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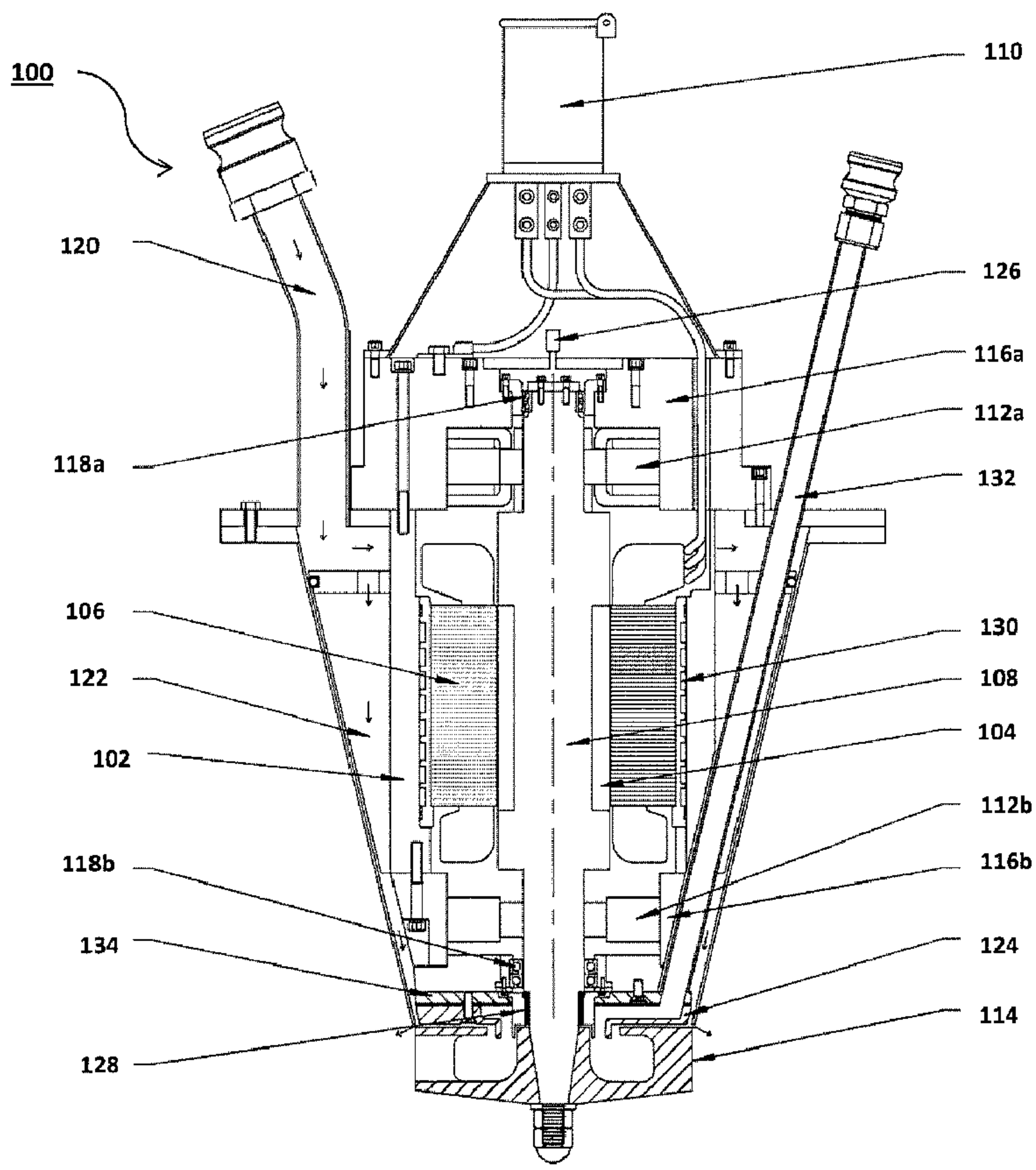
(54) **Titre : ATOMISEUR ROTATIF COMPORTANT DES PALIERS ELECTROMAGNETIQUES ET UN ROTOR A AIMANT PERMANENT**

(54) **Title: ROTARY ATOMIZER HAVING ELECTRO-MAGNETIC BEARINGS AND A PERMANENT MAGNET ROTOR**



(57) **Abrégé/Abstract:**

An improved rotary disc atomizer for use in, for example, spray dryers or congealers is disclosed. The rotary disc may be directly mounted to the shaft of a high-speed electrical motor. The high-speed electrical motor comprises a permanent magnet rotor and

(57) **Abrégé(suite)/Abstract(continued):**
electro-magnetic bearings. The electro-magnetic bearings may be supported by one or more upper/lower bearing housings and used to enable frictionless support of the shaft/rotor and rotary disc. The atomizer system may further comprise a gas distributor enabled to dynamically adjust the velocity at which the gas leaves the radial vanes and meets with the atomized droplets.

