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(54) **PUMPING SYSTEM WITH INNER SCROLLS**

(57) The present invention relates to a novel type of rotary positive displacement pump. Said pump achieves pumping by means of the translation and rotation of a type of gear inside a casing provided with inner grooves in the shape of a toroidal thread. The pump has a novel design with various properties depending on the various possible configurations.

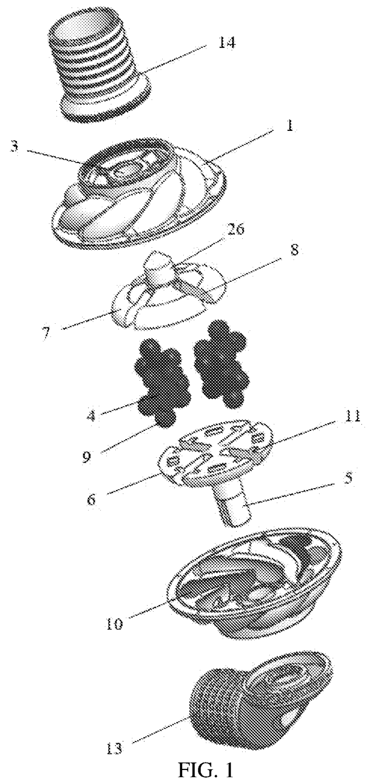


FIG. 1

Description

[0001] The present patent application refers to a new type of positive displacement rotary pump. The project presents varied properties according to the established configuration. One of the configurations has a higher flow capacity than the other types of positive displacement pumps. One of the models of the invention presents an internal compression between the elements of the chambers, an ideal property for use in compressors. The perfect dynamic balance and robust geometry favor use at high speeds, favorable conditions for use as a high-power hydraulic motor. Currently, centrifugal pumps are the lowest cost alternative when pumping requires a high flow and a low discharge pressure is sufficient. When the pumping process requires reaching a higher discharge pressure, a commonly used option is multistage centrifugal pumps. These pumps in series can have more than 40 stages. As the stages increase, the cost increases and the mechanical efficiency drops. There is a gap between turbopumps and volumetric pumps, as turbopumps have a reasonable mechanical performance and a great cost for use in low discharge pressure in onestage models, on the other hand, positive displacement pumps are capable of reaching high discharge pressures with excellent mechanical performance, however the flow capacity is low and the cost of acquisition and maintenance is extremely high.

[0002] With the development of the "internal spring pumping system" according to the geometric and functional results obtained, the project fits perfectly as a viable alternative to a high-volume, low-cost positive displacement pump capable of achieving a higher discharge pressure than single-stage centrifugal pumps.

[0003] The pumped volume is extremely high even when compared to some high-flow centrifugal pumps of the same size driven by standard 2-pole electric motors, rotation close to 3600 rpm. A pump with internal spring of 120 mm in diameter and 50 mm thick (not counting the collectors, in the illustrated case, spikes) can pump more than 50 m^3/hour at 3600 rpm. It is worth remembering that positive displacement pumps are capable of practically maintaining the flow as the discharge pressure increases, unlike centrifugal pumps, which present a sharp drop in flow in their flow x pressure curve.

[0004] The invention may be better understood through the following detailed description, in line with the figures below, where:

FIGURE 1 represents an exploded view of the "internal spring pumping system" in an 8-entry high-flow configuration.

FIGURE 2 represents the assembly in a radial section of the "internal spiral pumping system" shown in figure 1,

FIGURE 3 represents a view of a 5-lobe salient lobe gear used in the 8-entry pump configuration.

FIGURE 4 represents an inside view of a 4-entry housing for use with 5-lobe lobe gears.

FIGURES 5, 6 and 7 represent the trajectory of the toroidal thread that defines the generation of the spiral grooves of a pump with 8 entries, the last figure being in section.

FIGURE 8 represents a cross-sectional view of an 8-entry housing.

FIGURES 9, 10, 11 and 12 represent assemblies of a pump configuration with internal compression in the configuration with the housing with 3-entry containing the rotor 3 lobular gears with 12 lobes each.

FIGURE 9 represents a view of the pump without the smooth housing.

