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(54) Title: ROTARY COMPRESSOR HAVING A DISCHARGE VALVE ASSEMBLY

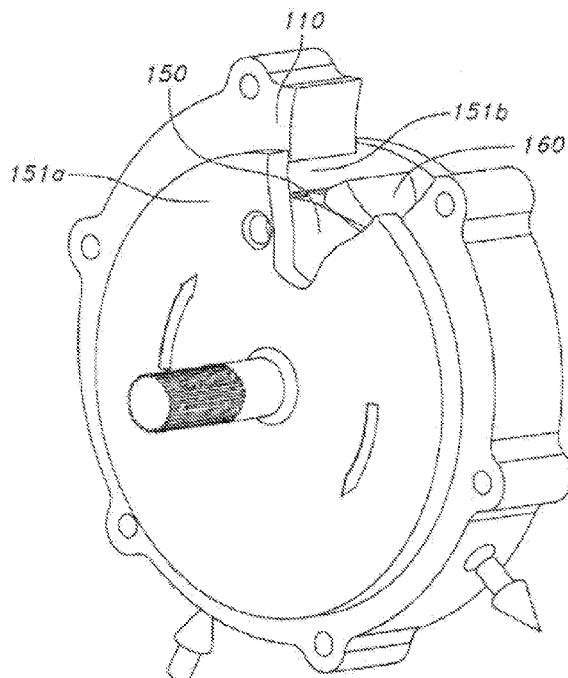


FIG. 1

(57) Abstract: A rotary compressor having a housing and a rotor positioned within an internal cavity of the housing is provided that is configured to rotate about a rotor axis of rotation eccentric to a housing longitudinal axis. A vane is also provided that is slidably mounted with the rotor and movable axially about and between a first position, in which a distal end of the vane is positioned at a first distance from the peripheral surface of the rotor, and a second position, in which the distal end of the vane is positioned at a second distance from the peripheral surface of the rotor. The distal end of the vane is constrained to be spaced proximate from the inner wall surface of the housing as the rotor rotates about the rotor axis of rotation.



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ROTARY COMPRESSOR HAVING A DISCHARGE VALVE ASSEMBLY

Field of Use

[0001] According to various aspects, a rotary compressor is provided. More particularly a rotary compressor is provided having a rotor housing assembly comprising at least one valve cavity having a corresponding at least one discharge valve assembly disposed therein.

Background

[0002] Various vane-type fluid displacement apparatuses have been proposed for use in certain limited applications. These proposed devices have primarily consisted of pumps, compressors, fluid driven motors, and fluid flow meters. The vane-type apparatuses heretofore proposed have generally performed satisfactorily and have gained acceptance for specific liquid applications. Common difficulties encountered with prior art vane-type apparatuses have included: an unsuitability for use with friction-reducing devices, which has traditionally limited their use to moderate power levels; a large fixed-surface to moving-surface contact area, resulting in high friction; an inability to withstand bending forces applied to the crankshaft; a reliance on discrete check valves or the like; and an inability to accommodate simultaneous reciprocating flow from each individual chamber.

[0003] Conventionally, a vane or vane compressor typically includes a cam ring, a rotor rotatably received within the cam ring, a drive shaft on which is secured the rotor, a front side block fixed to a front-side end face of the cam ring, a rear side block fixed to a rear-side end face of the same, a front head secured to a front-side end face of the front side block, a rear head secured to a rear-side end face of the rear side block, a plurality of axial vane slits formed in an outer peripheral surface of the rotor at circumferentially equal intervals, and a plurality of vanes radially slidably fitted in the axial vane slits, respectively. The drive shaft for rotating the rotor has opposite ends thereof rotatably supported by radial bearings arranged in the front and rear side blocks, respectively. Typically, a discharge chamber is defined by an inner wall surface of the front head, the front-side end face of the front side block, and the front-side end face of the cam ring, into which flows a liquid or gas delivered from compression chambers.

[0004] In another example of a prior art rotary compressor, the compressor mechanism can comprise a shaft adapted to be driven by a drive motor and having its upper and lower ends rotatably received by main and auxiliary bearings, respectively. An intermediate portion of the shaft extends through a cylinder that is fixed in position inside the

sealed vessel. An eccentric portion is mounted on a portion of the shaft positioned within the cylinder for rotation together. Further, a ring-shaped roller is operatively positioned between an inner wall surface of the cylinder and an outer peripheral surface of the crank and will, while the shaft is rotatably driven, undergo a planetary motion.

[0005] In one example, the cylinder will have a radial groove defined therein so as to extend in a direction radially thereof, and a slidable radial vane is accommodated within the radial groove for movement within the radial groove in a direction towards and away from the ring shaped roller. This slidable radial vane is normally biased by a biasing spring in one direction with a radially inward end thereof held in sliding contact with an outer peripheral surface of the ring-shaped roller such that, by dividing the volume of the cylinder into volumetrically variable, suction and compression chambers are defined on leading and trailing sides of the slidable radial vane, with respect to the direction of rotation of the shaft.

[0006] In this example, a liquid or gas is sucked into the suction chamber through the intake port and then compressed before it is discharged through a discharge port during the planetary motion of the ring-shaped roller as a result of the eccentric rotation of the crank. In order to facilitate a sliding motion of the ring-shaped roller relative to the inner wall surface of the cylinder and the radial inner end of the slidable radial vane and also a sliding motion of the radial vane within the radial groove, a quantity of lubricating oil is accommodated within the sealed vessel at a bottom portion thereof. In one example, the lubricating oil is sucked up by an oil pump mounted on the lower end of the shaft to oil various sliding elements within the compressor mechanism.

[0007] In other aspects, valves can be provided to regulate the pressure in the working chamber during operation of a conventional vane pump. Conventionally, reed valves would be utilized in this application. However, reed valves suffer a number of disadvantages in such applications. Reed valves fail to minimize the space between the bottom of the valve and the working chamber. Such gaps can cause operational losses and should be minimized. Reed valves also require relatively large, flat regions be machined in an otherwise cylindrical part to be fixed to. This requirement can limit the number and angular locations of the valves that can be placed on a given vane pump design.

[0008] Thus, what is needed is a rotary compressor type device that experiences reduced frictional forces within its articulated rotary assemblies and that allows for optimal placement and sizing of valves to regulate the pressure of the working chamber. Additionally, the device should be one that can be assembled, operated, and maintained cost effectively.

SUMMARY

[0009] In various aspects, a rotary compressor is provided that more efficiently compresses a fluid, such as a liquid or gas, for a given energy input and does so with a lighter construction and improved output per cubic inch of overall size. In various aspects, the rotary compressor described with respect to various aspects herein does not rely on fixed cycle phases, eccentric shafts that induce friction, problematic compression chamber shapes, and does not tax the current state of the art in material sciences to accomplish its operational goals. It is contemplated that, in various embodiments, the device described herein can be used as a compressor for gaseous flow under pressure, or as a vacuum pump, or as a portion of a refrigeration assembly, or as a portion of a fluid power assembly, or as an expander for high pressure gases such as steam, or as a flow meter, or as a portion of an engine assembly that is constructed to operate as an internal combustion engine. In the latter example of an internal combustion engine, one skilled in the art will appreciate that how well such an engine brings in air, compresses it, captures the expansive forces, and then exhausts the burned gases, all determine the engine's relative performance and efficiency. In another aspect, the rotary compressor can be used as the compressor stage of a turbine engine as a means to achieve high pressure ratios within a small package. In other aspects, the rotary compressor can be used as the air feed compressor to a fuel cell package to supply high volumes of air at relatively low pressures. In some aspects, the rotary compressor can be configured as a supercharger for an internal combustion engine. In yet another aspect, the rotary compressor can be used as a waste heat recovery device when adapted into a bottoming cycle for known thermodynamic operations.

[0010] A rotary compressor described according to various aspects herein provides a rotational device that minimizes the conventional compressor stresses, and thus, can be made from lighter materials with fewer structural requirements. In one aspect, the rotary compressor can be configured such that the intake fluid is ingested into an expanding space created by the relative motion between one solid element and another solid element. In this aspect, both solid elements form the ends of an expanding space as at least one of the elements moves in translation with respect to multiple inner surfaces disposed concentrically to the element's motion, the inner surfaces forming a passageway for the moving element to pass through and being sealed with sealing elements such that a substantial vacuum or substantial pressure can be created within the defined chamber as the moving element translates with respect to the volume-defining inner surfaces and with respect to the other element which can be fixed or moving in a chosen manner, typically also in a concentric nature to the first moving element. By providing ports that are fluidly connected to the working chamber provided during the intake stage of the device's operation, fluid (such as a

liquid, gas such as air, or a two or three phase material) can enter into the working chamber as desired.

[0011] In another aspect, the intake tract of the rotary compressor can be configured to have low turbulence during intake chamber filling, which reduces turbulence losses and improves volumetric efficiency.

[0012] To create a functional rotary compressor, it is contemplated that in some aspects of the assembly, the opposing elements that are placed within the working chamber and are surrounded by the inner surfaces described above can move relative to each other and a port can be opened such that a liquid or gas can be allowed to enter the working chamber and at some point the port can be closed and the opposing elements moved toward each other in such a way as to reduce the volume contained within the defined space. The reduction in volume serves to increase the pressure within the defined space and, at a chosen point, a port (an additional port or the same port) can be allowed to selectively open and the pressurized liquid or gas is allowed to escape the working chamber.

[0013] In other aspects, a discharge valve assembly communicating with the working chamber can be provided that are operable to allow pressure management of the fluid contained within the working chamber without significant pressure losses. Additionally, it is contemplated that such discharge valve assemblies can also minimize the volume bounded between the valve and the working chamber as such bounded volume presents an increasing operational loss with increasing volume.

[0014] In a further aspect, the rotary compressor's rotational elements can be used to pump oil and/or coolant within the compressor without the need for auxiliary pumps, which simplifies the overall mechanical design. In another aspect, the rotary compressor may not need to use an eccentric shaft and can thus have lower frictional losses and provide a more direct conversion of the energy required to rotate the shaft into a compressed gas/liquid.

[0015] Additional advantages will be set forth in part in the description which follows, and in part will be obvious from the description, or can be learned by practice of the device described according to various aspects herein. The advantages of the device will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the device, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several aspects of the invention and together with the description, serve to explain various principles of the invention.

[0017] FIG. 1 is an exemplary schematic perspective view of a portion of a rotary compressor, showing a rotor rotating clockwise therein a housing, a first end plate and a second end plate mounted to portions of the rotor, and a distal end portion of a vane that is movable with respect to the rotor.

[0018] FIG. 2 is an exemplary schematic cross-sectional view of the clockwise rotation of the rotor within the housing, showing respective compression and suction chambers being formed as a result of the rotation, and showing the vane moveable with respect to the rotor and about an eccentric cam.

[0019] FIGS. 3 are an exemplary schematic cross-sectional view and an exemplary partial front elevational view showing the relative positioning of the rotor, vane and eccentric cam therein the housing of the rotary compressor of Figure 1.

[0020] FIG. 4A is an exploded perspective view of one embodiment of a rotary compressor, showing, from left to right, a housing shaft seal, a housing front cover, a housing front spacer, a housing main bearing, a first end plate, a rotor front bearing, a rotor, a vane, a pair of front housing seals, a housing, a pair of back housing seals, an eccentric cam, an eccentric shaft, a rotor back bearing, a second end plate, a housing back spacer, and a housing back cover.

[0021] FIG. 4B is a partial assembled perspective view of the rotary compressor of FIG. 4A.

[0022] FIG. 5 is a side elevational exploded view of a housing assembly of the rotary compressor of FIG. 4A, showing, from left to right, a housing shaft seal, a housing front cover, a housing main bearing, a housing front spacer, a pair of front housing seals, a housing, a plate valve assembly, a pair of back housing seals, an eccentric cam, an eccentric shaft, a housing back spacer, a housing seal retainer, a housing intake seal, and a housing back cover.

[0023] FIG. 6 is a cross-sectional view of a housing front cover of the rotary compressor of FIG. 5.

[0024] FIG. 7 is a perspective view of a housing back cover of the rotary compressor of FIG. 4A.

[0025] FIG. 8 is a perspective view of an exemplary housing front or back spacer of the rotary compressor of FIG. 4A.

[0026] FIG. 9 is a perspective cutaway view of a discharge valve assembly disposed in a rotary compressor.

[0027] FIG. 10 is an exploded view of one exemplary embodiment of a discharge valve assembly.

[0028] FIG. 11 is an assembled view of the discharge valve assembly of FIG. 10.

[0029] FIG. 12 illustrates the fluid flow through a rotary compressor having a plurality of discharge valve assemblies disposed therein.

[0030] FIG. 13 is a cross-sectional view of a rotary compressor having a plurality of discharge valve assemblies disposed therein. One discharge valve assembly corresponds to the discharge valve assembly of Figure 10 and the second discharge valve assembly is an embodiment having the mating valve stem and valve stem cavity reversed.

[0031] FIG. 14 is a side elevational exploded view of one embodiment of the rotor assembly of the rotary compressor of FIG. 4A, showing, from left to right, a first end plate, a rotor front bearing, a rotor, a rotor back bearing, and a second end plate.

[0032] FIG. 15 is a perspective view of one embodiment of a housing of the rotary compressor of FIG. 4A, showing slots formed therein a portion of the housing front surface, which are configured for operative receipt of seals.

[0033] FIG. 16 is a schematic exploded perspective view of one embodiment of the rotary compressor, showing, from left to right, a housing front cover, a first end plate, a rotor, a vane, a housing, an eccentric cam mounted thereto an eccentric shaft, a second end plate and a housing back cover.

[0034] FIG. 17A is a schematic perspective view of an embodiment of a rotary compressor, showing a dual-end vane mounted therein, and movable relative to, a rotor of the rotary compressor.

[0035] FIG. 17B is a cross-sectional view of the rotary compressor of FIG. 17A, showing inlet ports formed therein the dual-end vane.

[0036] FIG. 18 is a schematic perspective view of the dual-end vane of FIG. 17A in operative cooperation with an eccentric cam.

DETAILED DESCRIPTION

[0037] The present invention can be understood more readily by reference to the following detailed description, examples, drawing, and claims, and their previous and following description. However, before the present devices, systems, and/or methods are disclosed and described, it is to be understood that this invention is not limited to the specific devices, systems, and/or methods disclosed unless otherwise specified, as such can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting.

[0038] The following description of the invention is provided as an enabling teaching of the invention in its best, currently known aspect. To this end, those skilled in the relevant art will recognize and appreciate that many changes can be made to the various aspects of the invention described herein, while still obtaining the beneficial results described herein. It will also be apparent that some of the desired benefits described herein can be obtained by selecting some of the features described herein without utilizing other features. Accordingly, those who work in the art will recognize that many modifications and adaptations to the present invention are possible and can even be desirable in certain circumstances and are a part described herein. Thus, the following description is provided as illustrative of the principles described herein and not in limitation thereof.

[0039] Reference will be made to the drawings to describe various aspects of one or more implementations of the invention. It is to be understood that the drawings are diagrammatic and schematic representations of one or more implementations, and are not limiting of the present disclosure. Moreover, while various drawings are provided at a scale that is considered functional for one or more implementations, the drawings are not necessarily drawn to scale for all contemplated implementations. The drawings thus represent an exemplary scale, but no inference should be drawn from the drawings as to any required scale.

[0040] In the following description, numerous specific details are set forth in order to provide a thorough understanding described herein. It will be obvious, however, to one skilled in the art that the present disclosure may be practiced without these specific details. In other instances, well-known aspects of rotary fluid-displacement assemblies have not been described in particular detail in order to avoid unnecessarily obscuring aspects of the disclosed implementations.

[0041] As used in the specification and the appended claims, the singular forms “a,” “an” and “the” include plural referents unless the context clearly dictates otherwise. Ranges may be expressed herein as from “about” one particular value, and/or to “about” another particular value. When such a range is expressed, another aspect includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent “about,” it will be understood that the particular value forms another aspect. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint.

[0042] “Optional” or “optionally” means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where the event or circumstance occurs and instances where it does not.

[0043] Throughout the description and claims of this specification, the word “comprise” and variations of the word, such as “comprising” and “comprises,” means “including but not limited to,” and is not intended to exclude, for example, other additives, components, integers or steps. “Exemplary” means “an example of” and is not intended to convey an indication of a preferred or ideal aspect. “Such as” is not used in a restrictive sense, but for explanatory purposes.