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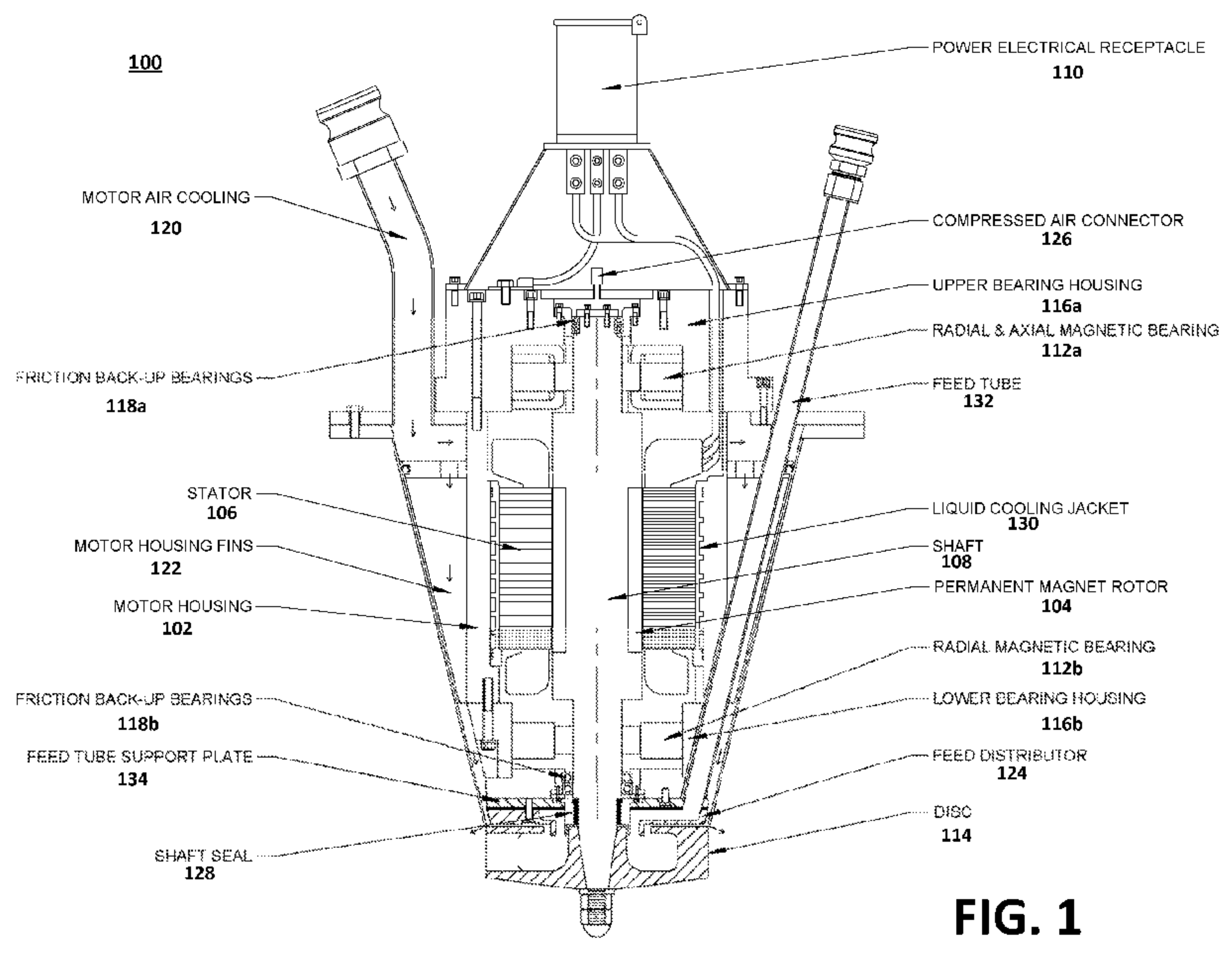

FIG. 1

(57) Abstract: An improved rotary disc atomizer for use in, for example, spray dryers or congealers is disclosed. The rotary disc may be directly mounted to the shaft of a high-speed electrical motor. The high-speed electrical motor comprises a permanent magnet rotor and electro-magnetic bearings. The electro-magnetic bearings may be supported by one or more upper/lower bearing housings and used to enable frictionless support of the shaft/rotor and rotary disc. The atomizer system may further comprise a gas distributor enabled to dynamically adjust the velocity at which the gas leaves the radial vanes and meets with the atomized droplets.

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ROTARY ATOMIZER HAVING ELECTRO-MAGNETIC BEARINGS AND A PERMANENT MAGNET ROTOR

TECHNICAL FIELD

[0001] The present invention relates generally to rotary disc atomizers for use in spray dryers or congealers, and more specifically to rotary atomizers having electro-magnetic bearings and/or a permanent magnet rotor. The present invention also relates to systems, methods, and apparatuses for adjusting gas stream velocity during atomizer use and, more specifically, to systems, methods, and apparatuses for dynamically adjusting gas stream velocity.

BACKGROUND

[0002] Spray drying is a method of producing dry powder/particles from a slurry or solution liquid by rapidly drying the liquid with a hot gas stream. Spray drying is the preferred method of drying many thermally sensitive materials such as foods and pharmaceuticals. A consistent particle size distribution is a reason for spray drying some industrial products, such as catalysts and other chemicals. Typically, air is the heated drying medium; however, nitrogen may be used if the liquid being atomized is a flammable solvent (e.g., ethanol) or if the product is oxygen-sensitive.

[0003] Generally speaking, spray dryers use an atomizer or spray nozzle to disperse a liquid into a controlled-drop-size spray. Common types of nozzle used in spray drying include rotary disc and single-fluid pressure swirl nozzles. Alternatively, for some applications, two-fluid or ultrasonic nozzles may be used. Depending on the process and/or product needs, drop sizes from 10 to 500 micrometers may be achieved with the appropriate choices. However, common applications are often in the 100 to 200 micrometer diameter range.

[0004] A hot, drying gas stream (e.g., air, nitrogen, etc.) may be passed as a co-current or counter-current flow to the atomizer direction. The co-current flow method enables the particles to have a lower residence time within the system, and the particle separator (typically a cyclone device) operates more efficiently. The counter-current flow method enables the particles to have a greater residence time in the chamber and usually is paired with a fluidized bed system.

