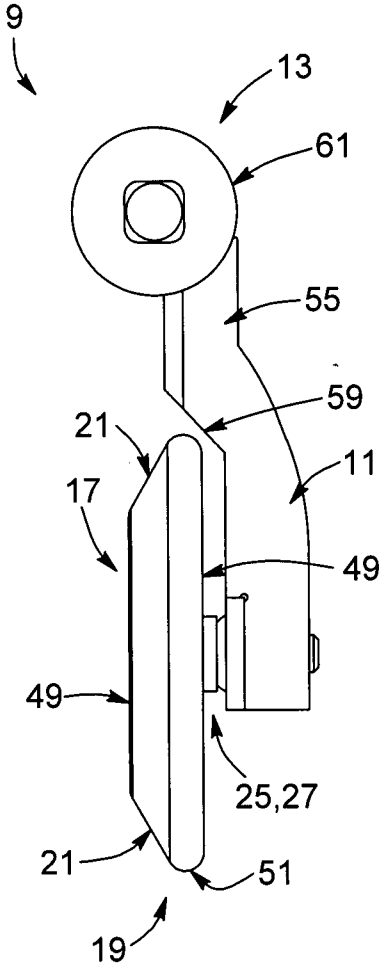

FIG. 22

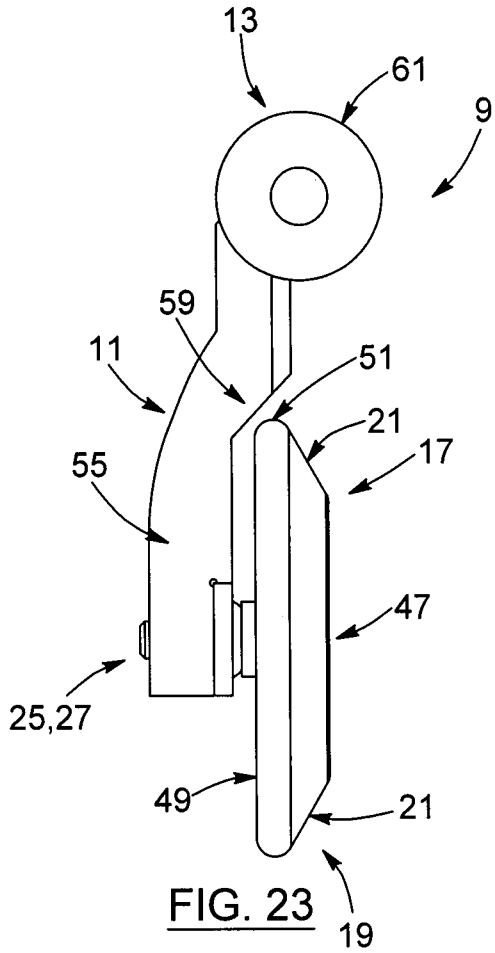

FIG. 23

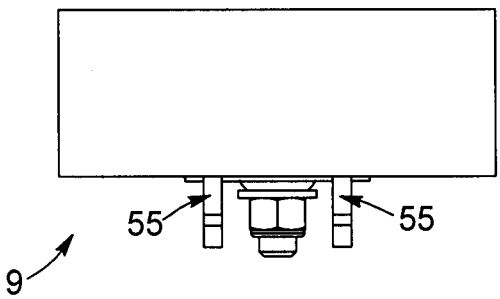

FIG. 24

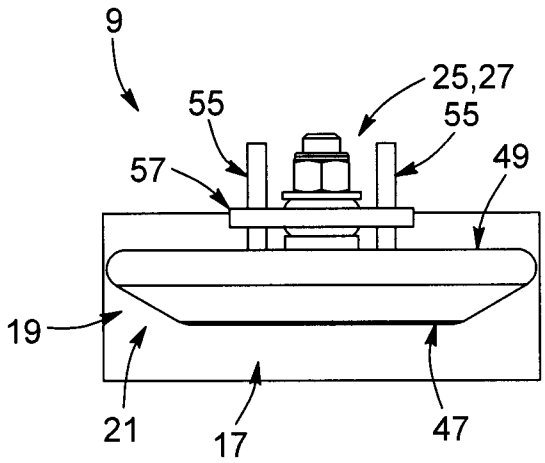

FIG. 25