[0044] Disclosed are components that can be used to perform the disclosed methods and systems. These and other components are disclosed herein, and it is understood that when combinations, subsets, interactions, groups, etc. of these components are disclosed that while specific reference of each various individual and collective combinations and permutation of these may not be explicitly disclosed, each is specifically contemplated and described herein, for all methods and systems. This applies to all aspects of this application including, but not limited to, steps in disclosed methods. Thus, if there are a variety of additional steps that can be perdefined it is understood that each of these additional steps can be perdefined with any specific aspect or combination of aspects of the disclosed methods.

[0045] It is contemplated that the device described according to various aspects herein can function as a compressor, a pump, a flow meter, an expander, and/or an engine. Generally, for clarity, the device is described herein as a rotary compressor, but it is of course contemplated, as one skilled in the art will appreciate, that the device can function in a variety of applications such as described above. The working fluid in any particular

application can be a liquid, a gas, or can comprise a two-phase flow regime as desired for the selected application of the device.

[0046] According to one aspect, a rotary compressor is provided that comprises a housing, a rotor, and a vane. An exemplary rotary compressor is illustrated in Figure 1. The housing assembly 110, in one aspect, defines an internal cavity having an inner wall surface. The housing further has a longitudinal axis that extends transverse to a housing plane that bisects the inner wall surface. The rotor 150, in one aspect, has a peripheral surface and can be positioned within the internal cavity of the housing. The rotor can be configured to rotate about a rotor axis of rotation. According to a particular aspect, the rotor axis of rotation (*Axis B* of Figure 3) is eccentric to the housing longitudinal axis (*Axis A*), such as illustrated in Figure 3. The vane 160, in one aspect, has a distal end and is configured to slidably mount with the rotor. The vane can be movable axially about and between a first position, in which the distal end of the vane is positioned at a first distance from the peripheral surface of the rotor, and a second position, in which the distal end of the vane is positioned at a second distance from the peripheral surface of the rotor. According to a further aspect, the distal end of the vane can be constrained to be spaced proximate from the inner wall surface of the housing as the rotor rotates about the rotor axis of rotation.

[0047] According to yet another aspect, at least portions of the peripheral surface of the rotor, portions of the inner wall surface of the housing, and varying portions of the vane proximate the distal end of the vane can define a compression chamber 102 of varying volume as the rotor rotates about the rotor axis of rotation. At least portions of the peripheral surface of the rotor, portions of the inner wall surface of the housing, and varying portions of the vane proximate the distal end of the vane can also define a suction chamber 104, such as illustrated in Figure 2. As shown in Figure 2, as the rotor is rotated (such as in the direction of the arrows), the suction chamber 104 volume behind the vane increases, while the compression chamber 102 volume decreases.

[0048] An exemplary rotary compressor is illustrated in Figures 4A and 4B. In one aspect, the rotary compressor comprises a housing assembly, such as illustrated in Figure 5. In a particular aspect, such as illustrated in Figure 5, a housing assembly is provided that comprises the housing assembly 110. The housing assembly, in one aspect, further comprises a housing front cover 113 and a housing back cover 114. The housing assembly can further comprise at least one of a housing shaft seal 115, a housing main bearing 116, a housing front spacer 117, a housing back spacer 118, a housing intake seal retainer 121, a housing intake seal 120 and a discharge valve 170.

[0049] An exemplary housing front cover 113 is illustrated in Figure 6. In one aspect, the housing front cover can be substantially plate-like and can have a front surface and an opposed back surface. The housing front cover can define a bore that extends through the front cover. Optionally, the bore can be formed in three portions, such that each portion has different dimensions, such as shown in Figure 6. At least a portion of the bore, such as the portion formed adjacent the back surface of the housing front cover, is configured to receive the housing main bearing. As one would appreciate, the housing main bearing can also define a bore that is configured to receive a proximal portion of an eccentric shaft (such as described in further detail below). In a further aspect, at least a portion of the bore of the housing front cover, such as the portion formed adjacent the front surface of the front cover, can be configured to receive the housing shaft seal.

[0050] An exemplary housing back cover is illustrated in Figure 7. In one aspect, the housing back cover 114 has at least one bore defined therein that is configured or complementarily shaped to receive a distal end of an eccentric shaft. As described further herein below, the distal end of the eccentric shaft can be configured or cut to have a predetermined cross-sectional shape, such as but not limited to a non-circular cross-sectional shape, for the purpose of locking the eccentric shaft from rotating. In another aspect, at least one hole can be defined in the housing back cover (for example, radially around the aforementioned back cover bore as shown in Figure 7) that is configured to provide an intake passageway. As will be described in more detail below, the intake passageway can be in fluid communication with an inlet port therein the rotor, the vane, the housing, and/or one or both of the first and second end plates. In a further aspect, a housing intake seal retainer 121 (shown for example in Figure 5) is provided, along with an intake seal 120, to seal the intake passageway. Optionally, the intake passageway can be formed therein the housing at a predetermined position to allow for sufficient fluid passage into the suction chamber of the rotary compressor.

[0051] Figure 8 illustrates an exemplary housing spacer, such as a housing front spacer 117 or a housing back spacer 118. As can be seen in Figure 5, the housing front spacer is configured to be positioned between the housing front cover 113 and the front surface of the housing 111. Likewise, the housing back spacer is configured to be positioned between the housing back cover 114 and the back surface of the housing 112. It is contemplated that, in various embodiments, either or both of the housing front and back covers, and/or the housing, can be constructed such that the spacing provided by the front and back spacers is integrated into the front and back covers and/or the housing.

[0052] Figure 9 illustrates an exemplary discharge valve assembly 170 configured to be movably disposed in a corresponding valve cavity 200 defined in the rotor housing

assembly 110. In this aspect, the valve cavity 200 extends radially from the inner wall surface 171 to the outer wall surface 172 of the rotor housing assembly 110. The discharge valve assembly can be configured to be movable along a single-axis about and between a first position, in which a portion of a valve seating member of the distal portion 175 of the discharge valve assembly is sealingly disposed against the opening 173 in the housing proximate the inner wall surface, and a second position, in which at least a portion of the valve seating member of the distal portion 175 of the discharge valve assembly is displaced from the opening proximate the inner wall surface. The discharge valve assembly is configured to move from the first position A to the second position B when the back pressure on the valve reaches a predetermined threshold. It is contemplated that the required back pressure on the valve can vary based on the system application, working fluid, configuration, and environmental conditions experienced by the unit.

[0053] In one aspect illustrated in Figures 10 and 11, the discharge valve assembly 170 can comprises a valve retainer 174 adapted to slidably receive a distal end of the valve 175. It is contemplated that the discharge valve can function to restrict the backflow of fluid through the rotary fluid-displacement assembly. In one aspect, the discharge valve assembly can further comprises a valve sealing member 176 and a valve stem 177 that extends distally therefrom. It is also contemplated that the valve sealing member can be substantially planar and can be positioned substantially transverse to the valve stem. In other aspects, at least a portion of the circumferential edge proximate the top surface of the valve sealing member can be distally tapered. In further aspects, the circumferential edge of the valve sealing member can further have a cross-section that is at least partially concave or, alternatively, at least partially convex. It is also contemplated that the portion of the valve cavity proximate the inner wall surface of the rotor housing assembly, or the valve seat, has a complementary shape to at least a portion of the circumferential edge proximate the top surface of the valve sealing member. In other aspects, the valve retainer and valve can comprise mating male and female retaining features. In one aspect depicted herein, the valve stem 177 can be configured to form a male retaining feature and the valve retainer can further define a valve stem cavity 178 that is configured to slidably receive at least a portion of the valve stem. One skilled in the art will appreciate that the male and female retaining features can be reversed such that the valve retainer 174 comprises the male retaining feature and the valve stem comprises the female retaining feature. In yet other aspects, the valve retainer 174 can further comprise at least one pressure balancing port 179 that is in fluid communication with the valve stem cavity and operable to equalize the pressure behind the valve stem and the discharge pressure external to and proximate the pressure balance port.

[0054] In other aspect, a biasing means can be disposed between the valve and the valve retainer. In one aspect, the biasing means can be at least one spring member. In a further aspect, the at least one spring member can comprise a first spring member 180 mounted between a distal end of the valve stem and a distal end of the distal end of the valve stem cavity and a second spring member 181 extending between a bottom surface of the valve sealing member and a base surface of the valve retainer. It is further contemplated that the biasing member can be pre-compressed to achieve a specific amount of load to be transmitted through the valve into the valve seat. In light of the present disclosure, one skilled in the art will appreciate that the selection of the biasing means and the mass of the valve can have significant influence on the dynamics, and thus performance, of the discharge valve assembly.

[0055] In one aspect, the discharge valve assembly 170 can be secured radially in the at least one valve cavity 200 via at least one retaining member 192, which, in a further aspect and not meant to be limiting, the at least one retaining member can comprise a spring clip. Here, the discharge valve assembly is retained radially by the valve retainer 174 and the valve seat 202, which is defined in the respective valve cavity. The valve sealing member and the valve seat are configured to prevent the valve sealing member from entering the working chamber in order to prevent interference due to the vane or vane tip seal. In operation, the valve stem serves to restrict the discharge valve assembly single-axis linear motion and the biasing means works to return the valve to a fully closed position when the pressure within the working chamber is beneath a predetermined pressure. Here, the valve is retained radially by the valve seat and the valve retainer.

[0056] One skilled in the art will appreciate the numerous advantages of the discharge valve assembly 170 of the present invention versus conventional valves, such as reed valves. In one aspect, the discharge valve assemblies of the present disclosure better minimize the space between the valve seat and the working chamber over conventional valves. In another aspect, the discharge valve assemblies of the present disclosure offer more flexibility in placement over conventional valves. Here, the discharge valve assemblies can be placed independently of one another with a minimal footprint required as compared to conventional valves. Accordingly, as shown in Figures 12 and 13, it is contemplated that a plurality of discharge valve assemblies 170 can be staggered throughout the discharge process in order to maximize the flow area of the compressor as described below.

[0057] In another aspect, the curtain area, the radial gap multiplied by the corresponding depth between the rotor and the leading edge of the first valve encountered by the vane, can be balanced with potential leakage back into the compression pocket. In one exemplary aspect, it has been found that the further away from the top dead center that

the discharge valve assembly is placed, the larger the curtain area and thus the lower the flow losses. One skilled in the art will appreciate in light of the present disclosure, such placement of the discharge valve assembly comes at the cost of a larger volume in front of the leading edge of the vane. This volume can leak back behind the vane as the vane crosses over the valve port. Both the pressure loss through the curtain area and leakage back into the subsequent compression pocket behind the valve are losses that require balancing of the associated features.

[0058] In another aspect, it is contemplated that the housing can comprise a plurality of valve cavities and the discharge valve assembly can comprise a corresponding plurality of discharge valve assemblies. In a further aspect, the plurality of valve cavities and corresponding plurality of discharge valve assemblies can be irregularly sized. In another aspect, each of the valve cavities can have an upper opening defined on the outer wall surface of the rotor housing assembly wherein the upper openings are circumferentially spaced about at least a portion of the outer wall surface. In a further aspect, the upper openings of the plurality of valve cavities can be circumferentially irregularly spaced about the outer wall surface and, in a further aspect, the plurality of valve cavities and the corresponding plurality of discharge valve assemblies can be irregularly sized.

[0059] In operation and as shown in Figure 12, fluid can enter the working chamber of the rotor housing assembly through a suction port as it is drawn in due to the movement of the vane. This fluid can be compressed to a smaller volume as the working chamber progresses through an operational cycle. When the pressure of the fluid exceeds the pressure of the fluid on the opposite end of the valve, the valve can be urged from the first position where the valve sealing member can be sealing sealingly disposed against the valve seat to the second position in which at least a portion of the valve sealing member is displaced from the valve seat. As one skilled in the art will appreciate, the extent of the displacement will depend on the pressure differential, the mass of the valve and the characteristics of the biasing member.

[0060] In yet another aspect illustrated in Figure 13, the discharge valve assembly can be constructed similarly to that disclosed in Figures 9-11 except that the valve stem cavity and valve stem are reversed.

[0061] An exemplary rotor 150 is illustrated in Figure 14. In one aspect, the rotor has a first side surface and an opposed second side surface. The rotor, in one aspect, can be generally cylindrical in shape; however, other geometries are contemplated, such as can be chosen to alter the volumetric flow of fluid within the rotary compressor. The rotary compressor can comprise a pair of end plates 151a, 151b that are mounted to and rotate

with the respective first and second side surfaces of the rotor. The housing assembly 110, in one aspect, has a front surface and an opposed back surface. In one aspect, portions of a first end plate 151a of the pair of end plates sealingly and slidably contact portions of the front surface of the housing. Similarly, portions of a second end plate 151b of the pair of end plates sealingly and slidably contact portions of the back surface of the housing.

[0062] According to one aspect, the rotary compressor further comprises means for providing a substantially fluid-impervious seal between the first end plate 151a and the front surface of the housing 111, and between the second end plate 151b and the back surface of the housing 112. In one exemplary aspect, at least one slot can be defined in peripheral portions of each of the first and second end plates. A plurality of seals can be provided, each seal being configured for complementary mounting therein one slot of the first and second end plates.

[0063] Optionally, at least one slot 122 can be defined in each of the front surface 111 and back surface 112 of the housing, the at least one slot substantially surrounding the interior cavity of the housing. At least one seal can be provided, each seal being configured for complementary mounting therein one slot of the housing. For example, as shown in Figure 15, one or more slots 122 (such as, but not limited to, two slots as shown in Figure 10) can be formed in each of the front and back surfaces of the housing and can be substantially concentric with the internal cavity of the housing. One or more seals 123 can be provided and configured for complementary mounting therein one slot of the housing, such as shown in Figure 5. Thus, for example, if two slots are formed on each of the front and back surfaces of the housing, four seals can be provided, each configured for complementary mounting therein a respective slot of the housing.

[0064] In yet another aspect, a first end plate of the pair of end plates can be mounted to the front surface of the housing, and a second end plate of the plurality of end plates can be mounted to the back surface of the housing. The rotary compressor can further comprise means for providing a substantially fluid-impervious seal between the first end plate and a first side surface of the rotor, and between the second end plate and a second side surface of the rotor. In one aspect, at least one slot is defined in peripheral portions of each of the respective first and second side surfaces of the rotor. At least one seal can be provided, each seal being configured for complementary mounting therein one slot of the rotor.

[0065] The rotary compressor, in one aspect, comprises a cam 128 that can be positioned therein the internal cavity of the housing about a cam axis, and can be configured to selectively engage select portions of the vane to effect the axial movement of the vane

about and between the first position, in which the distal end of the vane is positioned at a first distance from the peripheral surface of the rotor, and the second position, in which the distal end of the vane is positioned at a second distance from the peripheral surface of the rotor. The rotor can also be configured to act on the select portions of the vane to effect the constrained axial movement of the vane relative to the peripheral surface of the rotor. The cam 128, in one aspect, can be positioned along a shaft. For example, the cam can be positioned at a position between a proximal end and a distal end of the eccentric shaft 129.

[0066] The eccentric shaft, in one aspect, can be substantially cylindrical and has a proximal end and an opposed distal end. In one aspect, a portion of the eccentric shaft proximate the distal end can be removed such that the cross section of the distal end is non-circular. For example, and without limitation, the cross-sectional shape of the distal end can be semi-circular, partially circular (*i.e.*, a portion can be removed along a chord of the circle other than the diameter), or other geometric shape. Optionally, the eccentric shaft can have a non-circular cross section along a portion or substantially all of its length. According to various aspects, the eccentric shaft can be fixed with respect to the housing front and back covers 113, 114, such as described above, or using alternative attachment or integration (*i.e.* made as a part of the housing end plate, etc.) methods such as are known to those skilled in the art.

[0067] An exemplary cam 128 can be substantially cylindrical and can have a predetermined width. In one aspect, the cam can have a bore defined therein that is sized and shaped to receive the eccentric shaft. According to various aspects, the center of the bore can be offset from the center of the cam (*i.e.*, such that the bore is not concentric with the cam). In a further aspect, the cam can be positioned at a position between the proximal and distal ends of the eccentric shaft (such as shown in Figure 5). According to one aspect, it is contemplated that the cam can be fixed from rotation with respect to the housing assembly 110 through a chosen attachment method without the use of an eccentric shaft. In yet another embodiment, the cam can comprise a bearing such that the frictional forces between the cam and the vane can be reduced, such as through the use of a bushing, roller bearing, needle bearing, or similar low-friction device known to those skilled in the art. In further aspects, it is contemplated that the cam can be rotated at a constant or varying speed relative to the rotor's movement to affect the desired positioning of the vane as it rotates about the rotor axis of rotation. The cam rotation can be effected through means known to those skilled in the art, such as belts, gears, chain drives, linkages, and other similar means.