[0005] A nano spray dryer offers new possibilities in the field of spray drying. It allows production of particles in the range of 300 nm to 5 µm with a narrow size distribution. High yields are produced-up to 90%-and the minimum sample amount is 1 ml. In the past, the limitations of spray drying were the particle size (minimum 2 micrometers), the yield (maximum around 70%), and the sample volume (minimum 50 ml for devices in lab scale). Recently, minimum particle sizes have been reduced to 300 nm, yields up to 90% are possible, and the sample amount can be as small as 1 ml. These expanded limits are possible due to new technological developments to the spray head, the heating system, and the electrostatic particle collector. To emphasize the small particle sizes possible with this new technology, it has been described as "nano" spray drying. However, the smallest particles produced are typically in the sub-micrometer range common to fine particles rather than the nanometer scale of ultrafine particles.

[0006] Numerous attempts have been made over the years to improve rotary atomizer performance. For example, U.S. Patent No. 7,611,069 to Clifford, et al., entitled "Apparatus and Method for a Rotary Atomizer with Improved Pattern Control," discloses an apparatus and method for forming and controlling a pattern for spraying surfaces with a fluid using a rotary atomizer spray head having an air shaping ring with shaping air nozzles inclined in a direction of rotation of a bell cup to direct the air onto the cup surface near the cup edge. U.S. Patent No. 7,344,092 to Kim, entitled "Rotary Atomizer, And Air Bearing Protection System For Rotary Atomizer," discloses a rotary atomizer and an air-bearing protection system for the rotary atomizer to reduce the manufacturing cost. Kim recognizes that high-speed rotation generates a lot of heat and load upon the atomizer during continuous operation. In order to remove this heat, lubricating equipment is commonly used, which leads to complexity in the system structure and consequently to difficulties in maintenance and an increase in the manufacturing cost.

[0007] U.S. Patent No. 6,551,402 to Renyer, et al., entitled "Rotary Atomizer," discloses a system utilizing a rotary atomizer for applying a liquid-based substance to particles. Renyer recognizes that rotary atomizers typically require a high-speed rotational force within the vicinity of moving particles (as with a continuous flow process) and that machinery that utilizes rotary atomizers can be somewhat complicated, requiring several moving parts which can be subject to frequent breakdowns.

[0008] Despite the various advancements in and array of existing atomizers and atomizing systems, current technology still requires regular maintenance and repair, leading to unnecessary repair cost and downtime. Thus, a need exists for an improved rotary atomizer and atomizing system that requires minimal maintenance while yielding increased revolutions per minute ("RPM") and providing the ability to direct and adjust gas stream velocity.

SUMMARY OF THE INVENTION

[0009] The present application discloses a system and method for improving rotary atomizer reliability while producing increased RPM to yield an increased disc speed. The present application also discloses a system and method for providing the ability to dynamically direct and adjust gas stream velocity.

[0010] According to a first aspect of the present invention, a rotary atomizer comprises an electric motor having a stator and a permanent magnet rotor enabled to output a rotating force; a shaft vertically installed and having a desired length, the shaft capable of being rotated by the rotating force; one or more magnetic bearings for enabling frictionless radial and axial support of the shaft; and a rotating disc installed at a lower end of the shaft for spraying liquid in the form of fine particles.

[0011] In some aspects of the present invention, the rotary atomizer may further comprise cooling fins for directing cooling air from a blower across the stator to pick up heat dissipated by the stator. The cooling air may be expelled from the rotary atomizer through an annulus gap between the rotating disc and a feed distributor. Furthermore, the rotary atomizer's electric motor may be enabled to rotate the shaft at a speed allowing for disc peripheral tip speeds in excess of 900 feet per second ("ft/s"). For example, a 12-inch diameter disc could be rotated at about 18,000 RPM to yield a speed of about 940 ft/s. The rotary atomizer may further comprise a compressed air connector for receiving compressed air to be diverted into gaps between the shaft and the one or more magnetic bearings and/or to a liquid cooling jacket for removing excess electrical heat from the stator. A rotary atomizer may further comprise friction back-up bearings enabled to impede the shaft's rotation in the event of loss of magnetic levitation.

[0012] According to a second aspect of the present invention, an atomizer system comprises an adjustable outer cone; a fixed inner cone configured to receive an atomizer; a chamber; and one or more adjustable vertical members coupled to one or more height actuators for dynamically adjusting the adjustable outer cone. In some aspects, the atomizer system may further comprise one or more radial swirl vanes.

[0013] According to a third aspect of the present invention, a method for atomizing slurry material comprises feeding slurry material to a rotary atomizer, wherein the rotary atomizer comprises an electric motor enabled to rotate a shaft at a certain speed (this depends on the size of the disc; a small 8-inch diameter disc will need to rotate at 26,000 RPM); using the rotary atomizer to output the liquid material in the form of atomized droplets; and circulating the atomized droplets with process gas to produce substantially dry particles. In some aspects, the method may further comprise the step of dynamically adjusting gas stream velocity using at least one vertical member coupled to an actuator.

[0014] In certain aspects of the present invention, the adjustable outer cone may be dynamically adjusted to yield a first gas stream having a first velocity and a second gas steam having a second velocity that is greater than the first velocity. The one or more height actuators may comprise an actuator(s) chosen from a group consisting of (i) electric actuators; (ii) hydraulic actuators; (iii) pneumatic actuators; (iv) manual actuators; and (v) combinations thereof. The atomizer may be a rotary atomizer comprising a permanent magnet rotor and/or one or more electro-magnetic bearings enabled to provide frictionless radial and axial support of the shaft.