FIGURE 10 represents a view of the pump only with a housing of turns and the lobular gears in their respective positions.

FIGURE 11 represents another higher view of figure 10 for the internal compression observation.

FIGURE 12 represents a cross-sectional view of the pump assembly shown in figure 11.

FIGURES 13, 14 and 15 represent a pump with 4 entries with 5 gears with 14 lobes with internal compression.

FIGURE 13 represents a cross-sectional view of the assembly for comparison with figure 12, highlighting the smaller distance between the spiral grooves.

FIGURE 14 represents a view of the pump without the upper housing, the smooth housing.

FIGURE 15 represents a view of the pump only with a housing with 4-entry turns and the 5 lobe gears in their respective positions.

FIGURE 16 represents a side view of the 8-entry pump showing the position of a cross-section orthogonal to a spiral groove of the next figure.

FIGURE 17 represents a view facing the section shown in figure 16.

FIGURE 18 represents a view of a side region of the pump with 8 entries with transparency in the housing of turns.

FIGURES 19, 20, 21 and 22 represent views in progressive cuts of the 8-entry pump assembly, the housing in figure 19 being uncut, showing its flat surface.

FIGURE 23 represents a radial section of the assembly that was represented in figure 2, whose section is in a plane that passes outside the region of the lobular gears.

FIGURE 24 represents a side view of a pump configuration with grooves and lobes in rectangular shape without the upper housing.

FIGURE 25 represents a side view of a pump configuration that features 21 lobe gears in an inclined position, closer to planes orthogonal to the trajectory defined by the spiral grooves. Only 3 consecutive lobe gears are present in the design.

FIGURE 26 is a cross-sectional view of a 16-entry "internal spring pumping system" configuration with a motor incorporated within the rotor.

FIGURE 27 represents a view of the internal spring pumping system with 3 stages in a radial section.

FIGURE 28 represents a view of the complete rotor.

FIGURE 29 represents a cross-sectional view of the one-piece rotor.

FIGURE 30 is a photo of a prototype in the 8-entry configuration aimed at high flow capacity.

[0005] The "internal spring pumping system" is composed of 3 types of main elements. The pair of housings, rotor and lobe gears.

[0006] The description, layout and general function of the components will be shown below. The "lobe gears" (4) present the pumping agents, the lobes (9), just as a gear contains its teeth. A lobe gear is shown separately in figure 3. The "one-piece rotor" (25) is the central element that holds the lobular gears and features the "drive shaft" (5), the drive shaft of the mechanism. The rotor also admits a bipartite version in its equatorial plane to facilitate assembly or 3D printing. Sometimes in this text, to simplify the understanding of the function of the rotor, regardless of whether it is a bipartite model or not, it will be treated as a rotor. The housing is the external element, the wrapper, the cap that has spiral grooves on its inside. The project is composed of a pair of housings that are joined in their equatorial plane through the "central flange" (16) to enable assembly and closing. It is foreseen the use of models with the two housings with the same format without causing disadvantages, on the contrary, standardization is recommended and reduces costs. Some models have a housing that is slightly or quite different from the other housing depending on the purpose of the design configuration. A good example is that some configurations require one of the housings to be smooth internally, without any grooves. The housing model without grooves is called "smooth housing" (2). The "spiral housings" (1) are the type housings that have the elements individually named "spiral groove" (10). The set of grooves form a type of thread that describes a trajectory in a toroidal shape and admits having more than one entry, figures 5, 6 and 7 illustrate the generative trajectory of the grooves in the design of the pumping system with internal spring of 8-entry. The "groove spiral" is a type of thread or toroidal spiral that has a circular section in the cuts orthogonal to its trajectory, see figures 16 and 17. The two parts of the housing pair are joined through screws installed in holes at the ends of the central flange (16). Housings can be joined in other ways, press fitting, welding or gluing.