[0068] As described above, the rotary compressor in various aspects comprises a pair of end plates 151a, 151b that can be mounted to and rotate with the respective first and

second side surfaces of the rotor. In another aspect, a first end plate 151a can comprise a substantially circular plate-like structure with a shaft-like or male protrusion extending outwardly therefrom. In one exemplary aspect, the protrusion can be substantially cylindrical and can extend outwardly therefrom the first end plate substantially normal or perpendicular with respect to a plane of the first end plate. In a further aspect, the protrusion and the first end plate can be substantially concentric (*i.e.*, a longitudinal axis of the protrusion passes substantially through the geometric center of the first end plate). According to another aspect, the protrusion can be fixedly attached to the first end plate. In a further aspect, the protrusion can have a conventional keyed portion for non-slip transmission of torque. In various exemplary aspects, and not meant to be limiting, the keyed portion can be a splined shaft, a pinned shaft, or the like.

[0069] In a further aspect, the protrusion of the first end plate can have a blind bore that extends a predetermined depth from an inner surface of the first end plate into the protrusion. In this aspect, the bore can be configured to receive the proximal end of the eccentric shaft. The proximal end of the eccentric shaft can be inserted through a rotor front bearing 152 and inserted into the bore defined in the protrusion of the first end plate to allow the rotor to rotate about the eccentric shaft while the eccentric shaft remains fixed or stationary.

[0070] In one aspect, the eccentric shaft can be supported by a nested anti-friction bearing positioned therein the bore of the protrusion; the bearing can be constructed of known bearing elements, such as but not limited to, bushings, roller bearings, journal bearing, taper roller bearings, or the like. In some aspects, the nested bearing can be a taper roller bearing, and adjustment means can be provided within the distal end portion of the eccentric shaft to allow for some axial movement of the eccentric shaft and rotor to accommodate for wear or assembly tolerances, such that the rotor can be aligned properly with respect to the housing. In other aspects, thrust bearings can be provided to achieve the desired alignment for the rotational elements.

[0071] Similarly, it is contemplated that the second end plate 151b can define a bore that extends through the second end plate, which can be configured for receiving a distal end of the eccentric shaft. As described with respect to the rotor front bearing, the distal portion of the eccentric shaft can be inserted through a rotor back bearing 153 and then inserted through the bore in the second end plate to allow the rotor to rotate relative to and about the eccentric shaft.

[0072] According to various aspects, the rotor 150 defines a bore 155 configured for slidable receipt of the vane. The rotor, in one aspect, defines a centrally positioned chamber

configured for rotative receipt of the cam. The bore 155, in one aspect, has a bore axis that bisects a center of the chamber. The bore can be a blind bore (*i.e.*, it does not extend fully through the rotor).

[0073] In a further aspect, the vane can be generally cylindrical and the bore of the rotor can be complementarily cylindrical in shape to receive the vane. Optionally, the vane can have a non-cylindrical shape and the bore of the rotor can be complementarily shaped to receive the vane. A vane 160 can define a hollow 161 having at least one bearing surface that is configured for selective contact with portions of the cam 128. The at least one bearing surface, in one aspect, comprises a pair of opposed bearing surfaces 162a, 162b. According to a particular aspect, as described above, the bore axis can bisect a center of the chamber of the rotor. In this aspect, the pair of opposed bearing surfaces of the vane can be positioned substantially transverse to the bore axis when the vane is slidably received by the bore. In a further aspect, the pair of opposed bearing surfaces are spaced from each other along a longitudinal axis of the vane and are positioned opposite each other about the cam axis. At least a portion of at least one of the bearing surfaces can be curved.

[0074] In one aspect, the vane can comprise an upper eccentric plate 163a and a lower eccentric plate 163b. In one aspect, the upper and lower eccentric plates 163a, 163b can define the pair of opposed bearing surfaces 162a, 162b, respectively. Optionally, the vane can be machined such that the pair of opposed bearing surfaces are integrally formed with the vane. In either aspect, each bearing surface of the pair of bearing surfaces can be at least partially curved. The upper bearing surface 162a can have a first radius of curvature (r_1). The lower bearing surface 162b can have a second radius of curvature (r_2). In one aspect, the first radius of curvature (r_1) and second radius of curvature (r_2) can be selected such that the circles scribed by the first and second radii of curvature are substantially concentric. In a further aspect, the center of these scribed circles can be defined by an apex of the vane. In other aspects, the lower and upper eccentric plates (or the machined portions of the vanes that are in contact with the cam) can have flat profiles rather than curved or partially curved surfaces. As can be appreciated, the vane (and/or the upper and lower eccentric plates) can be surface treated or plated in areas that are in mechanical contact with the cam or the bore of the rotor to provide sufficient longevity of the components during operation of the rotary compressor.

[0075] In one aspect, the rotary compressor comprises means for minimizing distortion and deflection of the vane at high fluid pressures. In one aspect, at least a portion of the bore of the rotor can have a cylindrical cross-sectional shape and at least portions of the vane can have a cylindrical cross-sectional shape that is complementary to the bore of the rotor. In this aspect, the cylindrical shape of portions of the vane can provide improved

resistance to vane distortion and deflection at high fluid pressures and high rotational speeds due to a superior moment of inertia.

[0076] In a further aspect, the vane can have additional support for proper alignment during its axial movement via an internal guide pin affixed to the rotor and extending along the axis of the vane bore provided within the rotor. In this aspect, the guide pin can be received within a bore provided within the vane itself running along its longitudinal axis. In this way, the side forces pressing upon the vane can be carried by both the vane bore within the rotor and by the guide pin residing within the bore. Optionally, there can be bearing elements provided within the vane's internal bore upon which the guide pin can ride to reduce frictional loads.

[0077] In yet another aspect, the rotary compressor comprises at least one sealing element mounted thereon exterior portions of the portions of the vane having the cylindrical cross-sectional shape. For example, one or more grooves 171 can be formed proximate the distal end of the vane. Optionally, the one or more grooves can be formed proximate the proximal end of the vane, or both proximate the distal and proximal ends of the vane. One or more vane sealing elements 172 can be provided, each configured to be received by a respective groove. The vane sealing element(s) can provide a seal between the vane and the bore of the rotor, as is generally known in conventional piston and cylinder sealing technology. Thus, the vane sealing elements can act to seal the vane against the bore as the vane is axially moved between the first and second positions. It is also contemplated that, in various aspects in which at least portions of the vane have a non-cylindrical cross sectional shape, appropriate vane sealing elements can be provided at chosen locations along the vane's perimeter to achieve the desired level of sealing.

[0078] As described above, in one aspect, the vane is slidably mounted with the rotor and is movable axially about and between the first position, in which the distal end of the vane is positioned at a first distance from the peripheral surface of the rotor, and the second position, in which the distal end of the vane is positioned at a second distance from the peripheral surface of the rotor. In one aspect, the first distance is greater than the second distance. The second distance can be proximal to the peripheral surface of the rotor, in one aspect. In yet another aspect, in the second position, the distal end of the vane can be at or below the peripheral surface of the rotor.

[0079] The distal end of the vane can be constrained to be spaced proximate from the inner wall surface of the housing as the rotor rotates about the rotor axis of rotation. In one aspect, the distal end of the vane can be constrained to be proximate from the inner wall surface of the housing in a constrained range of between about 0.0001 inches to about

0.2000 inches. Optionally, the distal end of the vane can be constrained to be spaced proximate from the inner wall surface of the housing in a constrained range of between about 0.0003 inches to about 0.1500 inches. In yet another aspect, the distal end of the vane can be constrained to be spaced proximate from the inner wall surface of the housing in a constrained range of between about 0.0005 inches to about 0.1000 inches.

[0080] According to various aspects, the distal end of the vane defines a slot. The rotary compressor can further comprise a seal assembly comprising at least one planar member movable therein the slot of the vane, and a bias element configured to selectively act on the at least one planar member to maintain the outer edge of the at least one planar member in sliding contact with the inner wall surface of the housing as the rotor rotates. In one aspect, the mass of the at least one planar member is less than about 50 percent of the mass of the vane. In another aspect, the mass of the at least one planar member is less than about 10 percent of the mass of the vane. Optionally, the mass of the at least one planar member can be less than about 2 percent of the mass of the vane. According to yet another aspect, the mass of the at least one planar member can be between about 1 to about 60 percent of the mass of the vane. It is also contemplated that, optionally, the biasing force for the at least one planar member can be provided at least in part by the pressurized gases of the compression chamber through the provision of passageways fluidically connecting the compression chamber to the underside of the sealing element.

[0081] In one aspect, the distal end of the vane can be generally tapered, such as shown in Figure 17. The tapered end portion can be shaped such that two opposing sides of the distal end are tapered inwardly and come together substantially at an apex. In a further aspect, the two sides connecting the opposing tapered sides of the distal end are substantially parallel to and continuous with the cylindrical portions of the vane. In one aspect, the tapered end portion is configured to help create a larger area onto which the expanding pressure is acting as the vane retracts into the rotor. In conventional hydraulic vane motors, for example, as the vane retracts the exposed area is reduced, which reduces the effectiveness of the expander.

[0082] The noted configuration of the tapered end portion of the vane reduces the gradient for total volume reduction as the rotor spins, that is, as the vane retracts downwardly into the bore of the rotor, it is adding a small amount of incremental volume for each degree of rotor rotation, which reduces the rate at which the total volume decreases. Thus, the exemplified configuration moves some of the volume down into the bore as the crescent shape closes up. Because the "bore volume" increases slower than the reduction in the crescent volume, the result is a net compression event.

[0083] It is contemplated that alternative shapes for the distal end portion of the vane can be used. In various aspects, different geometric shapes can be used on one or both sides of the tapered end portion of the vane to optimize either a compression or an expansion operation. For example, in one aspect, if the end portion of the vane does not have a taper on the compression side, an increase in the compression ratio would result. Alternatively, by providing a steep taper (*i.e.*, a larger height to width ratio of the tapered portion of the distal end portion of the vane) on the suction side, the volume ingested for each “stroke” is increased. If the present device is used as an expander, it is contemplated that the tapered end portion of the vane can be configured to create the highest resultant moment reaction for a given portion of the rotation, such as, for example and not meant to be limiting, creating a substantially “constant volume expansion” stroke by varying the geometry of the vane’s profile on its distal end.

[0084] The exemplary tapered end portion of the vane, as described above, can provide a retracting ‘pocket’ in the vane on which the pressure can act or through which the suction volume can be increased. The tapered configuration allows some volume to grow in the compression chamber as the rotary compressor moves toward the final clearance volume. The particular shape of the tapered end portion provides a means for tuning the compression dynamics rather than just rely on the vane/housing geometry alone.

[0085] According to various aspects, at least one slot is defined by the distal end of the vane. In one aspect, the slot 164 defined by the distal end of the vane is a three-sided slot. A first, or apex-side, of the slot is formed along the apex of the tapered end portion. The latter two opposing side edges of the three-sided slot extend downwardly away from the apex along the sides of the vane that are substantially parallel to and continuous with the cylindrical portions of the vane. In one aspect, the three-sided slot is positioned in a common plane in the tapered end portion of the vane. In a further aspect, the distal end portion of the vane can further comprise a bore that is defined in and extends through the tapered end portion substantially parallel to the apex slot. In this aspect, the defined bore can be formed at the distal (non-apex) ends of the latter two side edges of the slot.

[0086] The slot 164, in one aspect, can be configured to complementarily and operatively receive an apex seal 166 and a pair of side seals 167. It is contemplated that, according to various aspects, the apex seal and side seals can be formed as a unitary seal for the distal end portion of the vane. For example, a unitary seal can comprise an elastic, biasable, or other material positioned therein the slot 164 and configured to seal the apex and sides of the distal end portion of the vane against the inner wall surface of the housing and the first and second end plates, respectively.

[0087] A pair of vane seal actuators 168 and a vane actuator spring 169 can be provided and operatively positioned therein the bore of the distal end portion of the vane, such as shown in Figure 18B. In one aspect, the vane actuator spring 169 can be placed into the bore and a respective one of the vane seal actuators 168 can be placed in the bore on either side of the vane actuator spring. The side seals 167 can be placed in the two side edges of the slot, and the apex seal 166 can be placed in the apex-side of the slot.

[0088] In one exemplary aspect, each of the side and apex seals is generally trapezoidal in shape. Due to the general geometry of the vane seal actuators, the side seals, and the apex seal, sealing of the vane against portions of the housing and/or the rotor can be effectuated. The vane actuator spring acts on the vane seal actuators, which can slide longitudinally within the bore in directional parallel to the longitudinal axis of the vane actuator spring. The vane seal actuators, in turn, act against the side seals 167, which in turn act against the apex seal 166. The angled-end geometries of the seals allow for applied forces from the spring to press the side seals outward against their respective mating surfaces (in one aspect, against the inner surfaces of the pair of end plates) while also translating this force up to the apex seal, thereby forcing it against the inner wall surface of the housing. Thus, the lateral force of the spring is transferred to the side seals, creating a seal between the vane and the first and second end plates. Due to the angled interface between the side seals and the apex seal, the lateral force of the spring is translated through the side seal as a lateral and upward force, pressing the apex seal against the inner wall surface of the housing. Optionally, the compression fluid within the compression chamber can be directed through passageways provided in the seals themselves or within the vane such that the pressurized fluid acts upon the underside of chosen seals to provide all or part of the biasing force necessary for fluidic sealing of given chambers.

[0089] According to yet another aspect, the rotary compressor further comprises a seal element extending outwardly from the inner wall surface of the housing proximate the location of minimal running clearance between the inner wall surface of the housing and the peripheral surface of the rotor. An edge of the seal element can be configured for selective slidable contact with the peripheral surface of the rotor. In a further aspect, the rotary compressor can comprise means for withdrawing the seal element within the housing such that the edge of the seal element is at or below the inner wall surface of the housing when the distal end of the vane passes over the seal element as the rotor rotates.

[0090] In one aspect portions of the peripheral surface of the rotor, portions of the inner wall surface of the housing, and varying portions of the vane proximate the distal end of the vane define a suction chamber 104 and a compression chamber 102, each of varying volume as the rotor rotates about the rotor axis of rotation. According to various aspects,

one or more inlet ports in fluid communication with the suction and/or compression chamber can be provided in one or more of the rotor 150, vane 160, housing assembly 110, first end plate 151a and/or second end plate 151b, or other component(s) of the rotary compressor. Similarly, one or more outlet ports can be provided in one or more of the rotor, vane, housing, first and/or second end plates, or other component(s) of the rotary compressor. For example, the rotor can comprise at least one rotor inlet port 156 in fluid communication with the suction chamber and/or compression chamber. In this aspect, the inlet port can extend from the peripheral surface of the rotor to a side surface of the rotor, such as the second side surface, to form a fluid passageway. According to another aspect, the second end plate 151b can comprise at least one inlet port. For example, the second end plate can comprise a first inlet port 157 and a second inlet port 158. The first inlet port 157, in one aspect, is in fluid communication with the rotor inlet port 156 to thereby provide a substantially continuous fluid passageway. At least one of the inlet ports formed therein the second end plate can be configured to cooperate with the one or more holes formed therein the housing back cover to provide a substantially continuous fluid intake passageway.

[0091] According to one aspect, the housing can have at least one housing inlet port 124 that is in fluid communication with the suction and/or compression chamber. In another aspect, the vane 160 can have at least one vane inlet port 175 in fluid communication with the suction and/or compression chamber. In this aspect, the rotary compressor can comprise means for selectively opening and closing the at least one inlet port therein the vane. It is contemplated that, in one aspect, the rotor of the rotary compressor can be configured to rotate in a counter-clockwise direction as viewed in the figure. In this aspect, and not meant to be limiting, it is contemplated that the one or more inlet ports formed therein the rotor, second end plate, and/or vane can be positioned such that when the rotor begins a rotation (*i.e.*, when the vane apex seal passes the TDC position), the inlet ports are positioned proximate the TDC position and can draw fluid into the suction chamber as the rotor continues its rotation. However, it is contemplated that the positions of the inlet ports can be selected as desired.