DESCRIPTION OF THE DRAWINGS

[0015] These and other advantages of the present invention will be readily understood with reference to the following specifications and attached drawings wherein:

[0016] Figure 1 is a cutaway side view of a rotary atomizer according to the present invention; and

[0017] Figure 2 is a cutaway side view of an exemplary apparatus utilizing a rotary atomizer according to the present invention.

DETAILED DESCRIPTION

[0018] Preferred embodiments of the present invention will be described hereinbelow with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail because they may obscure the invention in unnecessary detail. The present application discloses systems, methods, and apparatuses for improving rotary atomizer reliability while yielding higher RPM to yield an increased disc speed. The present application also discloses a system and method for providing the ability to dynamically direct and adjust gas stream velocity.

[0019] Figure 1 illustrates an exemplary rotary atomizer system **100** having improved reliability and enabled to yield increased RPM and disc speed. Rather than employing an induction rotor such as those used in existing rotary atomizer systems, the rotary atomizer system **100** uses an electric motor having a permanent magnet rotor **104**, resulting in a more efficient motor requiring less physical space for a given power output. The electric motor, which receives power via the power electrical receptacle **110**, generally comprises a motor housing **102**, permanent magnet rotor **104**, a stator **106**, and a shaft **108**. A smaller motor size typically allows for closer proximity of the disc to the lower motor bearing. For example, the motor of the present invention is preferably between about 10 inches by 10 inches through about 72 inches by 72 inches. More preferably, the motor can be approximately 25 inches by 25 inches through about 45 inches by 45 inches. Most preferably, the motor can be about 30 inches by 36 inches. In a preferred embodiment, the motor is about 30 inches by 36 inches, has a power of approximately 330 horsepower, and has internal discs capable of spinning around 16,000 RPM. The motor is preferably constructed with aluminum which is both resistant to corrosion and a good dissipater of heat. Other materials such as stainless steel, or other metals or plastics are envisioned. As a result of the ability to have closer proximity, a motor can operate throughout its speed range while remaining below the first critical speed of the shaft. Rotating shafts, even in the absence of an external load, can deflect during rotation. The combined weight of a shaft and disc can cause deflection that often creates resonant vibration above a certain speed, known as the critical speed. Thus, to function properly, the motor should be operated at speeds less than the critical speed. Also, this motor configuration permits use of a smaller disc diameter, which is generally less costly and easier to manipulate, leaving sufficient room around the motor for the placement of the liquid feed tube(s).

[0020] A permanent magnet rotor provides numerous advantages over its AC equivalents (e.g., induction or asynchronous motors). For instance, permanent magnet rotors generally yield a higher speed and higher torque output, while increasing power efficiency by eliminating the need for unnecessary current that would otherwise flow through the rotor windings of traditional induction motors. Another benefit attributed to the use of permanent magnet rotors is increased power density (i.e., the power that may be extracted from a given space). Generally speaking, a permanent magnet motor typically produces as much as 30% to 40% more power density than a conventional and similar-sized AC asynchronous motor. An increase in power density provides the opportunity to increase performance without requiring additional space for a larger motor or, alternatively, to reduce the motor size and weight while maintaining the original performance. Decreasing motor power size and consumption can lead to lower operating temperatures, thus reducing the efforts needed to cool the motor and/or motor system.

[0021] The electric motor system may further employ one or more electro-magnetic bearings **112a**, **112b**, which may be supported by one or more upper/lower bearing housings **116a**, **116b** to enable frictionless support of the shaft **108**, rotor **104**, and disc **114**. However, in certain embodiments, bearing housings may not be necessary. For example, a single housing may encompass both bearings and a stator. A benefit of the magnetic bearings **112a**, **112b** is that they are contactless and thus do not require lubrication or speed restrictions on the electric motor. The magnetic bearings **112a**, **112b** may also provide both primary radial and axial support for the shaft **108**, rotor **104**, and disc **114**. Therefore, the atomizer system of the present invention is able to safely operate at higher RPM to yield increased disc speeds.

[0022] The atomizer **100** may further comprise a set of friction back-up bearings **118a**, **118b** with a gap between the bearings' **118a**, **118b** inner surfaces and the shaft **108** during normal operation. In the event of loss of magnetic bearing **112a**, **112b** operation, the shaft **108** would contact the inner bearing **118a**, **118b** surfaces to bring the rotor **104** to a safe stop.

[0023] Using a permanent magnet rotor **104** in conjunction with frictionless magnetic bearings **112a**, **112b** permits the atomizer to reach greater and more favorable operating RPM speeds, thereby increasing spray drying efficiency while also reducing maintenance. A favorable operating speed (RPM) will vary depending on the size of the disc. Accordingly, discs are available in a plurality of sizes; however, smaller disc sizes may be preferable because they are generally less expensive and easier to manipulate. Therefore, the atomizer disclosed herein will be described as having a disc diameter of approximately 12.75 inches. However, it would be obvious to one having skill in the art to install a disc with a different diameter. For example, a smaller power atomizer may have an 8-inch diameter disc, and a larger unit could have a 16-inch diameter or larger disc.