[0007] One of the functions of the rotor is to act as a mobile support that exerts a force on the side of the "lobular gears" since the lobular gears are inserted in the "radial slots" (8). The "bipartite rotor" consists of 2 parts arranged together in their equatorial plane. In said flat region, in the plane of union between the rotors, there is a bearing support means (11) to accommodate the "lobe gear shaft" (12), the shaft that passes through the center of the lobe gear. One of the pairs that make up the split rotor is the "rotor shaft" (6), characterized by having the "drive shaft" (5), a shaft long enough to reach the external region of the pump to be coupled to the available driving source. The pump works well even at low speeds, with manual operation or any other driving source, such as wind turbines, hydraulic turbines, electric motors, combustion engines, steam. The "solidarity rotor" (7) is the other part of the rotor of the split-type rotor model and admits having a shorter shaft, the "secondary shaft" (26). One of the functions of the secondary shaft is to provide extra support when inserted into the bearing of the spiral housing. The so-called "secondary axis" is not a mandatory structure and can be removed from the project. The "one-piece rotor" is represented in figures 28 and 29, with figure 29 in section to illustrate the bearings (11), hollow holes to allow the insertion and removal of the lobular gear shafts. For illustrative purposes, only one axis is illustrated in figure 29. If the manufacturing process is machining, possibly before milling the spiral grooves in the spiral housing, a toroidal-shaped curved internal surface defined by the adjustment to the shape of the lateral surface of the rotor that comes into contact with the internal surface of the housing of turns must be machined, that is, by the revolution of the design of the lateral profile of the rotor. This internal toroidal surface will be called the "rotor sweep surface" (15). With the machining of the spiral grooves the so-called "rotor sweep surface" becomes segmented. The region defined by the space between the edges of the grooves will be called "groove entry".

[0008] The pumping chambers are defined by the action of the lobes when generating a mobile closing area in the section of the pumping ducts. The "pumping ducts" are formed by the internal area of the "spiral grooves" and by the toroidal surface of the rotors that touch the "rotor sweep surface" waxing, sealing the "spiral grooves" by closing the said region of the "groove entry".

[0009] With regard to operation, the rotation of the rotor causes a translational movement in the "lobular gears" under the action of the lateral force exerted on the "lobular gears" by the "radial slots" of the rotor. Said translation movement causes the rotation of the lobular gears since the gears are assembled with the "lobes" inserted, housed in the internal surface of the "spiral grooves" forcing the lobes to follow the path defined by the trajectory of the spiral grooves generating the rotation of the lobular gears in synchrony with their translation. Pumping is characterized by the transport of fluid generated by the displacement of the lobes of the lobe gears inside the spiral grooves during the compound movement of translation and rotation of the lobe gears, a process in which the lobes of the lobe gears transport the fluid from the beginning to the end of the spiral grooves (joined in the union plane of the central flange), transporting the fluid in front of or between the lobes that run through the "pumping ducts" transporting the fluid from the suction manifold towards the discharge manifold as the drive shaft rotates. When reversing the direction of rotation of the driving shaft, the direction of flow is reversed, therefore, each of the collectors can act as a suction or discharge collector. One of the collectors offers an internal path for the axis, the so-called "axis collector" (13) and the other a simple collector, (14).

[0010] The lobular gears rotate freely (mounted only on the rotors) through their axis which is supported by bearings present in the rotor. However, even without the use of the shaft, lobe gears can work well, as they are also guided and centered by the fit and constant contact of at least 2 of the 5 lobes of each fitted lobe gear in a spiral groove, the lobe gear being always supported also by its lateral contact surface of its internal disk with said sweeping surface of the rotor.

[0011] Said internal spirals are composed of a type of thread that presents, in some configurations, a complete single and continuous trajectory, being described on the internal surface of the housing of spirals. The complete trajectory of the drawing that generated the grooves of the 8-entry housing can be seen in figures 5, 6 and 7, with figure 7 being a central cut, the complete drawings of figures 5 and 6 consist of only one continuous line, because in the drawing that defines the trajectory of the grooves, the groove at the beginning of a "groove spring" must coincide with the end of this same spring or another spring, a possibility in case there is more than one entry. There is a relationship between the number of entries, translation diameter of lobe gears, diameter of lobe gears, number of lobes, pitch of turns and all these definitions in geometry must be stipulated so that they perfectly match the dimensions and the equidistant spacing between the lobes of the lobe gears as shown in all assembly figures.