[0092] Similarly, in one aspect, the rotor, vane, first and/or second end plates, housing, and/or other component(s) of the rotary compressor can have at least one outlet port in fluid communication with the compression chamber. For example, in a particular aspect, the vane can have at least one outlet port 195 in fluid communication with the compression chamber. Exemplary outlet ports 197, 198 in the first and second end plates, respectively, are shown in Figure 16. The rotary compressor can further comprise means for selectively opening and closing the at least one outlet port therein the vane. In yet another aspect, a housing outlet port 125 can be formed therein the housing. The housing outlet port

125, in one aspect, can be positioned such that as the rotor completes a rotation, substantially all of the fluid in the compression chamber exits the compression chamber via the housing outlet port. As described further below, in one aspect, a valve can be mounted therein the housing outlet port to act as a discharge valve for the rotary compressor.

[0093] In a further aspect, the axial movement of the vane within the rotor can be used to open ports provided in the vane as they become aligned with ports provided in the rotor. In this aspect, during select periods of rotor movement the outlet port is placed in fluid communication with one or more volumetric chambers to allow fluid flow there between. In yet other aspects, outlet ports can be provided in the rotor endplates, which are allowed to be placed in fluid communication with selected volumetric chambers as the rotor endplates moves eccentrically with respect to the housing. In this exemplified aspect, during select periods of rotor movement, the ports allow fluid communication to be established, which allows for the ingestion or discharge of fluid from one or more of the volumetric chambers. Alternatively, it is contemplated that ports can be provided in at least a portion of the housing that are configured to provide the primary inlet or outlet passageways for the working fluid, or the formed housing ports can serve as additional ports to main ports provided in other components as described above.

[0094] The rotary compressor can further comprise a discharge valve mounted thereto the housing that serves to prevent back flow of the compressed fluid in the compression chamber. In other aspects, the rotary compressor can comprise an intake valve positioned therein the intake passageway (such as, but not limited to, positioned therein an inlet port of the housing) to reduce or eliminate reversion flow of the intake fluid. According to various aspects, for example and not meant to be limiting, the discharge valve and/or intake valve can comprise a reed valve, a plate valve, a flapper valve, and the like.

[0095] In another aspect, an exemplary plate valve assembly 180 is illustrated, which can be positioned therein an outlet port of the housing to act as a discharge valve, for example. According to various aspects, a plate valve assembly can comprise a chamber seal 181, a valve plate 182, valve seats 183, sealing elements 184, seal springs 185, and a valve body 186. It is contemplated that, when assembled, the valve plate, valve seats, and valve body define a plurality of channels radially displaced around a common axis. In one aspect, a sealing element 184 and respective seal spring 185 is placed within each of the plurality of channels. In one example, the sealing elements can be substantially spherical. According to one aspect, and not meant to be limiting, five channels are formed in the valve body; thus, five sealing elements are mounted therein the respective formed channels. In one aspect, the valve body is shaped such that the seal springs and sealing elements are retained within the channels when the plate valve assembly is assembled

[0096] Optionally, the seal springs can be omitted and the movement and sealing function of the sealing elements can be controlled by fluid flow through the plate valve assembly. In other aspects, the sealing elements can be fitted within their respective channels with close tolerances such that the movement of the sealing elements is substantially restricted, thereby providing a damping mechanism to prevent the sealing elements from unconstrained movement. As can be appreciated, a plate valve assembly, or other like valve, can be provided and can be configured to act as a discharge valve for the rotary compressor.

[0097] According to various aspects, the rotary compressor can comprise a rotor having a peripheral surface and a rotor axis, and a housing defining an internal cavity having an inner wall surface, and the housing can be configured to rotate about a housing longitudinal axis eccentric to the rotor axis. The rotor can be positioned within the internal cavity of the housing. A vane, such as described herein, can be slidably mounted with the rotor and movable axially about and between a first position, in which the distal end of the vane is positioned at a first distance from the peripheral surface of the rotor, and a second position, in which the distal end of the vane is positioned at a second distance from the peripheral surface of the rotor. In this aspect, first and second end plates can be provided and can be fixedly attached or mounted thereto the rotor. Thus, the rotor and the end plates can be held or maintained in a stationary position as the housing rotates about the housing longitudinal axis. Such a rotary compressor can be used for example, as a compressor, pump, expander, or any combination thereof.

[0098] It is contemplated that compound devices can be assembled using two or more rotary compressors as described herein to create high pressure ratios as can be desired. In an exemplary aspect, the first stage rotary compressor can have its outlet port or ports positioned selectively in fluid connection with the inlet of a secondary stage rotary compressor. In various aspects, the secondary stage can be, without limitation, any one of a number of known compressor devices such as a centrifugal compressor, a scroll compressor, a reciprocating compressor, an axial turbine compressor, or the like. Alternatively, it is contemplated that the first stage can be comprised of a known compressor or pump, as exemplarily described above, and subsequent stages can be assembled using a rotary compressor as described according to various aspects herein, or combinations thereof. Such a multi-stage compressor can be used, for example and without limitation, as a compressor, pump, expander, engine, or any combination thereof.

[0099] With reference to Figures 4A and 4B, a rotary compressor can be assembled to comprise any or all of the components as described above. In one aspect, the vane can be assembled by inserting the seal actuator into the bore of the tapered end portion of the

vane. The apex seal and side seals can be inserted into the respective portions of the three-sided slot at the apex of the vane. The one or more vane sealing elements can be positioned within the grooves formed in the portions of the vane having the cylindrical cross-sectional shape. In one aspect, vane lower and upper eccentric plates are provided, which define a pair of opposed bearing surfaces when positioned therein the vane. Thus, in one aspect, the upper eccentric plate and lower eccentric plate can be positioned within the body of the vane. The vane can then be inserted into the bore of the rotor.

[00100] According to various aspects, it is contemplated that the seal actuator presses against the vane side seals, pressing the vane side seals against the inner surfaces of the first and second end plates. As described above, due to the construction and geometrical shape of the vane side seals and vane apex seal, the lateral force experienced by the vane side seals is translated to the vane apex seal in a transverse direction, thereby pressing the vane apex seal against the inner wall surface of the housing. These pressing forces can serve to ensure proper sealing during operation of the rotary compressor. In one aspect, the vane side seals experience pressing forces in the range of between about 0.01 pounds and about 15.0 pounds. In a further aspect, the vane side seals experience preferably about 4.0 pounds of force. According to another aspect, the vane apex seal experiences a pressing force in the range of between about 2.0 to about 40.0 pounds. In yet another aspect, the vane apex seal and vane side seals can be constructed with alternative spring elements to cause the forces described herein above.

[00101] The eccentric shaft and cam can be inserted therein the centrally positioned chamber of the rotor and the defined hollow portion of the vane. The cam can be positioned along the eccentric shaft such that it is positioned therein the hollow of the vane, proximate the at least one bearing surface defined by the hollow. In one aspect, the cam can be positioned between the upper and lower eccentric plates of the vane. It is contemplated, according to various aspects, that the shape of the cam can be chosen such that the vane, which is constrained within the rotor by the rotor bore, has its radial position defined by the contact points between the cam and the mating contact points on the at least one bearing surface of the vane hollow, such as the upper and lower eccentric plates. As the rotor rotates about the rotor axis of rotation, the circumferential path of the vane is defined by the center of rotation of the rotor, and the vane's radial distension is fixed by the geometry of the cam. In this way, the distal end of the vane is constrained to be spaced proximate from the inner wall surface of the housing, and is constrained from pressing with excessive or erratic force against the inner wall surface of the housing.

[00102] In one aspect, the cam is designed such that the distal end of the vane can be maintained at a spaced distance proximate from the inner wall surface of the housing. In

one aspect, the distal end of the vane is constrained to be spaced proximate from the inner wall surface of the housing in a constrained range of between about 0.0001 inches to about 0.2000 inches, in a constrained range of between about 0.0003 inches to about 0.1500 inches, or in a constrained range of between about 0.0005 inches to about 0.1000 inches. In another aspect, the distal end of the vane is constrained to be spaced proximate from the inner wall surface of the housing in a constrained range of between 0.01% and 15.0% of the diameter of the housing inner surface.

[00103] In this manner, wear and contact friction between the vane and the inner wall surface of the housing can be minimized or eliminated. As described herein, sealing between the distal end of the vane and the inner wall surface of the housing (and/or the inner surfaces of the first and second end plates) can be accomplished by the spring force of the vane seal actuator acting on the vane side seals and the vane apex seal. In other aspects, sealing between the distal end of the vane and the inner wall surface of the housing (and/or the inner surfaces of the first and second end plates) can be accomplished by close running clearances achieved through exact machining and assembly tolerances, thereby creating a non-contact sealing function and thus reducing friction and wear.

[00104] A proximal portion of the eccentric shaft can be inserted through the rotor front bearing into the bore formed in the shaft of the first end plate. Similarly, a distal portion of the eccentric shaft can be inserted through the rotor back bearing, through the second end plate, and inserted into the mating bore in the housing back cover. In one aspect, the housing front spacer is positioned between the housing front cover and the front surface of the housing. As shown in Figure 8, the housing front spacer can define a void in which the first end plate can rotate freely. Similarly, the housing back spacer can be positioned between the housing back cover and the back surface of the housing, and can define a void in which the second end plate can rotate freely. Optionally, as described above, the housing front and back spacers can be eliminated and the housing front and back covers and/or the housing can be constructed to provide the respective voids when the rotary compressor is assembled.

[00105] It is contemplated that the rotary compressor can be joined together or assembled with conventional means, such as, for example and without limitation, mechanical fasteners such as, without limitation, screws, bolts, rivets, clamps, pressed studs with nuts, and the like, or any combination thereof. Complementary fastener holes can be defined, such as illustrated for example in Figures 6-8 and 15, with respect to the housing front cover, housing front spacer, housing, housing back spacer, and housing back cover. However, it is also contemplated that any number of the elements of the housing assembly can be formed integrally together into a single machine part or casting.

[00106] According to various aspects, the first and second end plates can be fixedly attached to the first and second side surfaces of the rotor, respectively, such that they rotate simultaneously with the rotor. In one aspect, the first and second end plates can be substantially sealed against the front and back surfaces of the housing by at least one seal positioned therein a respective slot defined in the front and/or back surface of the housing. In this aspect, the vane side seals translate axially up and down relative to the inner surfaces of the first and second end plates, rather than sweeping against them if they were fixed relative to the rotation of the rotor. In this manner, sealing performance can be improved and friction can be reduced. As can be appreciated, any number of seals can be used to provide sealing of the vane within the rotor and of the vane against the inner wall surface of the housing, and it is contemplated that various aspects can include more or fewer seals than described herein. It is contemplated that, in some aspects, one or more of the seals can be urged against their mating surfaces through, for example and not meant to be limiting, the use of fluid pressure routed from the compression chamber or elsewhere, or through the use of bias elements, or a combination thereof.

[00107] According to other aspects, the first and second end plates can be fixedly attached to the housing. For example, the first end plate can be mounted to the front surface of the housing and the second end plate can be mounted to the back surface of the housing. Means can be provided for providing a substantially fluid-impervious seal between the first end plate and the first side surface of the rotor and between the second end plate and the second side surface of the rotor. In this aspect, it is contemplated that the vane side seals will 'sweep' against the inner surfaces of the first and second end plates, rather than moving axially or laterally against them as described herein in accordance with various other aspects. According to various aspects, it is contemplated that fewer seals (e.g., vane seals, etc.) can be provided and sealing can be effectively achieved through close assembly tolerances at selected interfaces between components of the rotary compressor. Optionally, an oil-less compressor or vacuum pump can be constructed through the elimination of chosen sealing elements such that the desired performance can be achieved through the exact positioning of the vane relative to the housing, *i.e.*, by positioning the vane such that the distal end of the vane remains at a close select tolerance from the housing. This aspect can achieve long service life through the reduction of friction and wear at the typical seal contact points.

[00108] In operation, fluid intake (such as air or other gas intake, liquid intake, etc.) is achieved via the various inlet ports described above. For example, and not meant to be limiting, inlet port(s) can be formed in the housing back cover that are in sealed fluid communication with an inlet port formed on the second end plate. The inlet port of the

second end plate can be in fluid communication with an inlet port of the rotor. Thus, fluid, such as air, can be brought into the suction chamber of the rotary compressor. As can be appreciated, in an initial rotation of the rotor, fluid will be drawn into the suction chamber of the rotary compressor, defined behind the vane. At the end of the initial rotation, when the vane passes the TDC position, the fluid that was drawn into the suction chamber of the initial rotation becomes fluid in the compression chamber of the subsequent rotation.

[00109] Through this air (or other fluid) passageway, for example, air can be naturally pumped or drawn into the suction chamber by the rotation of the rotor and the low pressure (e.g., vacuum) force created by the movement of the rotor assembly (*i.e.*, as the suction chamber volume behind the vane expands). Additionally, by having the air enter into the suction chamber through a side surface of the rotor, less flow inertia is necessary to fill the working chamber than in known compressors. Rather, air is “laid out” into the suction chamber by the inlet port in the rotor’s side surface as the rotor rotates about the rotor axis of rotation. Each discrete element of the air enters into the suction chamber without having to push additional air out of its way, as is the case with known poppet and flapper valves. Instead, each discrete element of air is “pulled” into the suction chamber by the pressure gradient created by the rotor’s movement.

[00110] In an expansion mode of operation, fluid flow can be sent through the rotor and out its periphery into the expansion chamber through a port provided proximate to and behind the vane. In this aspect, the fluid that is pressing against the vane does not have to transfer its pressure force through all the previously injected fluid, but rather the fresh charge of fluid pressure is always fed proximate to and behind the vane’s distal end.

[00111] In another aspect, the air (or other fluid) intake allows the rotor to be cooled by the incoming air charge, which can aid in the longevity and efficiency of a rotary compressor assembled according to various aspects described herein.

[00112] In one aspect, the compression ratio of the rotary compressor can be determined by the selective positioning of the inlet and outlet ports described herein. The full rotation of the rotor within the rotary compressor can provide nearly a full 360 degree intake and compression “stroke.” This can be altered in a fixed manner through the selective location of the inlet and/or outlet ports. Optionally, the stroke of the rotary compressor can also be made changeable, or variable in real time by using a moving port location. In this aspect, conventional shutters, sliding ports, sleeves, or similar means to change the location of the ports (inlet ports, outlet ports, or both) with respect to the rotor’s position in its rotation can be used to vary the stroke of the rotary compressor. Likewise, it is contemplated that the amount of fluid ingested into the suction chamber can be variable using similar means.

[00113] According to yet another aspect, the bottom portion of the vane (*i.e.*, the proximal portion opposite the distal end of the vane) can be used as a control valve, pump, etc. as can be envisioned from observing that the proximal portion of the vane is moved axially within the rotor bore. In this aspect, the rotor bore can be a blind bore. Thus, in the closed bottom portion of the bore, a closed working volume can be created wherein the up and down axial motion of the vane will expand and contract the volume of this closed working volume. This expansion and contraction can be used, through the incorporation of chosen valves, ports, and similar components of pumps or compressors, to affect a pump or compressor function in the bottom portion of the bore. Likewise, the proximal portion of the vane can be used as a sliding valve or sleeve valve through the use of ports formed therein the rotor bore at selected locations.

[00114] According to various aspects, the bottom or proximal portion of the vane can be configured to act as an additional vane, and can comprise a vane seal assembly (*i.e.*, a vane apex seal and vane side seals positioned therein a respective slot at the proximal end of the vane) configured to contact the inner wall surface of the housing. As can be appreciated, by doubling the number of vanes, the number of chambers therein the rotary compressor can be doubled. It is contemplated that additional inlet and outlet ports can be provided within the rotor and/or housing to effect the fluid flow into and out of the rotary compressor to maximize pumping efficiency. According to yet another aspect, a plurality of vanes can be provided to increase the suction, compression, and/or pumping functions of the rotary compressor.

[00115] In another aspect, an exemplary lubrication system of a rotary compressor is illustrated. In one aspect, the radial edges of the respective first and second end plates are configured to pass through an oil bath that is positioned therein the lower portions of the assembled rotary compressor as the rotor rotates. Oil that adheres to the portions of the first and second end plates is brought into the upper portions of the assembled rotary compressor. As the oil is brought into the upper portions, the housing seals are wetted and oil is flung off into the substantially open void between the first and second end plates and the respective housing front and back covers. Such an exemplary lubrication system can be used, for example, with an internally lubricated compressor or pump. It is of course contemplated that an oil bath can be omitted and the working fluid being compressed or pumped by the rotary compressor can act as a lubricant. In other aspects, a lubricant can be mixed with the working fluid to provide the necessary lubrication for the rotary compressor, including the various seals and contact surfaces.