[0024] As mentioned, the RPM necessary to reach a target peripheral disc tip speed will vary depending on the size of the disc being used. For example, to maintain a peripheral disc tip speed of 900 ft/s, a smaller 8-inch diameter disc will need to be rotated at 26,000 RPM while a larger 12-inch diameter disc will need to be rotated at 18,000 RPM. Due to limitations on the motors and frictional losses, current atomizers typically yield a disc peripheral tip speed only up to 800 ft/s; however, the atomizer of the present invention is advantageous in that it is capable of producing more preferable speeds without needing to employ a larger disc size (e.g., speeds greater than 800 ft/s; more preferably, greater than 900 ft/s; even more preferably, 900–1,125 ft/s). For instance, a peripheral disc tip speed of 1,000 ft/s may be readily ascertained using the system of the present invention by rotating a 12.75-inch disc at a speed of about 18,000 RPM. Similarly, a peripheral disc tip speed of 1,100 ft/s may reached by rotating a 12.75-inch disc at a speed of about 19,800 RPM or, alternatively, by rotating a 16-inch diameter disc at about 15,750 RPM. These higher rotational speeds permit higher throughput for a given-diameter disc and achieve smaller particle sizes that do not hit and/or become deposited on the chamber walls. By adjusting disc size and RPM, a designer may achieve virtually any desired peripheral disc tip speed using the following equation, where ***TipSpeed*** is the peripheral disc tip speed in ft/s, ***D*** is the diameter of the disc in inches, and ***s*** is the RPM of the disc.

[0025]

$$TipSpeed = D(\pi)(s)\frac{1}{12} \bullet \frac{1}{60}$$

Equation 1

[0026] Electrical heat losses from the motor stator **106** may be removed and/or regulated using cooling air **120.** To promote temperature regulation, the stator housing **102** may have cooling fins **122** distributed evenly along its periphery. While the fins **122** are preferably evenly distributed, they may be adjusted to divert air to, or away from, particular areas if one area requires additional cooling. Above the fins **122** is a distributor with holes that line up with each fin cavity. Cooling air from a blower enters the distributor and exits through the holes, and then proceeds to pick up the heat dissipated into the stator housing fins **122.** The same cooling air **120,** now heated, may be directed and expelled to the outside of the atomizer cone housing through an annulus gap between the feed distributor **124** and the rotating disc **114.** The feed, which may be a slurry (e.g., particles and fluid), may be fed to the disc **114** by way of the feed tube **132.** The feed tube **132** may be supported by the feed tube support plate **134.**

[0027] The rotating disc **114** can function as a pump impeller, thus creating a suction pressure at its central annulus opening. This phenomenon has the tendency to entrain process gas along with partially dried atomized feed droplets from the surroundings. This negative effect causes feed product to deposit and build up on the disc top surface, resulting in disc imbalance and possible blockage between the disc top surface and the feed distributor bottom surface, and preventing the disc from rotating properly.

[0028] Therefore, the cooling air **120** may serve a second function of acting as a clean gas barrier between the suction pressure of the disc **114** and the atomized droplets, thus preventing the ingress of particles while supplying the rotating disc **114** with clean air.

[0029] An alternative, or supplemental, motor cooling method may be to have a coolant passage jacket **130** surrounding the stator **106**, whereby coolant may be supplied either as a once-through or as a recirculated loop with a heat exchanger to remove the excess electrical heat from the stator.

[0030] Further cooling of the motor may be accomplished by supplying cooled compressed air (or air from a high-pressure blower) into the gaps between the shaft **108** and magnetic bearings **112a**, **112b**, and the rotor **104** and stator **106**. This air may be introduced at the top of the motor assembly via an air connector **126** and may be expelled at the bottom through a labyrinth shaft seal **128** and into the disc **114**. This now pressurized non-contact shaft seal **128** prevents the ingress of liquid feed from the disc **114** into the motor cavity.

[0031] Referring now to the system **200** of Figure 2, the atomizer **100** of Figure 1 may be positioned in the fixed inner cone **212** at the center of a gas distributor **202** to evenly distribute either heated or cooled process gas around the atomized droplets **204** produced by the rotating disc. Because the atomizer **100** of Figure 1 may be constructed to be the same size and dimension of more traditional atomizers, the atomizer **100** may be coupled to existing gas distributors **202**, thereby enabling users to easily upgrade existing atomizer systems without the need to make modifications. Included as part of this distributor **202** of Figure 2 is a series of radial vanes **206** that can impart a swirl pattern to the process gas **208a**, **208b**. The swirl pattern may be used to ensure proper flow patterns of the gas and droplets through the spray chamber. A notable design parameter in an air distributor system of Figure 2 is the ability to dynamically adjust the velocity at which the gas stream leaves the radial vanes **206** and meets with the atomized droplets **204**. For example, a low gas velocity **208a** could allow for larger droplets to travel in a more horizontal trajectory and hit the wall, whereas a high gas velocity **208b** could have the opposite effect of forcing the gas along with the droplets in a downward trajectory, keeping the walls clean, but considerably reducing the residence time (i.e., the amount of time the particles are airborne) in the chamber **210**.

[0032] Determination of the appropriate gas velocity is dependent upon the nature of the feed and the size of the droplets required. In prior systems, changing the gas velocity required physical removal and replacement of components in the gas distributor. However, as disclosed herein, the process gas velocity may be dynamically adjusted while the spray dryer/congealer is in operation, allowing for immediate feedback with no equipment downtime. For instance, an ideal gas velocity would typically be the minimum velocity required, for a desired particle size, to disperse the particles into a chamber without hitting the walls. The dynamic adjustments may be either manually triggered by a user (e.g., one monitoring the system) or controlled by a computer system that measures one or more system parameters and responds by adjusting the gas velocity pursuant to a computer algorithm.