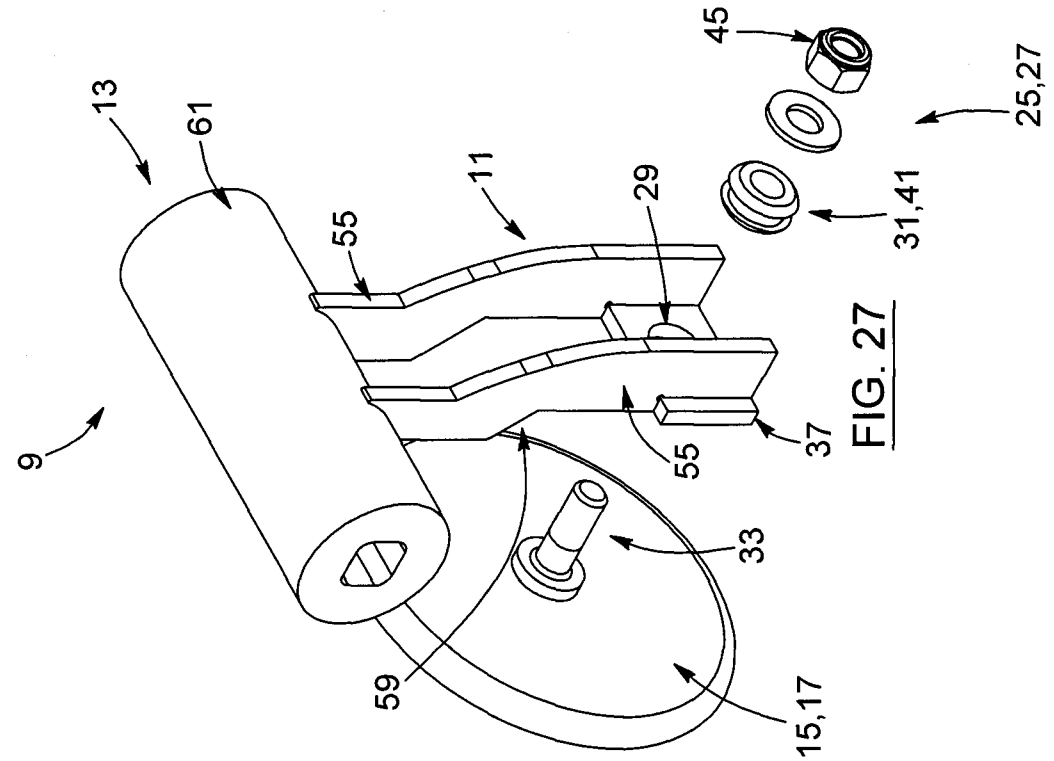
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FIG. 27

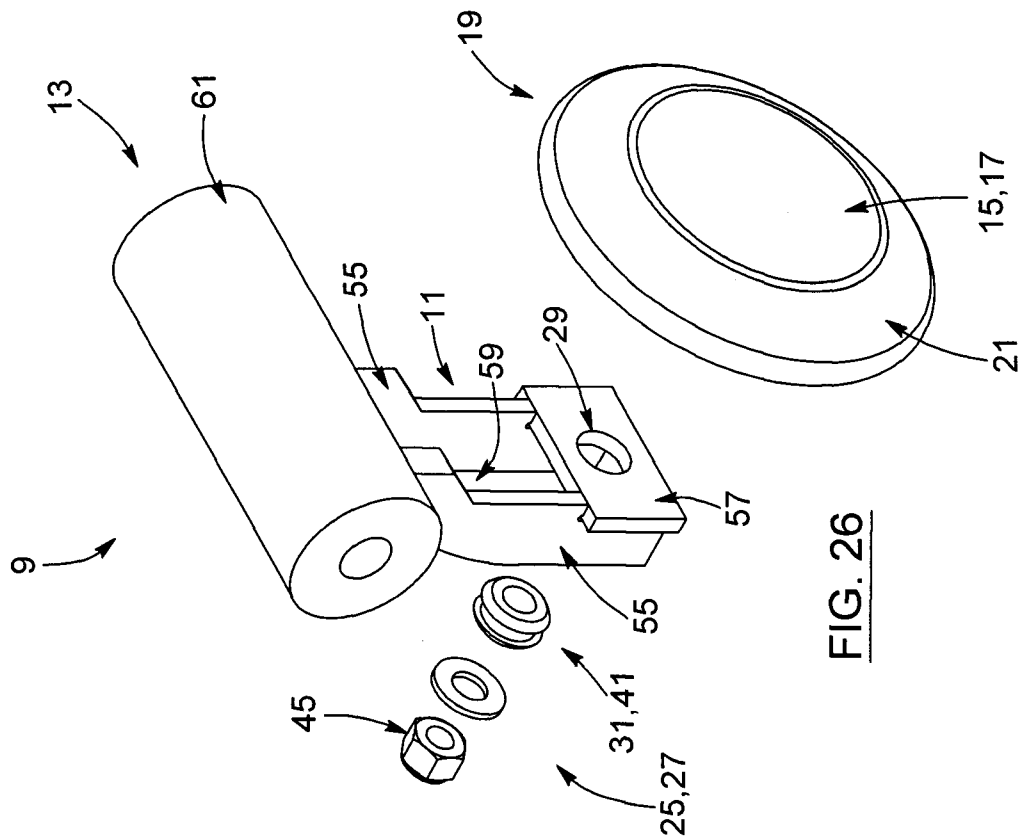
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FIG. 26