[00116] According to various aspects, means for cooling the rotary compressor can be provided, such as but not limited to cooling fins placed in selected locations on the

exterior of the housing, first and second end plates, and/or other locations, such that ambient air can access the cooling fins and promote heat transfer away from the apparatus into the ambient air. In other aspects, specific cooling circuits can be provided that incorporate air-to-air, liquid-to-air, air-to-liquid, or liquid-to-liquid cooling processes to achieve the desired cooling.

[00117] According to yet another aspect, the intake air can be routed through passages provided in the high temperature components of the rotary compressor to augment heat flux out of these areas and into the intake air stream. In some aspects, an external fan can be provided to facilitate air flow over the rotary compressor. Optionally, an oil cooling circuit can be utilized to provide the desired level of cooling. In some aspects, an oil separator device can be incorporated into the oil cooling circuit in which the outlet air is conditioned such that any airborne oil within the discharge stream is removed, cooled, and recirculated into the device.

[00118] As described above, in one aspect, the opposed bearing surfaces of the vane can interact with an eccentric cam to effect the axial movement of the vane within the rotor. According to another aspect, a connecting rod assembly can be provided to interact with the eccentric cam to effect the axial movement of the vane. For example, a connecting rod 191 can be attached to the vane 260 (such as, but not limited to, with a pin 192) proximate the distal end of the vane. The connecting rod can extend downwardly into the hollow of the vane. In one aspect, the portion of the connecting rod that extends into the hollow defines a hole sized and shaped to receive the cam. As the rotor rotates about the rotor axis of rotation, the connecting rod will likewise rotate about the cam, thereby causing the axial movement of the vane within the rotor bore.

[00119] According to yet another aspect, the axial movement of the vane can be effected by a cam-follower mechanism in the vane 360. In this aspect, it is contemplated that the cam 328 can have any shape, such as but not limited to the non-circular shape. A cam-follower mechanism comprising a roller 393 can be provided therein the vane, with the roller extending into the hollow of the vane to interact with the cam. In another aspect, a spring 394 can be provided to urge the roller against the surface of the cam. As the rotor rotates about the rotor axis of rotation, the roller will follow the cam, thereby causing the axial movement of the vane within the bore of the rotor. It is contemplated that in this aspect, the housing 310 can define an internal cavity having any cross-sectional shape, such as but not limited to a non-circular shape.

[00120] As exemplarily illustrated, in the various embodiments described herein, it is contemplated that the shape of the internal cavity of the housing can be selected to

complement the shape of the cam, and vice versa, such that the distal end of the vane can be constrained to be spaced proximate from the inner wall surface of the housing as the rotor rotates about the rotor axis of rotation.

[00121] According to various other aspects, the rotary compressor can comprise vane assemblies comprising one or more vanes and/or comprising one or more end portions configured to be spaced proximate from the inner wall surface of the housing. For example, as illustrated in Figures 17A and 17B, the rotary compressor can comprise a dual-end vane 460. In this aspect, the bore of the rotor can be configured to extend fully through the rotor to receive the dual-end vane 460 and the dual-end vane can be slidably mounted with the rotor 450 and movable axially therein. The dual-end vane can have a distal end and an opposed proximal end. The dual-end vane can be movable axially therein the rotor bore about and between a first position in which the distal end of the dual-end vane is positioned at a first distance from the peripheral surface of the rotor, and a second position in which the distal end of the dual-end vane is positioned at a second distance from the peripheral surface of the rotor. It is contemplated that, in the first position, the proximal end of the dual-end vane is positioned at substantially the second distance from the peripheral surface of the rotor, and in the second position, the proximal end of the dual-end vane is positioned at substantially the first distance from the peripheral surface of the rotor. Each of the distal end and proximal end of the dual-end vane can be constrained to be spaced proximate from the inner wall surface of the housing as the rotor rotates about the rotor axis of rotation.

[00122] In one aspect, at least portions of the peripheral surface of the rotor 450, portions of the inner wall surface of the housing 410, and varying portions of the dual-end vane 460 proximate the distal end of the dual-end vane define a first compression chamber of varying volume as the rotor rotates about the rotor axis of rotation. Similarly, at least portions of the peripheral surface of the rotor, portions of the inner wall surface of the housing, and varying portions of the dual-end vane proximate the proximal end of the dual-end vane define a second compression chamber of varying volume as the rotor rotates about the rotor axis of rotation.

[00123] According to yet another aspect, at least one inlet port 475 can be formed therein the dual-end vane assembly. In a particular aspect, an inlet port is formed therein each of the distal and proximal ends of the dual-end vane. In one aspect, the distal end can define at least one inlet port in fluid communication with the first compression chamber. In another aspect, the proximal end can define at least one inlet port in fluid communication with the second compression chamber. According to yet another aspect, each of the distal end and proximal end can define at least one inlet port in fluid communication with the first compression chamber and second compression chamber, respectively.

[00124] According to various aspects, the rotary compressor can further comprise means for selectively opening and closing the at least one inlet port therein the respective distal end and proximal ends of the dual-end vane. For example and not meant to be limiting, as illustrated in the cross-sectional view of Figure 17B, the inlet port(s) 475 of the dual-end vane can be configured to align with a respective inlet port 457 of an end plate, such as but not limited to a second end plate 451b, of the rotary compressor at a predetermined position in the dual-end vane's axial movement within the bore of the rotor. At this predetermined position, the vane inlet port(s) 475 can provide an intake passageway between the inlet port of the second end plate and a respective one of the first or second compression chambers. As the rotor rotates about the rotor axis of rotation, thereby effecting the axial movement of the dual-end vane therein the rotor bore, the intake passageway can be selectively opened and closed based on the alignment or non-alignment, respectively, of the vane inlet port(s) 475 and the end plate inlet port(s) 457.

[00125] In another aspect, the dual-end vane 460 can define a hollow 461 having at least one bearing surface that is configured for selective contact with portions of the cam 428. The distal end and an opposing proximal end of the dual-end vane can each define a respective slot 464 for receiving a respective vane apex seal 466. In one aspect, the vane apex seal 466 can be a unitary seal configured to provide side and apex sealing of the vane against the first and second end plates and the inner wall surface of the housing, respectively. Optionally, a vane apex seal and side seals can be provided. According to another aspect, each end portion of the dual-end vane assembly can define at least one groove 471 for receiving a respective vane sealing element 472.

[00126] As described above, a vane having dual end portions can be formed as a unitary dual-end vane assembly. Optionally, a double-vane assembly can be provided that comprises a first vane portion 560a and a second vane portion 560b, each in operative cooperation with the eccentric cam 528. Each of the first and second vane portions can comprise a respective distal end portion that can be constrained to be spaced proximate from the inner wall surface of the housing as the rotor rotates about the rotor axis of rotation. As described above with regard to an exemplary vane assembly 160, each vane portion 560a, 560b of the double-vane assembly can define a hollow having at least one bearing surface that is configured for selective contact with portions of the cam 528. The at least one bearing surface can comprise a pair of opposed bearing surfaces machined in each of the vane portions, and/or provided by an upper and lower eccentric plate such as described above. In one aspect, each of the first and second vane portions can comprise a pair of opposed bearing surfaces that are at least partially curved such as described with respect to the vane shown in Figure 17. As the rotor 550 rotates about the rotor axis of rotation, each

of the first and second vane portions 560a, 560b can operatively cooperate with the cam 528 to effect the axial movement of the first and second vane portions therein the rotor bore, thereby effectively controlling the position of the distal end of each of the vane portions with respect to the inner wall surface of the housing 510.

[00127] According to yet another aspect, the rotary compressor can comprise a quad-vane assembly 660. In one aspect, the quad-vane assembly can comprise two dual-sided vane assemblies, each having opposing end portions and defining a substantially central hollow having at least one bearing surface configured for selective contact with portions of the cam 628. The dual-sided vane assemblies can be positioned substantially perpendicularly to each other such that the cam is positioned therein the hollow of each of the dual-sided vane assemblies. According to one aspect, at least portions of the peripheral surface of the rotor 650, portions of the inner wall surface of the housing 610, and varying portions of the quad-vane assembly 660 proximate each end portion of the dual-sided vane assemblies can define a plurality of suction and/or compression chambers.

[00128] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Other aspects of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

CLAIMS

What is claimed is:

1. A rotary fluid-displacement assembly, comprising:

a rotor housing assembly defining an internal cavity having an inner wall surface and an outer wall surface, wherein the rotor housing assembly has a rotor housing assembly longitudinal axis extending transverse to a rotor housing assembly plane that bisects the inner wall surface, and wherein the rotary housing assembly comprises:

at least one valve cavity defined in the rotor housing assembly extending radially from the inner wall surface to the outer wall surface; and

at least one discharge valve assembly, each discharge valve assembly comprising a valve that is configured to be movably disposed in one respective valve cavity, wherein each valve of each discharge valve assembly being movable about and between a first position, in which at least a portion of the valve is disposed against the opening proximate the inner wall surface, and a second position, in which at least a portion of the valve is displaced from the opening proximate the inner wall surface;

a rotor having a peripheral surface and being positioned within the internal cavity of the rotor housing assembly, the rotor configured to rotate about a rotor axis of rotation; and

a vane having a distal end, the vane being slidably mounted with the rotor;

wherein at least portions of the peripheral surface of the rotor, portions of the inner wall surface of the rotor housing assembly, and varying portions of the vane proximate the distal end of the vane define a compression chamber of varying volume as the rotor rotates about the rotor axis of rotation; and

wherein the discharge assembly selectively moves from the first closed position to the second open position when a compression chamber pressure reaches a pressure which is higher than back pressure on valve.

2. The rotary fluid-displacement assembly of claim 1, wherein the at least one discharge valve assembly further comprises a valve retainer adapted to slidably receive a distal end of the valve.

3. The rotary fluid-displacement assembly of claim 2, wherein the valve further comprises a valve sealing member and a valve stem that extends distally from a bottom surface of the valve sealing member to the distal end of the valve.
4. The rotary fluid-displacement assembly of claim 3, wherein the valve sealing member is substantially planar and is positioned substantially transverse to the valve stem, wherein at least a portion of the circumferential edge proximate the top surface of the valve sealing member is distally tapered.
5. The rotary fluid-displacement assembly of claim 4, wherein at least a portion of the circumferential edge proximate the top surface of the valve sealing member has a cross-section that is at least partially concave.
6. The rotary fluid-displacement assembly of claim 4, wherein at least a portion of the circumferential edge proximate the top surface of the valve sealing member has a cross-section that is at least partially convex.
7. The rotary fluid-displacement assembly of claim 4, wherein at least a portion of the at least one valve cavity proximate the inner wall surface of the rotor housing assembly has a complementary shape to the at least a portion of the circumferential edge proximate the top surface of the valve sealing member.
8. The rotary fluid-displacement assembly of claim 3, wherein the valve retainer defines a valve stem retaining feature adapted to slidably receive a portion of the valve stem.
9. The rotary fluid-displacement assembly of claim 4, wherein the valve retainer comprises at least one pressure balancing port that is in fluid communication with the valve stem cavity.
10. The rotary fluid-displacement assembly of claim 2, further comprising a biasing means disposed between the valve and the valve retainer;
11. The rotary fluid-displacement assembly of claim 10, wherein the biasing means comprises at least one spring member.
12. The rotary fluid-displacement assembly of claim 11, wherein the at least one spring member comprises a first spring mounted between a distal end of the valve stem and a distal end of the valve stem cavity and a second spring extending between the bottom surface of the valve sealing member and a base surface of the valve retainer.

13. The rotary fluid-displacement assembly of claim 1, wherein the at least one valve cavity comprises a plurality of valve cavities, and wherein the at least one discharge valve assembly comprises a plurality of discharge valve assemblies.
14. The rotary fluid-displacement assembly of claim 13, wherein a plurality of valve cavities and a corresponding plurality of discharge valve assemblies are irregularly sized.
15. The rotary fluid-displacement assembly of claim 13, wherein each of the valve cavities has an upper opening defined on the outer wall surface of the rotor housing assembly, and wherein the upper openings of the plurality of valve cavities are circumferentially spaced about at least a portion of the outer wall surface.
16. The rotary fluid-displacement assembly of claim 15, wherein the upper openings of the plurality of valve cavities are circumferentially spaced about the outer wall surface and are staggered about the rotor housing assembly plane.
17. The rotary fluid-displacement assembly of claim 16, wherein the upper openings of the plurality of valve cavities are circumferentially irregularly spaced about the outer wall surface.
18. The rotary fluid-displacement assembly of claim 14, wherein a plurality of valve cavities and a corresponding plurality of discharge valve assemblies are irregularly sized.
19. The rotary fluid-displacement assembly of claim 1, wherein the at least one discharge valve assembly is secured radially in the at least one valve cavity via at least retaining member.
20. The rotary fluid-displacement assembly of claim 19, wherein the at least one retaining member is a spring clip.
21. The rotary fluid-displacement assembly of claim 1, wherein the vane is movable axially about and between a first position, in which the distal end of the vane is positioned at a first distance from the peripheral surface of the rotor, and a second position, in which the distal end of the vane is positioned at a second distance from the peripheral surface of the rotor, wherein the distal end of the vane is constrained to be spaced proximate to the inner wall surface of the housing as the rotor rotates about the rotor axis of rotation.
22. The rotary fluid-displacement assembly of claim 1, wherein the rotor has at least one inlet port in fluid communication with the compression chamber.

23. The rotary fluid-displacement assembly of claim 1, wherein the vane has at least one inlet port in fluid communication with the compression chamber.
24. The rotary fluid-displacement assembly of claim 23, further comprising means for selectively opening and closing the at least one inlet port therein the vane.
25. The rotary fluid-displacement assembly of claim 1, wherein the housing has at least one inlet port in fluid communication with the compression chamber.
26. The rotary fluid-displacement assembly of claim 1, wherein the first distance is greater than the second distance.
27. The rotary fluid-displacement assembly of claim 1, wherein the second distance is proximal to the peripheral surface of the rotor.
28. The rotary fluid-displacement assembly of claim 1, wherein, in the second position, the distal end of the vane is at or below the peripheral surface of the rotor.
29. The rotary fluid-displacement assembly of claim 1, wherein the housing has at least one outlet port in fluid communication with the compression chamber.