[0033] The radial vanes **206** may be repositioned from their normal conical discharge section to a cylindrical section above, thus allowing the process gas to exit through two concentric cones. The inner cone is fixed **212** and may be used to support the atomizer **100** and is typically insulated to prevent the often high temperatures of the gas from affecting the atomizer casing. The outer cone **214** serves to contain the process gas and define its velocity by the cross-sectional area between the two cones. This outer cone may be supported by a series of vertical members **216** that can be varied in height (i.e., lengthwise), thereby changing the vertical position of the outer cone **214** with respect to the fixed inner cone **212.** This in turn will vary the cross-sectional area between the two cones and ultimately vary the velocity of the process gas. A smaller cross-sectional area will typically produce a higher gas velocity **208b,** while a larger area will result in a lower gas velocity **208a.**

[0034] Vertical members **216** may be adjusted using one or more height actuators **218.** The actuators **218** may be operated, for example, using electric current, hydraulic fluid pressure, or pneumatic pressure or may be operated manually. In applications where adjustment precision is necessary, position feedback elements may be used to actuate vertical members **216** to a predetermined desired position for a particular product.

[0035] Although various embodiments have been described with reference to a particular arrangement of parts, features, and the like, these are not intended to exhaust all possible arrangements or features, and indeed many other embodiments, modifications, and variations will be ascertainable to those of skill in the art. Thus, it is to be understood that the invention may be practiced otherwise than as specifically described in the detailed description of the preferred embodiments, in keeping with the scope of the description and claims as a whole.

What is claimed is:

1. A rotary atomizer comprising:

an electric motor, said electric motor having a stator and a permanent magnet rotor, wherein said permanent magnet rotor is configured to output a rotational force;

a shaft vertically installed, the shaft configured to be rotated by the rotational force;

one or more magnetic bearings, said one or more magnetic bearings configured to provide frictionless radial and axial support to the shaft;

a rotating disc installed at a lower end of the shaft, said rotating disc configured to spray liquid into the form of fine particles; and

an air connector, wherein the air connector receives air to be diverted into one or more gaps between the shaft and the one or more magnetic bearings.

2. The rotary atomizer of claim 1 further comprising one or more cooling fins, wherein the one or more cooling fins direct cooling air from a blower across the stator.

3. The rotary atomizer of claim 2, wherein the cooling air is expelled outside of the rotary atomizer through an annulus gap between the rotating disc and a feed distributor.

4. The rotary atomizer of any one of claims 1 to 3, wherein the electric motor is configured to rotate the shaft to yield a disc peripheral tip speed of between 800 and 1125 ft/sec.

5. The rotary atomizer of any one of claims 1 to 4, wherein the air connector receives compressed air.

6. The rotary atomizer of any one of claims 1 to 5 further comprising a liquid cooling jacket in thermal communication with the stator.

7. The rotary atomizer of any one of claims 1 to 6 further comprising one or more friction back-up bearings.

8. An atomizer system comprising:

an adjustable outer cone;

a rotary atomizer having a permanent magnet rotor;

a fixed inner cone, said fixed inner cone configured to receive the atomizer;

a chamber; and

one or more adjustable vertical members, each of said one or more adjustable vertical members coupled to one or more height actuators, said one or more height actuators configured to dynamically adjust the adjustable outer cone,

wherein the adjustable outer cone, when dynamically adjusted, yields a first gas stream having a first velocity and a second gas steam having a second velocity, the second velocity being different from the first velocity.

9. The atomizer system of claim 8, wherein at least one of the one or more height actuators is an actuator selected from a group consisting of: (i) electric actuators; (ii) hydraulic actuators; (iii) pneumatic actuators; and (iv) manual actuators.

10. The atomizer system of claim 8 or 9, wherein the rotary atomizer has a shaft and one or more electro-magnetic bearings configured to provide frictionless radial and axial support to the shaft.

11. The atomizer system of any one of claims 8 to 10 further comprising one or more radial swirl vanes.

12. A method for atomizing liquid material comprising:

feeding the liquid material to a rotary atomizer having a permanent magnet rotor, wherein the rotary atomizer comprises an electric motor configured to rotate a shaft;

using the rotary atomizer to output the liquid material in the form of atomized droplets;

circulating the atomized droplets with a process gas stream to produce substantially dry particles; and

dynamically adjusting said process gas stream's velocity using an adjustable outer cone operatively coupled with an actuator.

13. The method of claim 12, wherein the electric motor is configured to rotate the shaft to yield a disc peripheral tip speed between 800 and 1125 ft/sec.

14. The method of claim 12 or 13, wherein the rotary atomizer comprises one or more magnetic bearings.

15. The rotary atomizer of any one of claims 1 to 7, wherein at least one of said one or more magnetic bearings is an electro-magnetic bearing.

16. The rotary atomizer of claim 5, wherein said compressed air is cooled compressed air.

17. The rotary atomizer of claim 7, wherein said one or more friction back-up bearings is configured to impede the shaft's rotation upon failure of at least one of said one or more magnetic bearings.