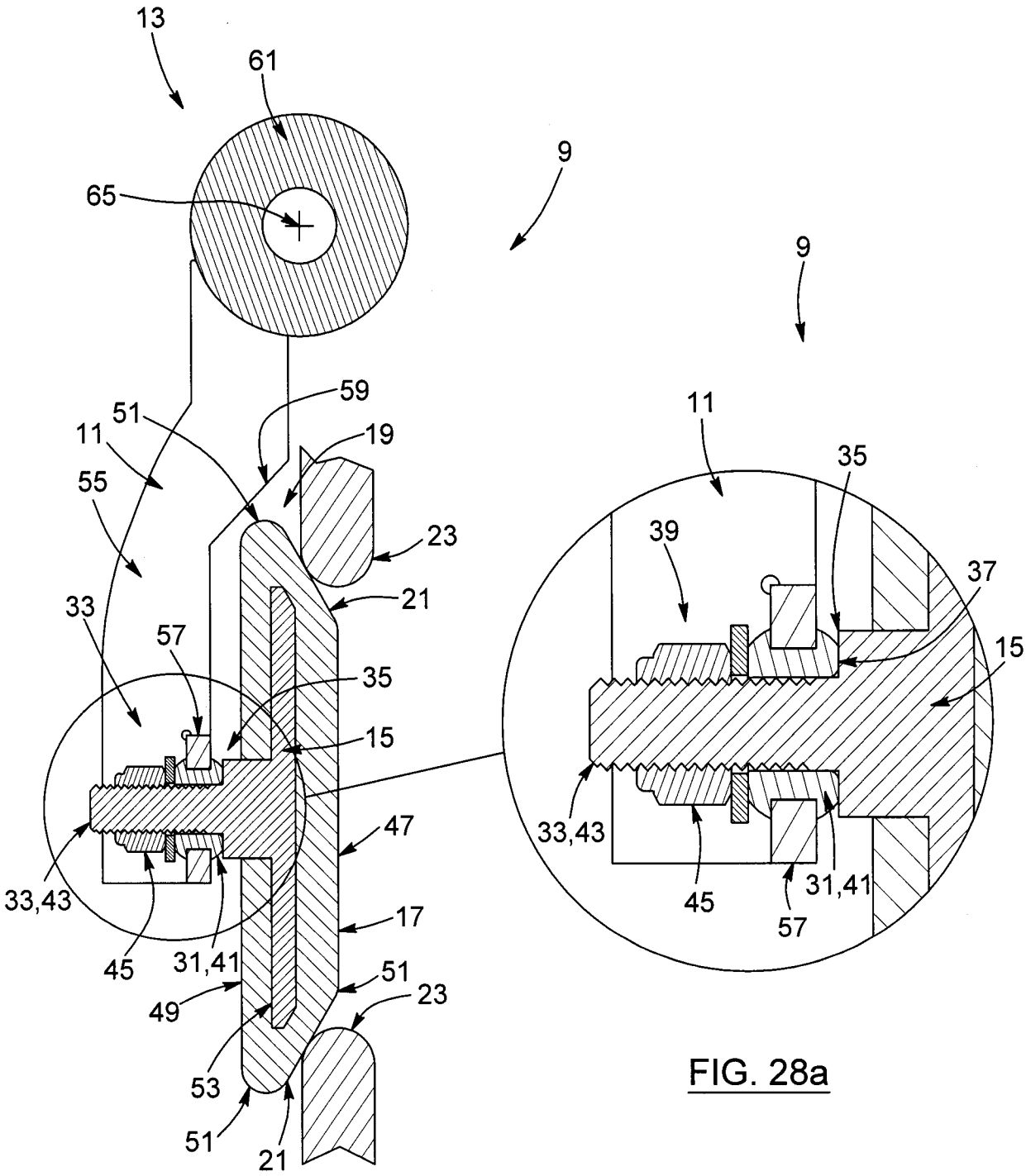

FIG. 28

FIG. 28a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2011/000899

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***F16K 1/36*** (2006.01) , ***F04B 15/02*** (2006.01) , ***F04B 53/10*** (2006.01) , ***F16K 1/20*** (2006.01) , ***F16K 15/03*** (2006.01) , ***F16K 25/04*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: ***F16K 1/36*** (2006.01) , ***F04B 15/02*** (2006.01) , ***F04B 53/10*** (2006.01) , ***F16K 1/20*** (2006.01) , ***F16K 15/03*** (2006.01) , ***F16K 25/04*** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Epodoc; Search terms considered for use in combination: twin vertical piston pump pressure seal solids liquid check valve tapered flexible manure dung swing reinforcement endo/exo skeleton hinge embedded tilt hybrid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 1352735 A; (EGERTON); 14 SEP 1920 (14-08-1920) Entire document	Claims 1 to 50
A	US 3310277 A; (NIELSON et al.); 21 MAR 1967 (21-03-1967) Entire document	Claims 1 to 50
A	US 4129144 A; (ANDERSSON et al.); 12 DEC 1978 (12-12-1978) Entire document	Claims 1 to 50
A	US 4757974 A; (WARD et al.); 19 JUL 1988 (19-07-1988) Entire document	Claims 1 to 50
A	GB 2078909 A; (IQBAL); 13 JAN 1982 (13-01-1982) Entire document	Claims 1 to 50
A	JP 2001 004053 A; (HITOSHI et al.); 09 JAN 2001 (09-01-2001) Entire document	Claims 1 to 50