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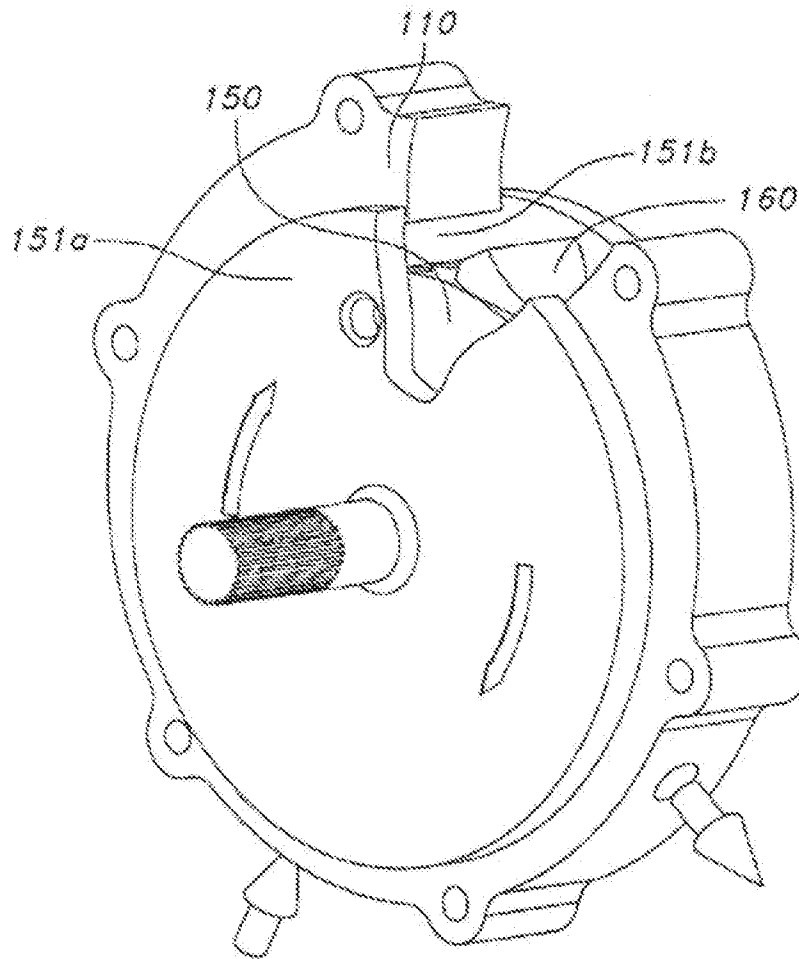


FIG. 1

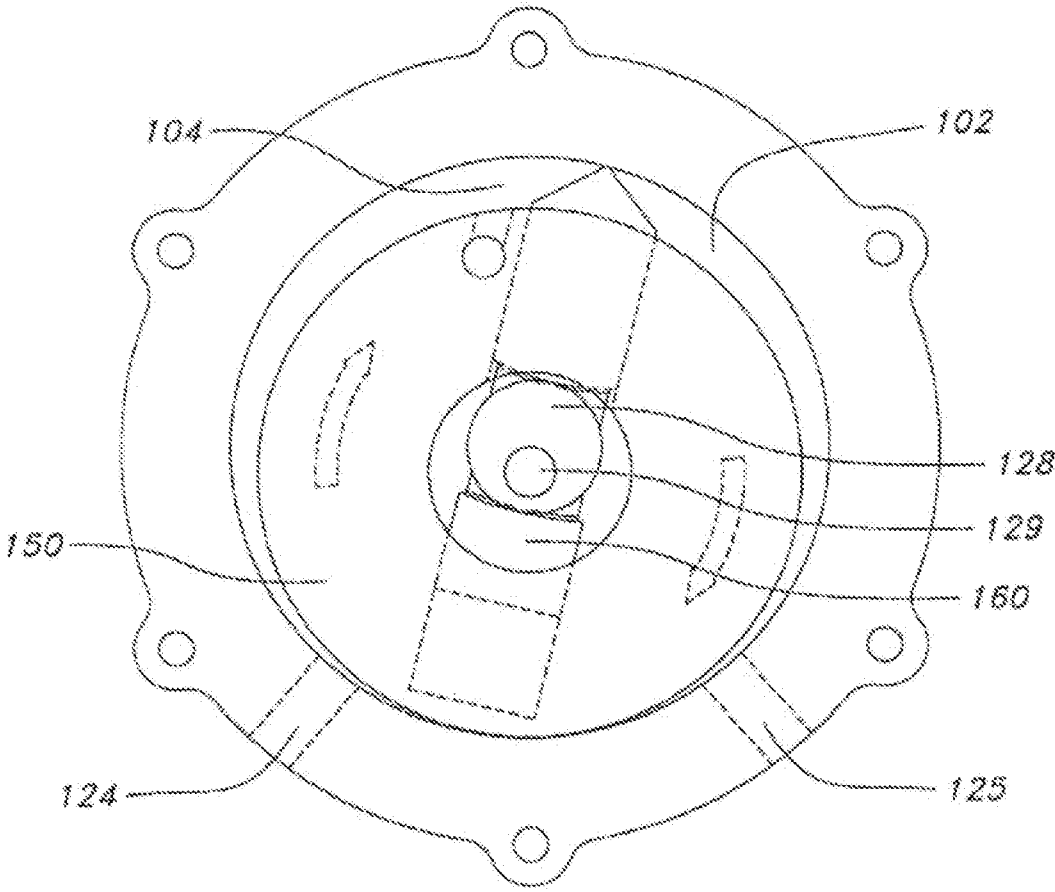


FIG. 2

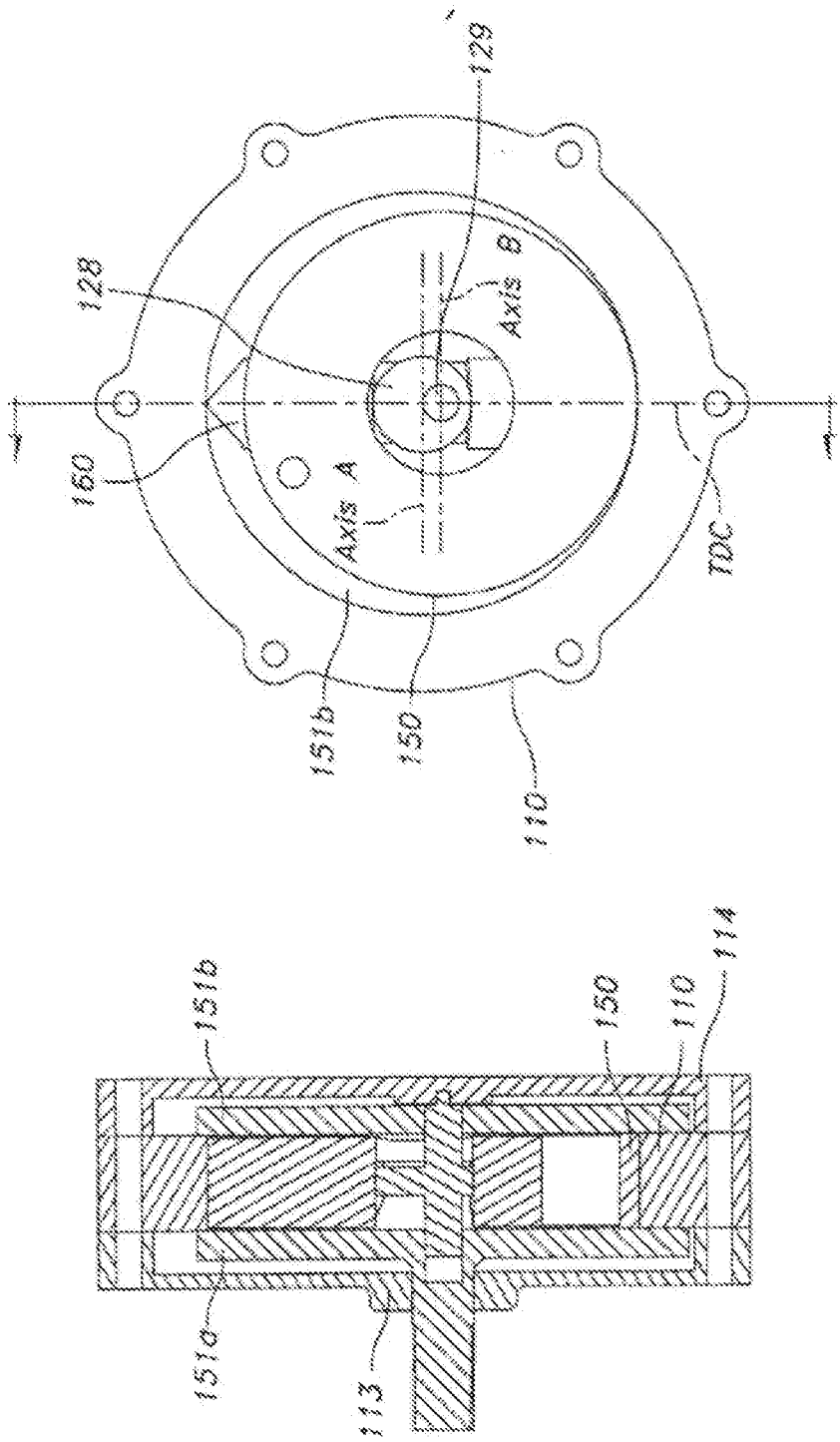


FIG. 3

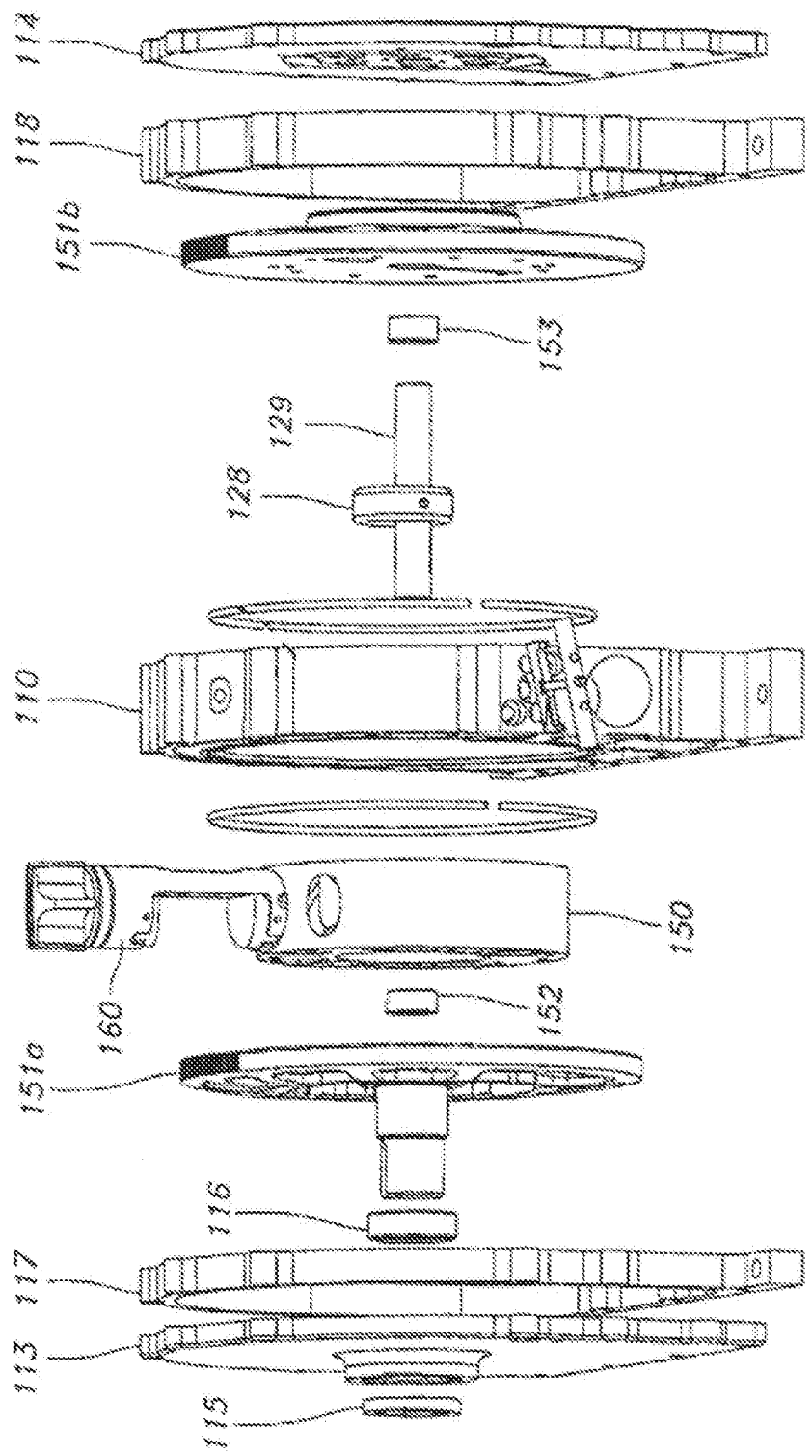


FIG. 4A

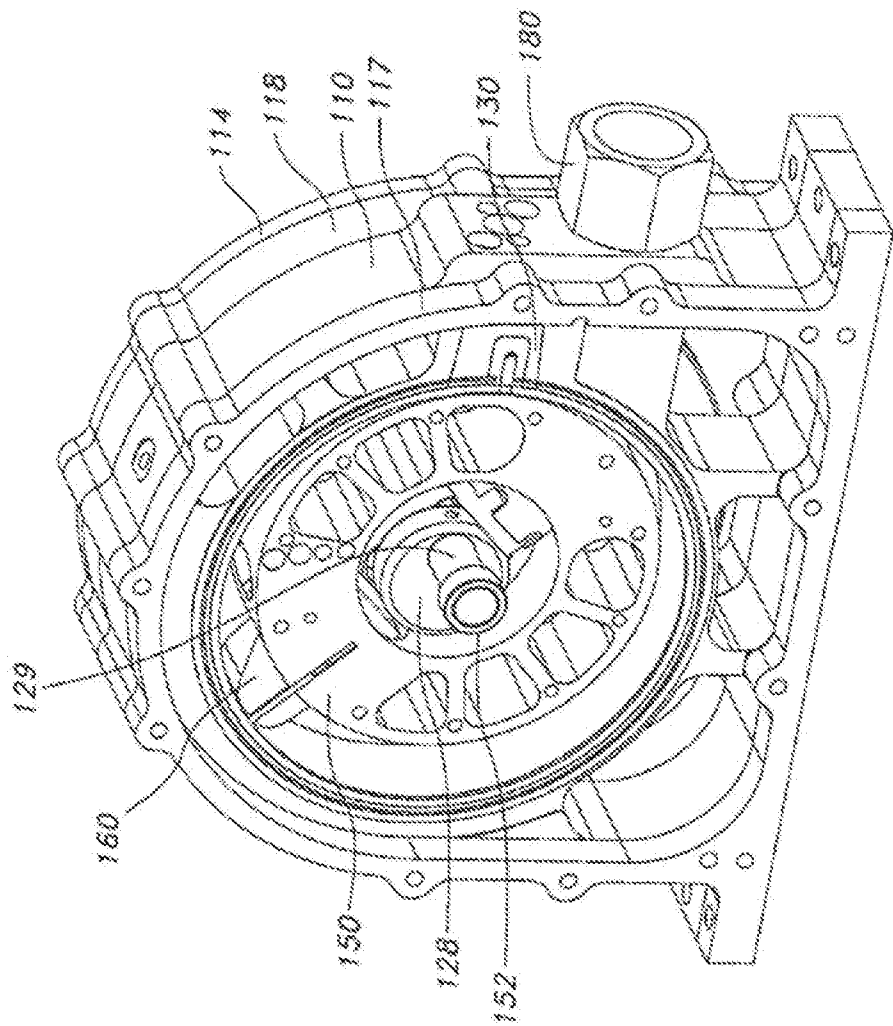
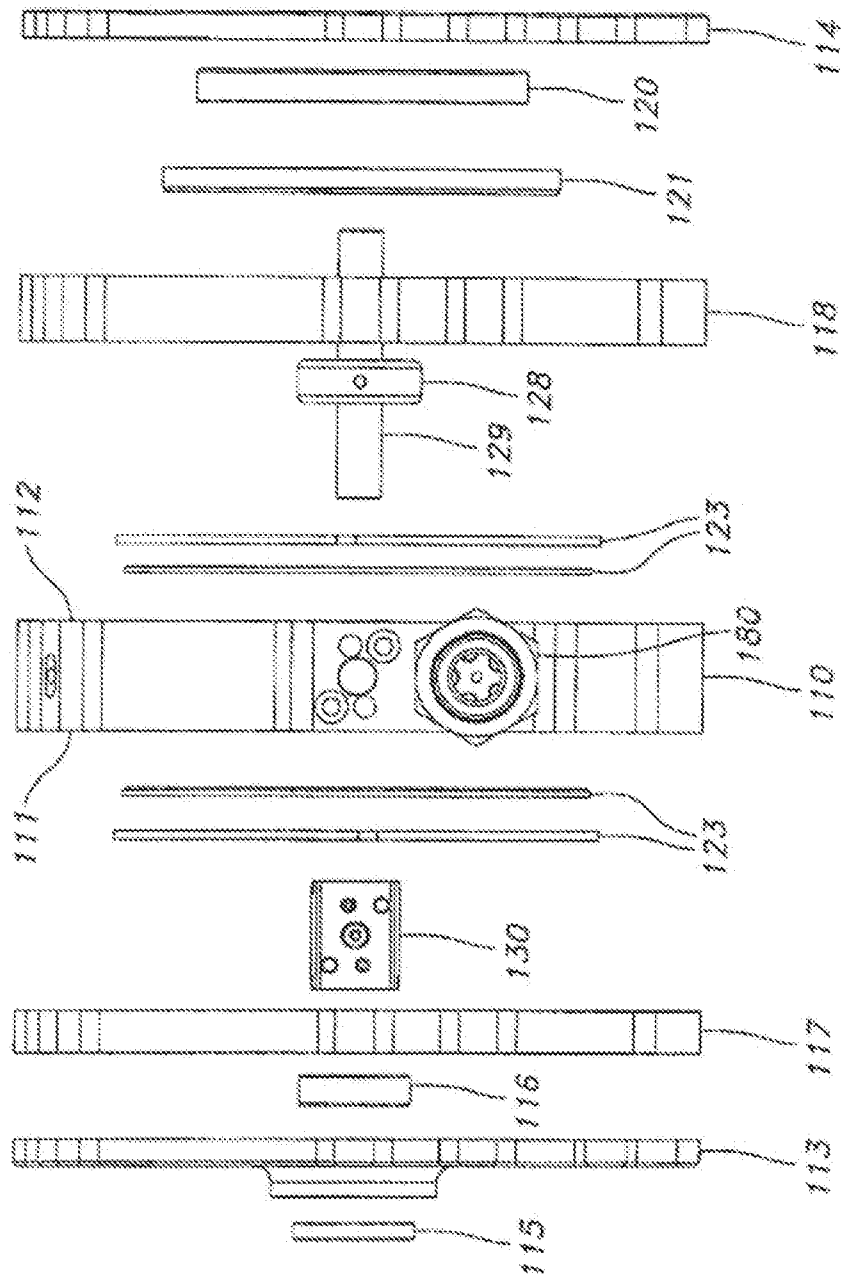