[0012] Each of the housings admits to have a bearing (3), but there is the freedom to be defined in the project to support only one of the rotor shafts in a bearing in only one of the housings or to dispense with the adoption of bearings in both housings, especially if the pump is driven directly by a motor shaft, preferably a flanged type motor to ensure perfect alignment with the rotor shaft, dispensing with the use of couplings and/or flexible joints between the motor shaft and the rotor. A surface treatment is indicated and/or the adoption of a surface coating on the surfaces that will act on the bearing to reduce friction between the parts. The adoption of sleeves made of synthetic material or bearings to act as a bearing between the shaft and the housing is foreseen and recommended.

[0013] The spiral housing can be the fastening element, the static part that can be fixed by means of feet or a fixed flange on the "central flange". Nothing prevents the spools from being set to rotate, the rotor axis being static or rotating in the opposite direction. The radial symmetry of the design is favorable to the external movement of the referred housings.

[0014] The "internal spiral pumping system" presents several models, configurations in the most varied proportions, being more or less flattened, closer to the shape of a sphere or a disc, according to the adopted configuration. In this same premise, the pump admits a configuration with an internal thread of only one entry, as well as configurations with 10 entries or more. Similarly, according to the design configuration settings, lobe gears have different numbers of lobes, making it possible to define a lobe gear with more than 10 lobes, defined according to the design pressure to which the system will be applied, since the greater the number of lobes present in each spiral groove, the greater the pressure reached by the system. Configurations with more than 5 lobes are normally designed for pumping gases and have a complementary housing without spiral grooves, the so-called "smooth housing" (2). To demonstrate the versatility of number of entries and lobes in lobular gears, 2 models will be presented. An example will be a pump configuration (figs. 9, 10, 11 and 12) with 3-entry with 3 lobe gears with 12 lobes. Another configuration (figs. 13, 14 and 15) presented will be a pump with 4 entries with 5 lobe gears with 14 lobes. In the configuration of 4 entries represented by figures 13, 14 and 15, each sulcus or entry presents 9 acting lobes forming 7 chambers of decreasing volume towards the central discharge for each of the entries, totaling 28 chambers, similar to what happens in a scroll type pump. Due to the progressive reduction in the size of the chambers, these configurations are not recommended for pumping incompressible fluids. Configurations such as those exemplified with the smooth housing admit 2 or more lobe gears, whose maximum number of lobe gears is defined according to the design pressure to which the system will be applied, since the greater the number of lobular gears, allows more than one lobe to act in each groove at the same time in the spiral grooves in order to achieve a greater capacity for holding pressure. In this way, in the case of using 10 lobular gears, the number of lobes acting in each spiral groove would increase, providing a better seal and consequently a greater capacity to reach higher pressures. According to the project, the distance to be defined between the grooves and the spirals can be changed, a greater distance between the grooves provides a better seal between the contact surfaces of the rotor and the housing of the spirals, as the area of adjustment or minimum contact between the "scanning surface of the rotor" (15) and the toroidal side of the rotor becomes larger. The 3-entry pump with 12-lobe gears has the lobes farther apart than the 14-lobe model, so the "impeller sweep surface" region is less prone to leaks. These configurations with gears with many lobes, have fewer protruding lobes than the configurations geared towards high flow and, therefore, have shallower "spiral grooves", with a positive profile. Models with less protruding or shallow lobes are individually named "shallow sulcus" (10). As a consequence of the high number of lobes and, therefore, a larger diameter of the lobular gears, logically the diameter in the lateral region of the rotors, the toroidshaped outermost curved part of the rotors is much larger, as is the radius of the so-called "rotor scan surface". The configurations with shallow spiral grooves allow the assembly of lobular gears with 6 or more lobes as long as these are also slightly salient and with the condition that only the lower housing has the grooves.

[0015] The configurations discussed in this patent application with more than 5 lobes per lobe gear present an internal compression during operation and allow the assembly of multiple lobe gears due to the fact that the lobe gears have a much smaller thickness, the reason will be explained later. These factors favor the possibility of this configuration acting as a gas compressor, for example, in refrigeration systems. Series mounting option is also possible for this configuration with shallow grooves and multiple lobe gears with more than 5 lobes using a "smooth housing". The pump in the configuration for pumping gases is a very balanced compact option, with excellent mechanical performance, with emphasis on the extremely low sound emission as it does not have alternating or oscillating movement. It is relatively compact in relation to the enormous flow capacity presented by the configuration of the "internal spring pumping system" with 8 entries with salient lobes, a project aimed at high flow in the pumping of liquids to be discussed below.