18. The method of claim 17, wherein at least one of said one or more magnetic bearings is an electro-magnetic bearing.

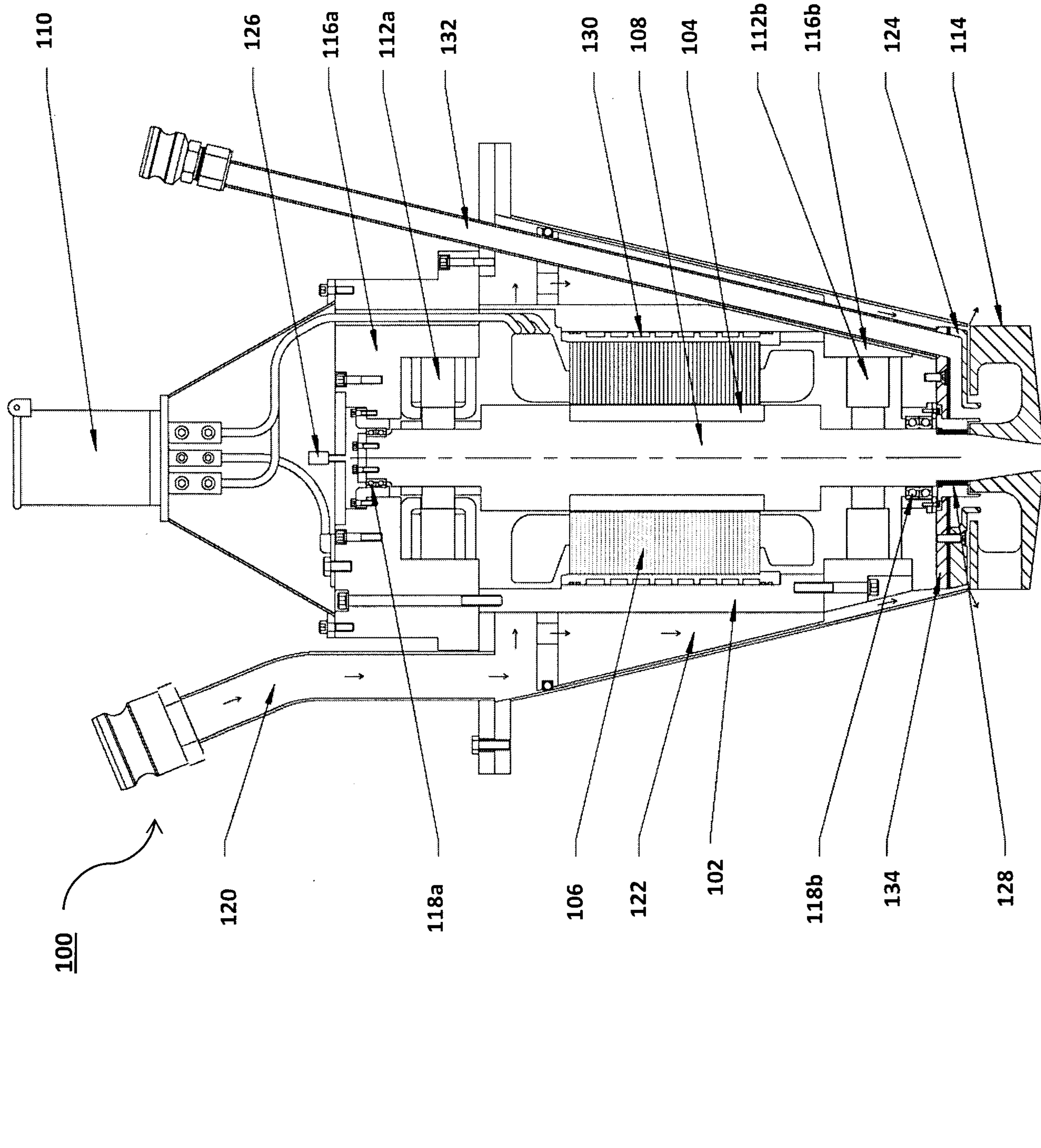

100
110
126
116a
112a
132
130
108
104
112b
116b
124
114
120
118a
106
122
102
118b
134
128