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

"P" document published prior to the international filing date but later than the priority date claimed

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2011 (31-10-2011)	8 November 2011 (08-11-2011)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Steven A. Menyhart (819) 994-5348

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009 281496 A; (OSAMU); 03 DEC 2009 (03-12-2009) Entire document	Claims 1 to 50

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2011/000899

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US1352735A	14 September 1920 (14-09-1920)	None	
US3310277A	21 March 1967 (21-03-1967)	AT248814B	25 August 1966 (25-08-1966)
		BE650162A	
		CH409559A	15 March 1966 (15-03-1966)
		DE1218243B	02 June 1966 (02-06-1966)
		DK117809B	01 June 1970 (01-06-1970)
		DK117809C	29 December 1975 (29-12-1975)
		GB1036968A	20 July 1966 (20-07-1966)
		NL6407601A	07 January 1965 (07-01-1965)
		SE302226B	08 July 1968 (08-07-1968)
US4129144A	12 December 1978 (12-12-1978)	CA1074660A1	01 April 1980 (01-04-1980)
US4757974A	19 July 1988 (19-07-1988)	US4757974A	19 July 1988 (19-07-1988)
		US4849041A	18 July 1989 (18-07-1989)
GB2078909A	13 January 1982 (13-01-1982)	GB2078909A	13 January 1982 (13-01-1982)
		GB2078909B	21 December 1983 (21-12-1983)
JP2001004053A	09 January 2001 (09-01-2001)	None	
JP2009281496A	03 December 2009 (03-12-2009)	None	