[0016] Aiming to achieve a high flow rate with a minimum external volume, a configuration of the "internal spring pumping system" was developed, with protruding lobes shown in figures 1, 2, 3, 5, 6, 7, 8 and 16 to 23 and in series in figure 27. The high flow configuration utilizes salient lobe gears with only 5 lobes, with only one lobe per groove performing most of the pumping, while a lobe is coming out of one end of a groove, another lobe has just entered the beginning of this spiral groove (in the other housing) to avoid reflux at low revs. The highest flow capacity configuration to be illustrated features 4 lobe gears of 5 lobes and the 5 "spire housings" with an internal thread with 8 spiral groove entries. A similar configuration with 4-entry salient grooves will also be shown. The 4-entry design will be commented on more superficially, it only shows a view of a housing in this model (figure 4). The objective is only to illustrate the possible variations and some implications of this geometric variation.

[0017] The configuration of the pump with internal spirals with lobular gears with only 5 lobes and salient type presents spiral grooves (10) of the surrounding type to house the most salient lobes. The objective is to increase the area of the sweep section of the lobes so that the pumping ducts, that is, the inner region of the spiral grooves that define the pumping chambers, present a greater volume. Instead of the edge of the groove involving the lobe only up to its maximum width as in the examples of the pumps exemplified with shallower grooves, the surrounding groove goes beyond the diameter of the lobe, making the lobes embedded in the groove's spirals in the assembly. In the same way, as can be seen in the figures with gears with 5 lobes, their lobes are more prominent, the widest region of each lobe is well above its attachment region in the lobe gear. At first sight, it seems that the geometry with a negative profile of the spiral groove makes assembly impossible, since the measurement of the diameter of the side of the lobe is greater than the said region called the entry of the groove. However, assembly is possible and was proven during the assembly of the prototype (figure 30) in operation in the photo. During assembly, the gears must be inserted right after the end of the entry of a turn, with the outermost lobe located in the region where the housings join, surrounded by the junction of the two housings through the "central flange" (16). In this demonstrated position, a lobe of a lobe gear is at the entry of a groove, the next one is in the middle of the course of another groove, region of the union of the grooves and the third following lobe is at the exit of another subsequent groove.

[0018] Comparing "internal spring pumping system" with 8-entry wraparound grooves with 4 entries configuration, 8-entry pump has much higher volumetric capacity than 4 entries inner spring pump. Both with 115mm in diameter, the configuration with 8 ports in figure 30 pumps 260 ml against 150 ml for the configuration with 4-entry. The 4-entry pump must have at least 2 opposing lobe gears of 5 lobes, while the 8-entry pump must have the same external diameter, it must have at least 4 lobe gears with 5 lobes also equidistant to ensure that there is at least one lobe inside each pumping duct. The pump with 4 entries has a smaller angle on the windings and therefore needs a much smaller lobular gear. This effect of the configuration enabling the use of narrower lobular gears due to the said lower angulation of the spiral grooves can be observed in figures 10, 11, 14 and 15 in the configurations of shallow grooves. On the other hand, the need for a thicker lobe gear can be better seen in the cuts of the 8-entry configuration shown in figures 18 to 22, as the contact point between the groove surface is awfully close to the end of the lobe curvature, if the lobular gear were narrower, it would lose contact with the surface of the groove, generating a leakage point or pumping return. Going back to comparing the 4 entries configuration with the 8-entry configuration, the 8-entry pump, as it has a greater angle in the turns, when turning only 90 degrees, the lobes run completely along the length of the grooves, therefore, it pumps the entire volume of the 8 pumping ducts 4 times for each turn of the impeller drive shaft, this is one of the main factors for the high flow capacity. The 4-entry pump, in turn, requires half a turn for each lobe to travel the entire length of the spiral groove, greatly reducing the flow capacity. The lobe gears on the 4-entry pump turn 4/5 of a turn whereas on the 8-entry pump the lobe gears turn 8/5 of a turn for each revolution of the driveshaft. Due to the lower rotation of the lobular gears, the 4-entry pump has a smoother movement and less wear because it has fewer lobes passing through a spiral groove at each rotation. On the other hand, due to its smoother operation due to the smaller angle of the turns and the lower rotation of the lobular gears, the 4-entry pump is more capable of turning at a higher maximum rotation, a condition of greater wear that would partly compensate for the lower volumetric capacity. Analogously, the 8-entry model, when rotating at a speed 40% lower than the 4-entry model, still has a slightly higher flow rate.