FIG. 4B



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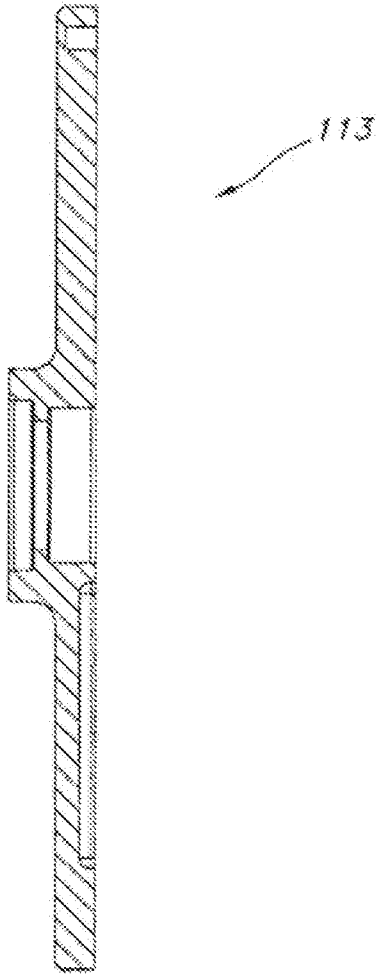


FIG. 6

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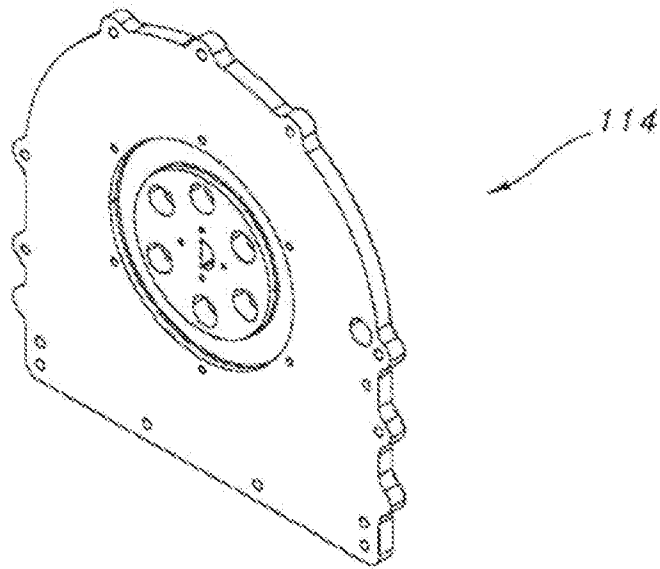


FIG. 7

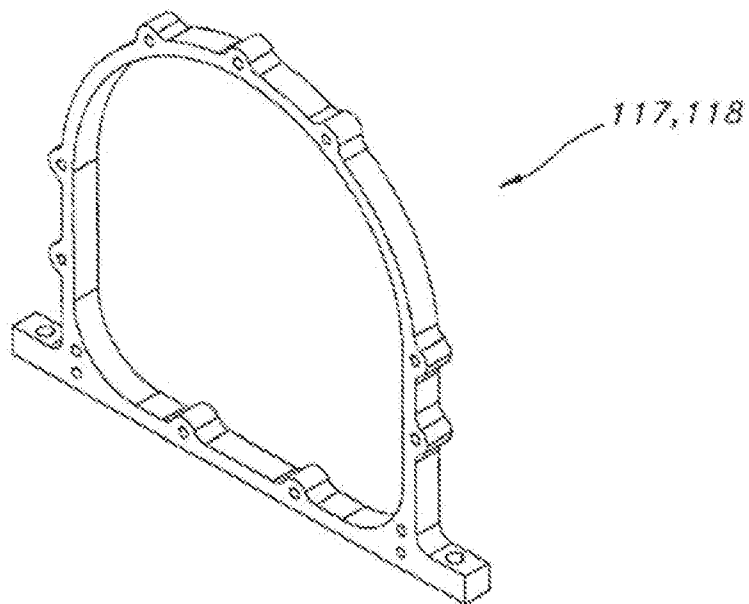


FIG. 8

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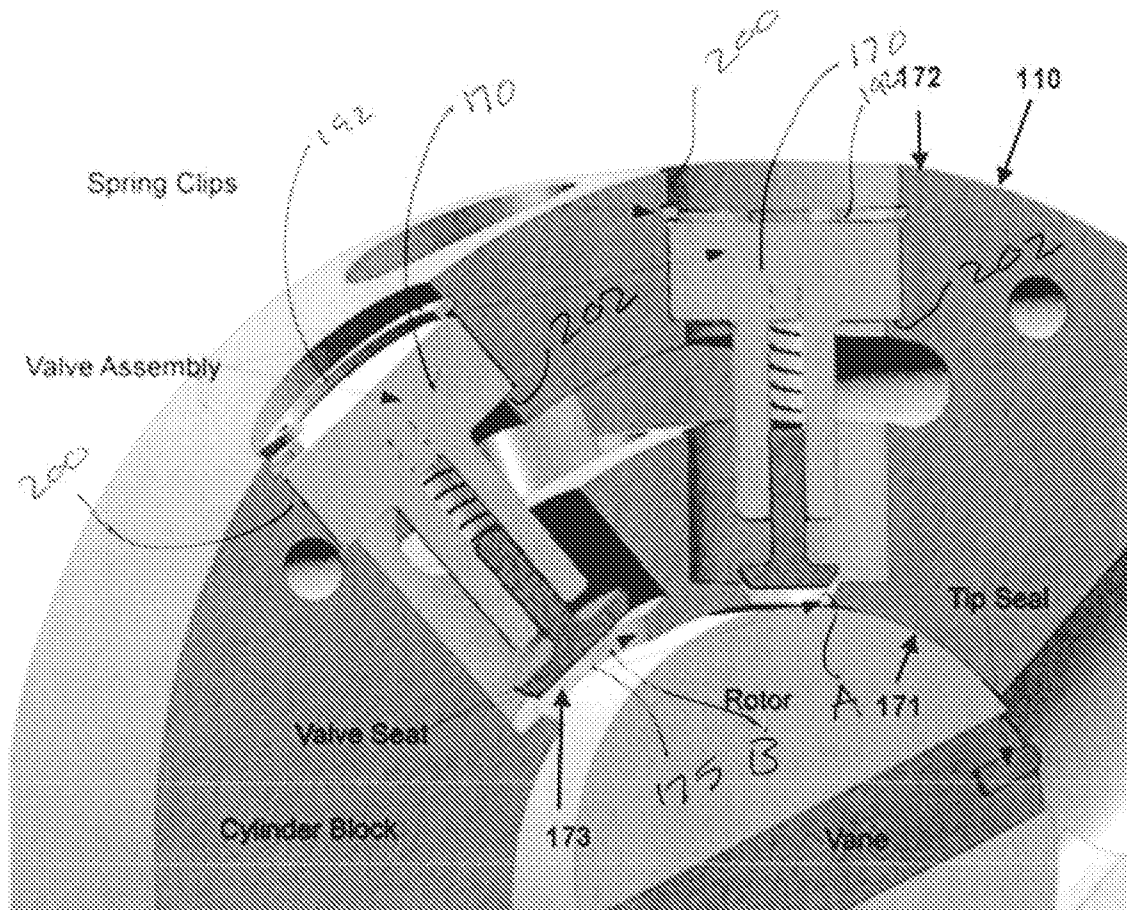


FIG. 9

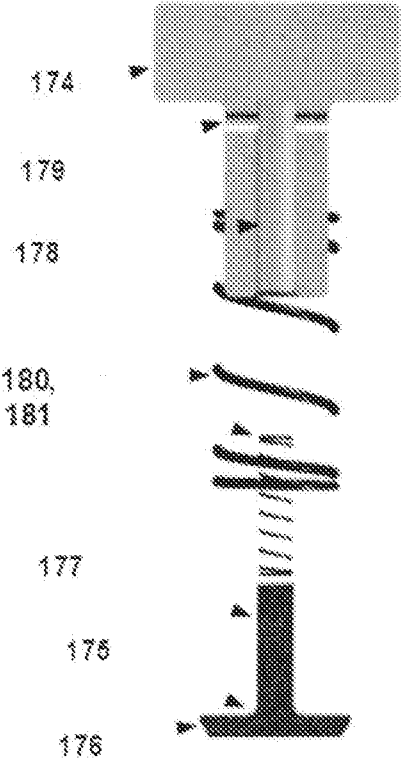


FIG. 10

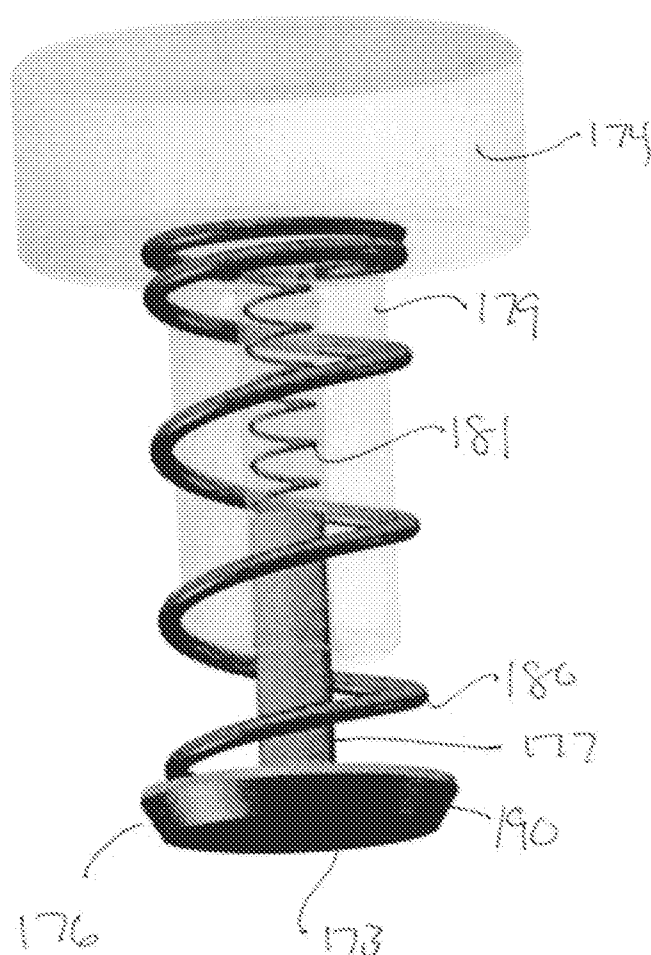


FIG. 11

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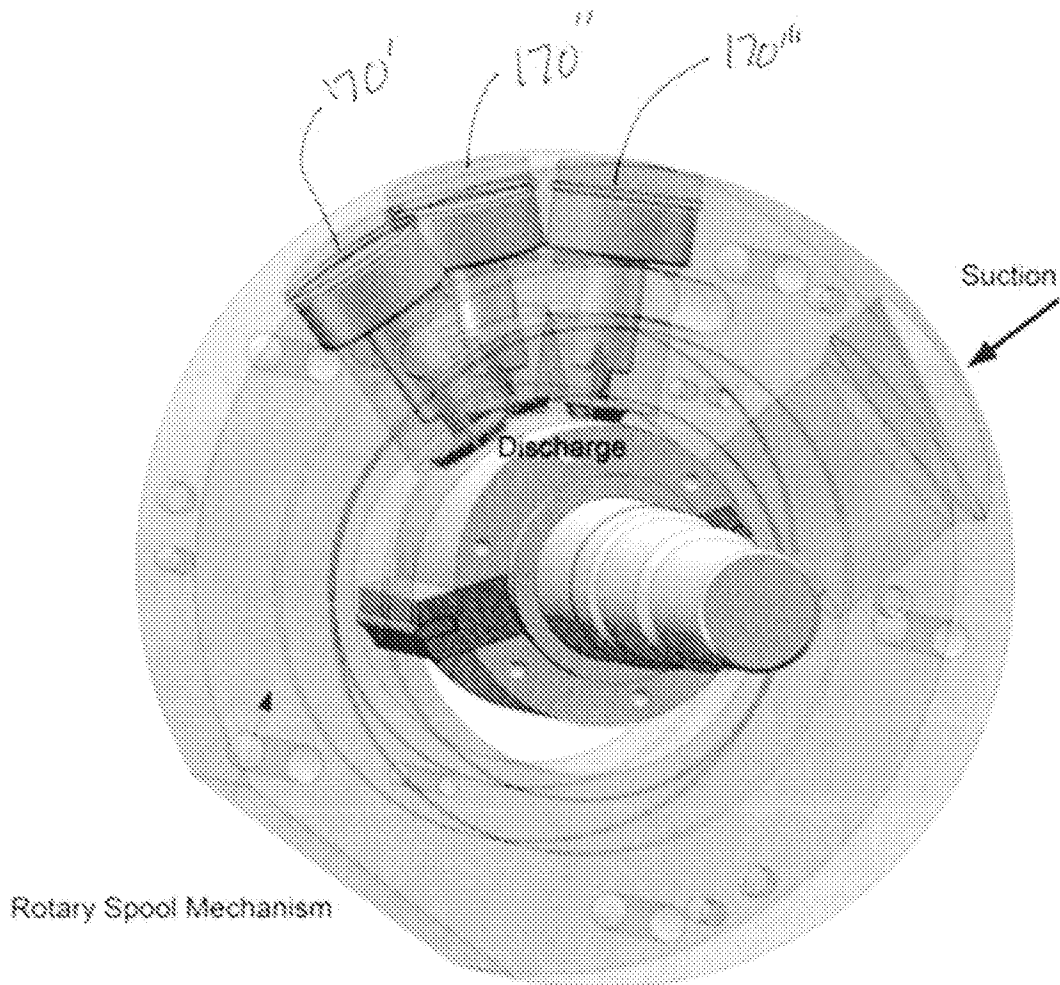