FIG. 1

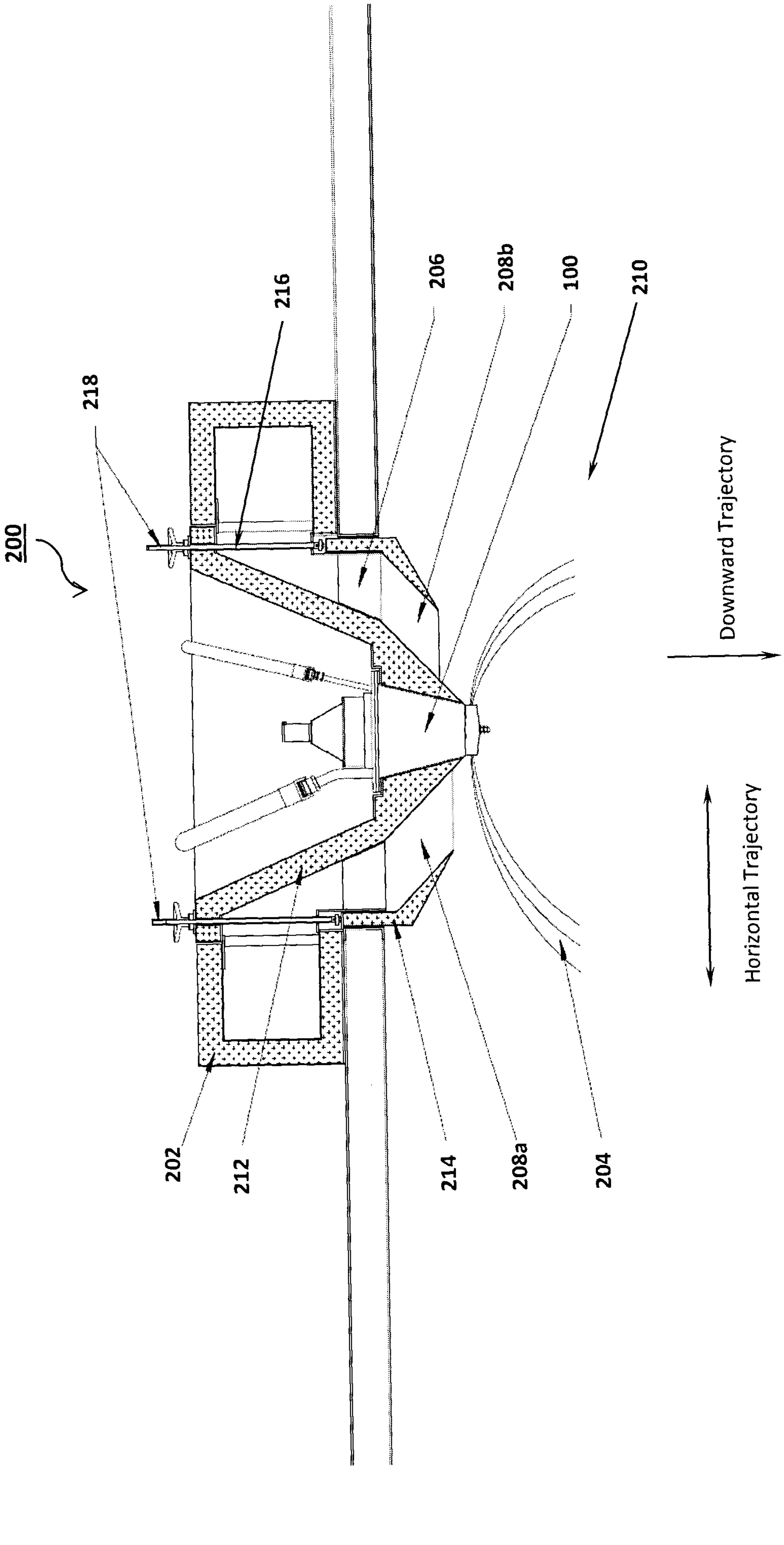
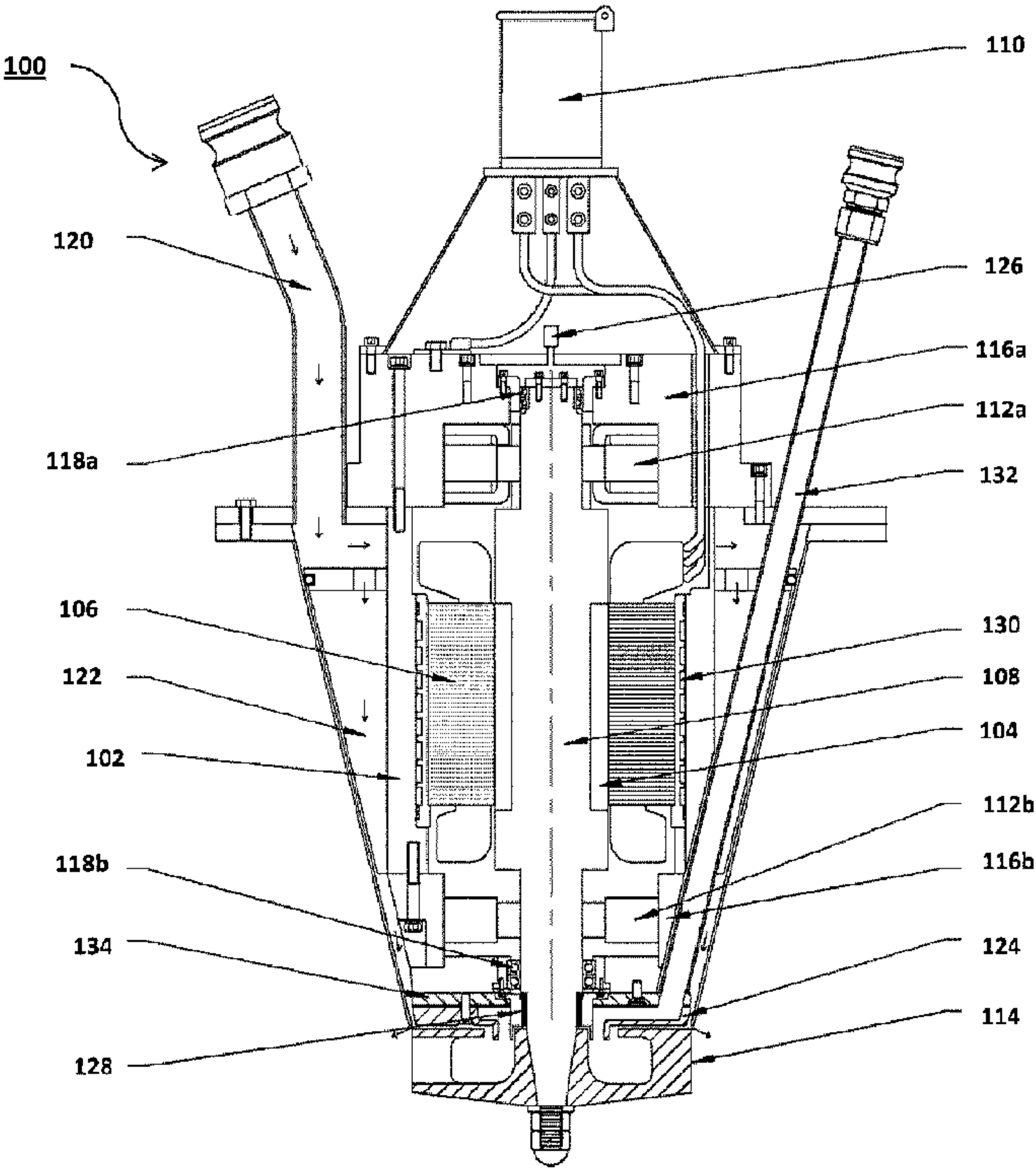

200
218
216
206
208b
100
210
Downward Trajectory
Horizontal Trajectory
202
212
214
208a
204

FIG. 2



100
110
120
126
116a
112a
118a
132
106
130
122
108
104
102
112b
118b
116b
134
124
114
128