[0019] The "internal spiral pumping system" is suitable for being assembled in series in order to reach a higher discharge pressure in relation to the use of only one stage. The multistage configuration can be seen in a radial sectional view of a 3-stage assembly, figure 27. There is a rotor model that has a small, splined shaft end or with one or more keyways at its end to serve as a base for the coupling between the shafts of the stages through a compatible sleeve. Said coupling was illustrated through the adoption of a "coupling sleeve" (23). To be compatible with the keyways (24) the type of fitting present at the end of the rotor shaft in the model that is exemplified in figure 27, the so-called "coupling sleeve" logically has 3 keyways where the keys are inserted. The keys are hidden in the drawing, as they are inside the coupling sleeves. Instead of using keyways, the project admits the adoption of a splined shaft compatible with the internal spline to be adopted in the coupling sleeve. The coupling sleeve, therefore, is inserted in the union region between the shafts of each stage. To couple the housings in the union between the stages and at the same time to join the manifolds, a simple solution is the "coupling manifold" (22), a sleeve with a type of coupling at both ends, in the case shown the coupling manifold is a cylinder with a continuous external thread. Therefore, the "coupling collector" performs the function of uniting the stages so that the discharge of the previous stage is coupled to the suction of the next stage. The "internal spring pumping system" admits to having 10 stages or more, as it was said, it will depend on the pumping pressure to be required by the project.

[0020] When observing the representation of the assembly of the pump with 8 entries (figure 2), due to the cutting plane, as the contact line of the lobe with the housing does not occur in a radial plane, it is not possible to visualize the adjustment between the pieces, a factor responsible for the sealing between the lobe and the spiral groove. Figure 16 shows the position of the orthogonal cut in relation to a spiral groove, and figure 17 shows a cross-sectional view of the outermost lobe. Figure 18 shows the internal spiral housings with transparency. Through this transparency it is possible to observe a zigzag stain (18) formed by the contact line between the lobular gear and the spiral grooves.

[0021] The thickness of the internal part of the rotor, that is, the region between the axis and the beginning of the toroid surface, must be defined so that the length of the path of the path of the lobes in this internal region of the rotor, allow that, during the return of the lobes to the interior of the rotors, at least one of the lobes is present in this path described inside the rotors, this passage channel of the lobes is called "reflux channel" (17). The objective is to always keep this section obstructed by at least 1 lobe to avoid a free return of the fluid in this region. As can be seen in figure 2, 2 lobes are located inside the radial slot of the rotors, one at the entry and the other in the region close to the outlet of the "reflux channel", preventing the free return of flow in this region of the radial slot of the rotors. In the operating position illustrated in figure 12, there is only one lobe in the reflux channel and in figure 13 the lobe gear is in the position that has 2 lobes in the reflux channel, always guaranteeing the obstruction of the "reflux channel".

[0022] Figures 19, 20, 21 and 22 are consecutive cuts in the design of the 8-entry pump to demonstrate, from another angle, the perfect fit between the lobes and the spiral grooves.

[0023] Figure 23 is a representation of the 8-port pump in a radial section outside the lobe gear region to demonstrate the fit between the toroidal lateral surface of the impellers and the impeller sweep area (15).