FIG. 12

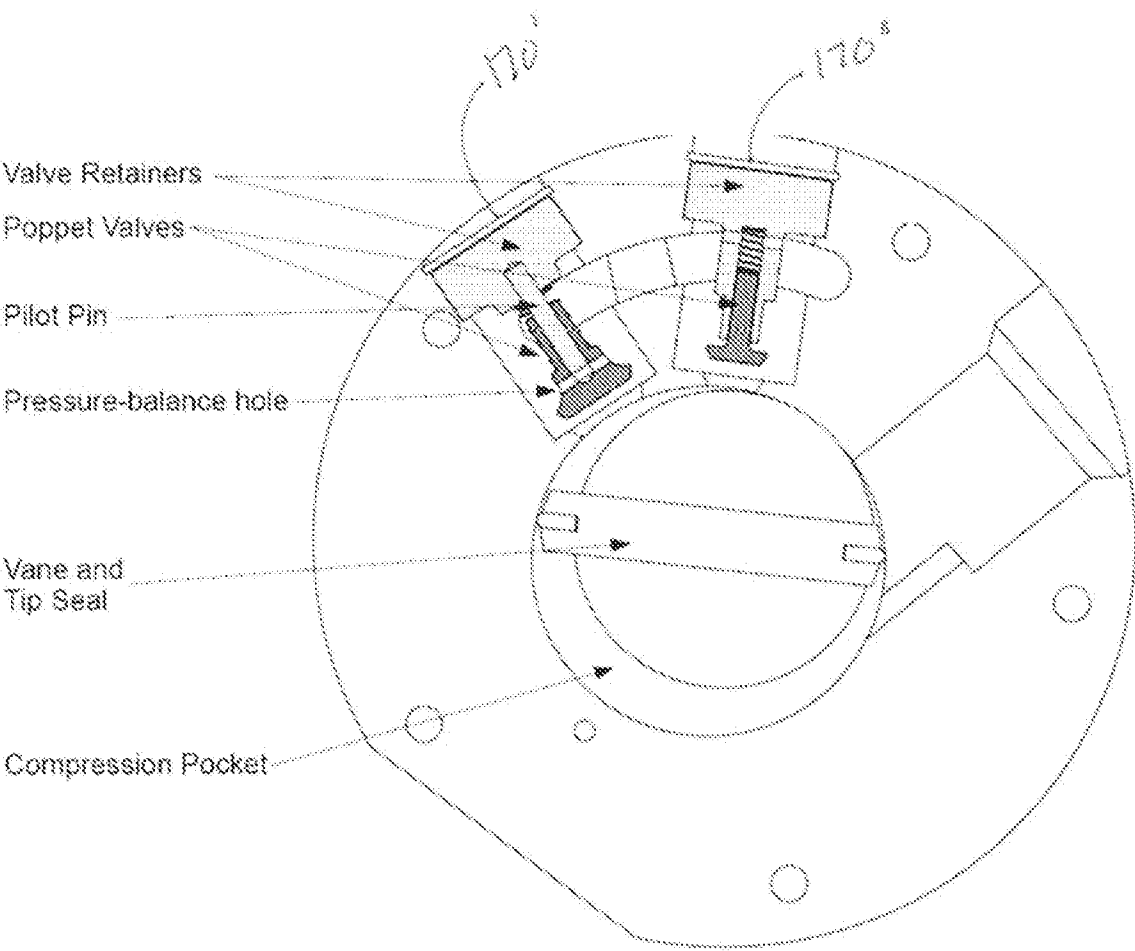


FIG. 13

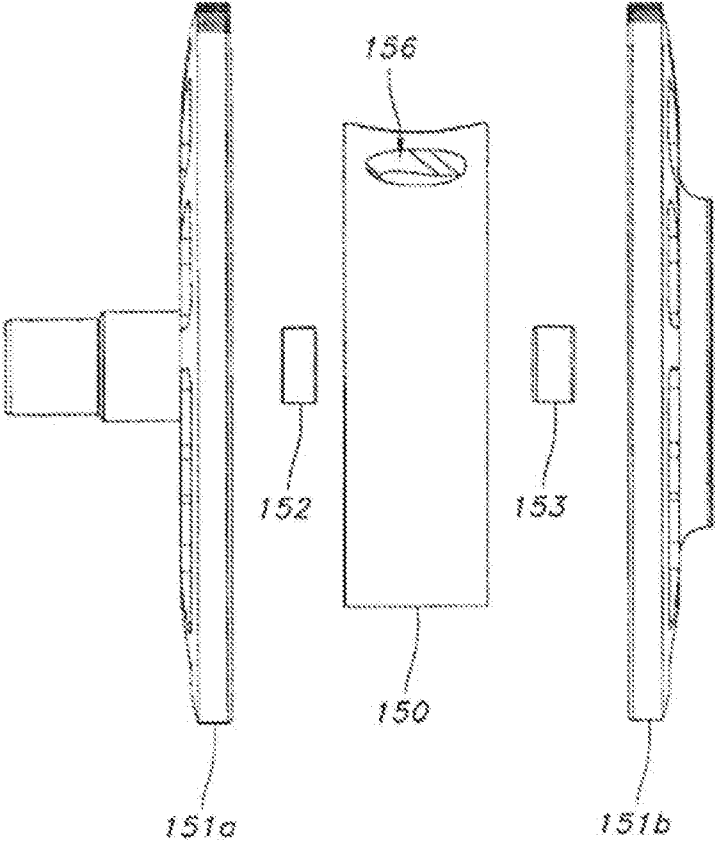


FIG. 14

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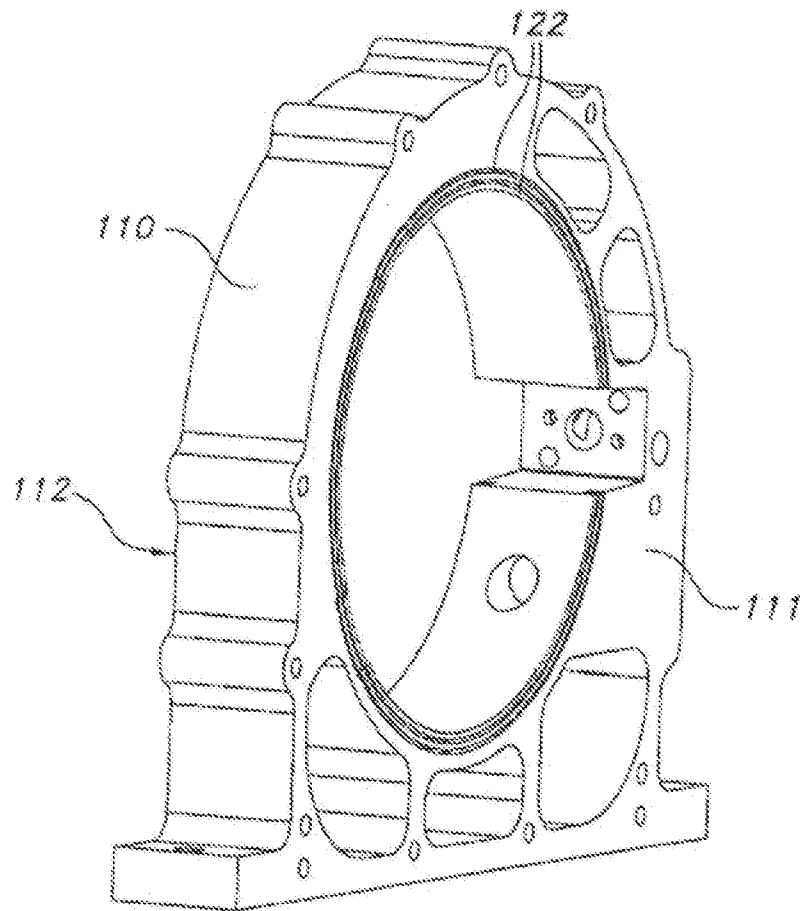


FIG. 15

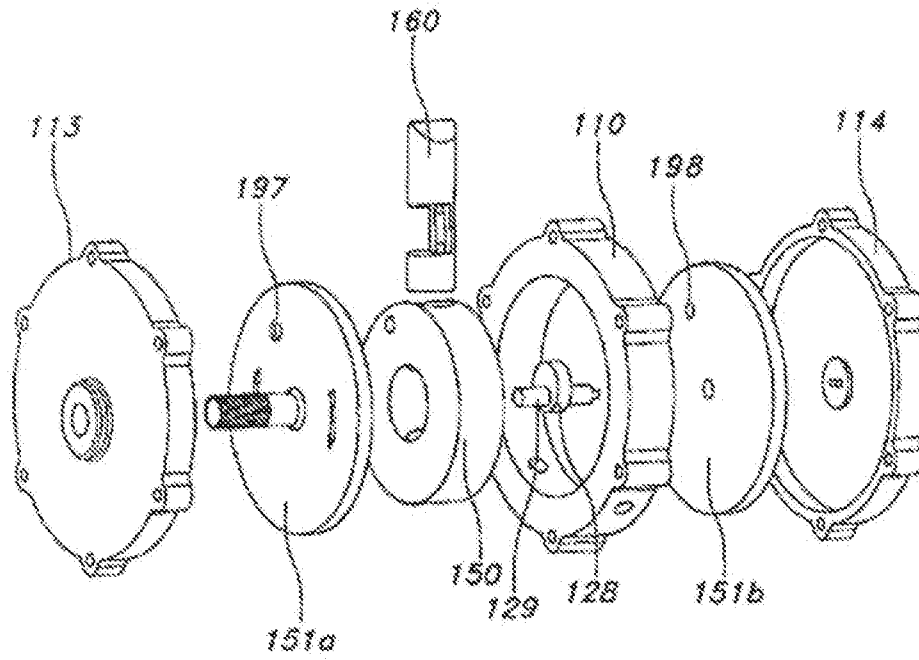


FIG. 16

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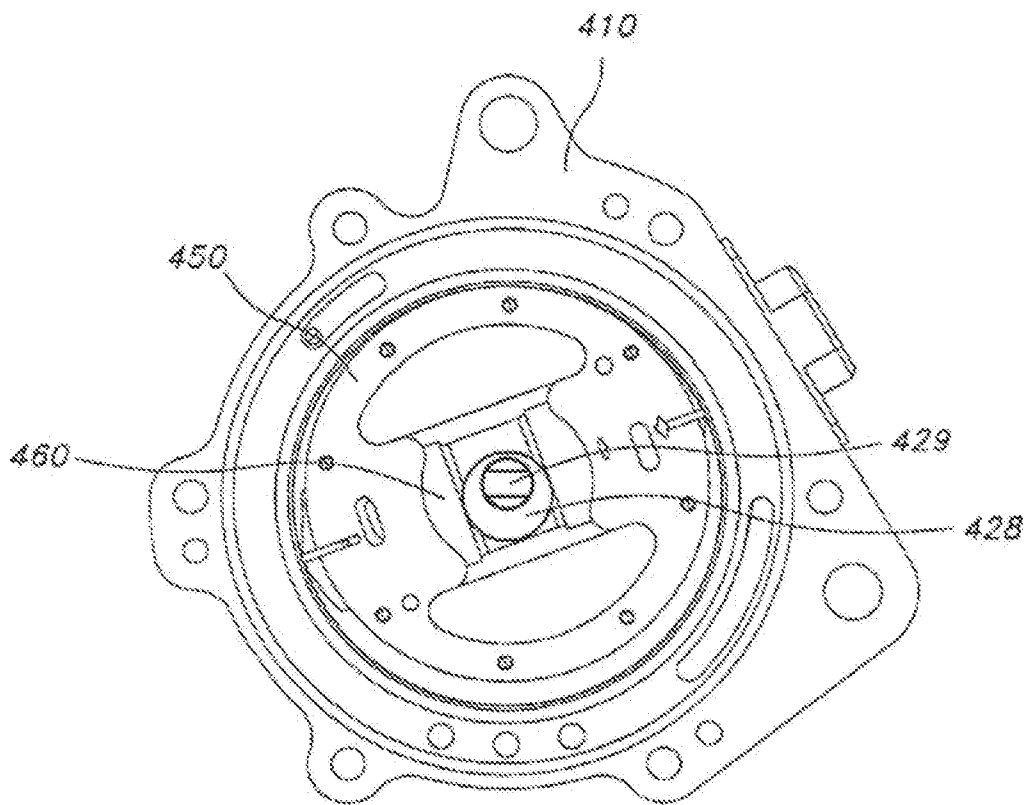


FIG. 17A

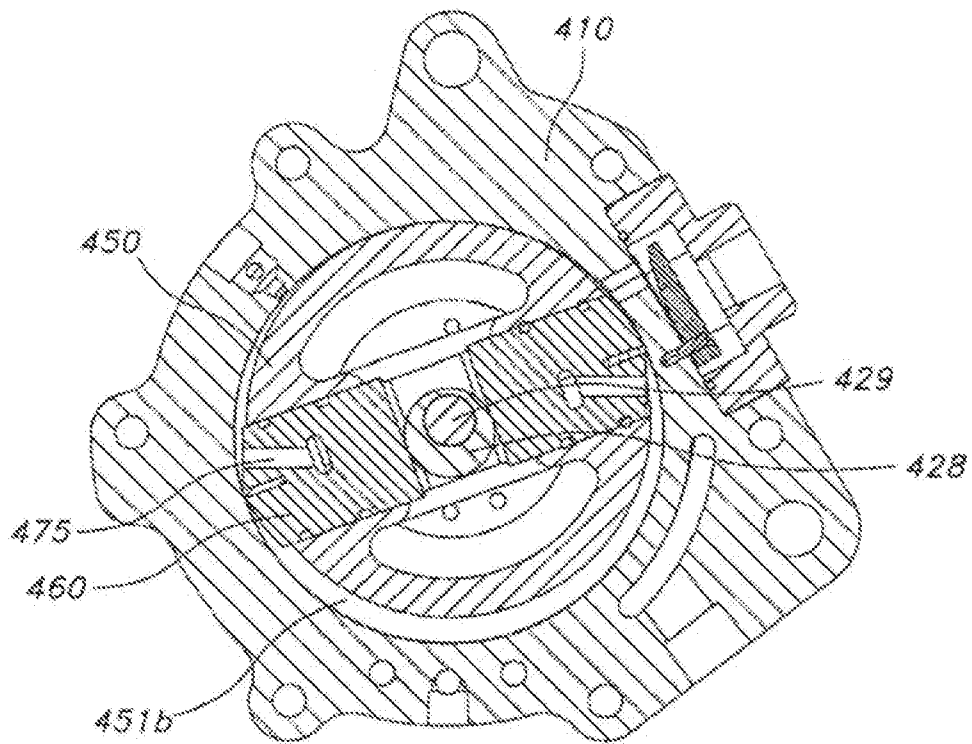


FIG. 17B

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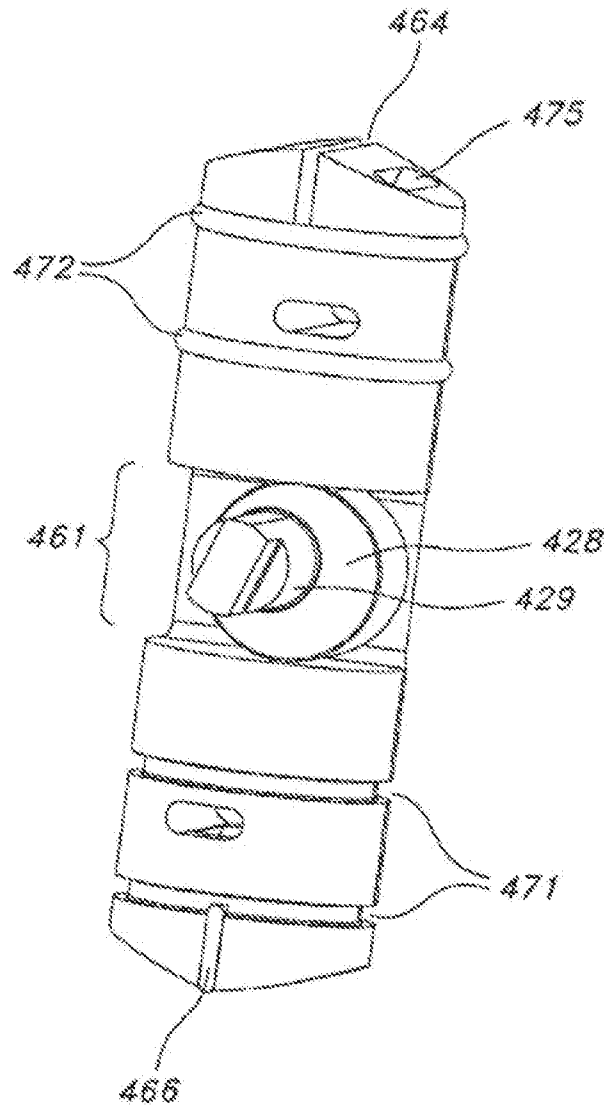


FIG. 18

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/039104

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F04C 18/00 (2015.01)

CPC - F04C 18/00 (2015.07)

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(8) - F01C 1/00; F03C 2/00; F04C 2/00, 18/00, 18/344 (2015.01)

USPC - 123/231, 235, 236, 243; 137/455, 535; 251/321, 322, 323, 337; 415/232; 417/212, 283, 299, 310; 418/11, 29, 140, 145, 259

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

CPC - F01C 1/00; F03C 2/00; F04C 2/00, 18/00, 18/344 (2015.07) (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Scholar, Google, YouTube.

Search terms used: rotor, compressor, pump, vane, valve, spring, bias, pressure, balance, open, translate, stem, seal, radial, seat, case, housing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 37 37 949 A1 (VEB KOMBINAT MEDIZIN – UND LABORTECHNIK LEIPZIG) 18 August 1988 (18.08.1988) see machine translation	1,2,10,11,13-15,18,19,21, 23-29
Y	US 2002/0187050 A1 (NARNEY, II et al) 12 December 2002 (12.12.2002) entire document	1,2,10,11,13-15,18,19,21, 23-29
Y	US 4,664,608 A (ADAMS et al) 12 May 1987 (12.05.1987) entire document	23,24
A	US 2008/0307808 A1 (MASAO) 18 December 2008 (18.12.2008) entire document	1-29

☐ Further documents are listed in the continuation of Box C.☐ 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

26 August 2015

Date of mailing of the international search report

30 SEP 2015

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