[0024] Regarding the distribution of forces, the pumping pressure acts exerting a lateral force on the lobe gears through the line of contact between the lobe and the inner surface of the spiral grooves, this line of contact of the lobe can be seen in detail 18 of figure 18. This pumping reaction force does little to interfere with the rotational movement of the lobe gears, since the angle between the pumping reaction force exerted on the lobes is close to the perpendicular to the face of the lobe. Therefore, the closer the angle between the face of the lobe and the trajectory of the spiral groove is to the perpendicular, the better it will be for the greater durability of the pump. In this way, the smaller the pitch angle of the toroidal thread, the closer the angle between the direction of the force applied by the fluid pressure and the lateral surface of the lobes will be to the perpendicular. The fewer entries the pump design has, as well as a larger translation diameter, the smaller the average helix angle established by the "groove turns". Surface treatment or coating with suitable metals is provided for acting as bearings on the surface of the lateral region of the central disc of the lobular gear and on the lateral surface of the radial slots. The adoption of essentially metallic axial bushings, bearings or synthetic bushings or axial bearings installed between the radial slot side of the rotors and the side of the lobular gears is recommended to guarantee a low coefficient of friction in this region of strong support between the components.

[0025] Another factor favorable to the rotation of the lobes is the reverse pumping that occurs by the passage of fluid between the lobes in the region of the "reflux channel", this flow providing a torque in the direction of rotation of these gears. Despite generating a loss to the volume pumped, this return generates considerable advantages for the operation of the pump. The reflux in this region occurs in the direction of the region of greater pressure to a region of lower pressure, interconnecting the discharge with the suction transferring torque to the lobular gears and in this process, depending on the configuration, it is possible to make the lobular gears conductive in their rotation movement instead of being driven by the spiral grooves. The condition of the lobular gears to present a driving source in addition to the rotation defined by the spiral grooves leads to the generation of lower surface pressures between the lobes and the spiral grooves, therefore less wear and vibrations.

[0026] The "lobes" admit having a rectangular (figure 24), continuing curved on its side, being the piece in this rectangular shape called a "rectangular gear" (19). Logically, the shape of the spiral grooves would be changed to adapt to this new shape of the lobes, being called "rectangular spiral groove" (20). This new geometry of the lobes and spiral grooves aims to further increase the volumetric capacity of the "internal spiral pumping system". This type of pump with rectangular lobes will be called "Pump with rectangular internal spring".

[0027] The pump with internal turns presents a version in which the lobular gears are arranged obliquely, seeking to be closer to the orthogonal position in relation to the grooves, as can be seen in the geometric study shown in figure 25. One of the objectives of the lobular gears is to be in a plane as orthogonal as possible to the section of the pumping ducts previously discussed, is related to a reduction in wear due to the decomposition of reaction forces to pumping that act on the lobes, preventing the pressure exerted on the fluid during pumping from generating forces contrary to the rotation movement of the lobe gear. This geometry allows for a greater number of lobular gears as these can be much narrower, the pump may have more entries and a greater volumetric capacity, much greater than the 8-entry pump cited as an example. Another factor would be a smaller volume of reverse pumping due to the smaller thickness of the lobular gears, resulting in a narrower "reflux channel" and, therefore, a smaller volume between the lobular gears in the "reflux channel". This configuration of the internal spiral pump with the lobe gears on an inclined plane would be called an "internal spiral pump with oblique gears". The design of the concept pump in Figure 25 has 21 entries and 21 lobe gears with 3 lobes acting in each groove. Only 3 lobe gears are shown in consecutive slots, but in the complete assembly, a lobe gear must be installed in each of the slots. In this configuration shown in figure 25, the minimum quantity would be 7 equidistant lobe gears to ensure that at least one lobe is present in each groove during pumping. The rotors always have a number of "radial slots" equivalent to the number of lobular gears adopted in the design.

[0028] Observing figure 26, it is possible to observe the variations in the design configuration, allowing the rotor to present a larger internal space to the point of fitting an engine (21). Figure 26 shows an electric motor embedded inside the pump rotor, its housing being fixed to said rotor, with the shaft of said motor being fixed in one of the housings with internal turns.

[0029] Parts of internal spiral pumps can be manufactured via injection into plastic or resins, printed (with thermoplastics or metals), sintered (powder metallurgy), cast in lost wax using the micro fusion process and/or machined. Surface treatment on parts is an option as a device to increase durability in metals with low machining costs such as aluminum, another option is chemical coatings with low coefficient of friction and self-lubrication.

[0030] The application of self-lubricating coatings facilitates the use of the internal spiral pumping system to act in the pumping of gases. A foreseen function is the use as an air feeder performing the function of a supercharger or blower in combustion engines. Another use in this premise is acting as a vacuum pump. Designed to perform these functions, they are respectively called "internal spiral compressor" and "internal spiral vacuum pump".

[0031] The "internal spiral pumping system" acts as an engine, when coupled to a pressurized fluid in one of its collectors, being suitable for use in hydroelectric power plants due to its reduced size in relation to other positive displacement pumps. The "internal coil pumping system" can act as an engine using pressurized gas flows as energy sources by coupling a source of steam pressure to one of its collectors, pressurized air or pressurized gases from burning fuels. When designed to perform the motor function, it is called an "internal spiral motor".

[0032] It is foreseen that the "internal spring pumping system" performs the function of a hydraulic pump and, when designed for this function, it is called an "internal spring pump". The "internal spring pump" can be used in several ways. Use as a water pump for pumping clean or dirty water, with abrasive particles such as sand or less abrasive particles, food pump, sanitary pump, oil pump, fuel pump, hydraulic fluid pump, hemodialysis pump, auxiliary cardiac pump for internal or external use or in the function of an artificial heart. It has good suction capacity due to its long-term expansion in pumping ducts, similar to piston systems. Due to the fact that it does not have a central crushing area (as in a gear pump, for example), it is indicated for pumping very viscous fluids, such as food pasta. The internal spiral pump is indicated for use as a heart pump for internal use because it is very compact and has a small internal surface area in relation to its flow capacity, favorable factor to generate less rejection in contact with blood, therefore it is also indicated for use as a hemodialysis pump.

Claims

1. "Internal spring pumping system", a positive displacement pump **characterized in that** it is equipped with a set of pumping chambers consisting of grooves "groove spiral" (10) that describe a trajectory defined by a toroidal thread "with one or more entries of grooves spirals present on the inner surface of the " spiral housings"(1); inserted in the so-called "spiral grooves" are the "lobes" (9) present in the "lobular gears" (4); the "lobular gears" being housed in the "radial slots" (8) present in an internal rotor (25), being integral or consisting of 2 parts, one of the parts of the rotor, the "axle rotor" (6), and the

another part of the rotor made up of the "solidarity rotor" (7).

2. "Internal spring pumping system", according to claim 1, **characterized by** establishing a configuration with "spiral grooves" (10) in the "surrounding groove" model.

3. "Internal spring pumping system", according to claim 1, **characterized by** establishing a "smooth housing" (2) configuration, and only one of the housings has "spiral grooves" with 2 or more lobe gears, each lobe gear having 5 lobes or more, in which these 2 parameters are defined according to the geometry of the "internal spiral pumping system", and the space conditions, proportions between parts, and design guidelines pressure and flow capacities and compression factor.

4. "Internal spring pumping system", according to claim 1 is **characterized by** presenting in a configuration, "the pump with rectangular spirals" the lobes in rectangular or trapezoidal shape, the so-called "rectangular gear" (19) that acts in the "grooves rectangular spirals" (20).

5. "Internal spring pumping system", according to claim 1, is **characterized by** presenting a configuration with lobular gears arranged obliquely, that is, not parallel to the axis of rotation.

6. "Internal spring pumping system", according to claim 1 is **characterized by** having, in one of the configurations, an electric motor (21) installed inside the rotor.

7. "Internal spring pumping system", **characterized by** exercising the function of a hydraulic pump, acting in the pumping of clean water or with particulates, food pump, pump for more viscous fluids, sanitary pump, pump of Oil, fuel pump, hydraulic fluid pump, hemodialysis pump, cardiac pump for internal or external use to act as an auxiliary or main pump replacing a heart performing the function of an artificial heart; use separately or as part of other systems such as combustion engines, jet turbines and rockets performing the function of oil and/or fuel pump and or in the role of supplying hydraulic power to a separate hydraulic motor or hydraulic piston or to a hydraulic component of a machine such as a tractor, crane, excavator, industrial press, aircraft or vehicle.

8. "Internal spring pumping system", **characterized in that** it performs the function of an engine when a source of pressurized fluid is coupled to one of the collectors; acting the "hydraulic motor of internal turns" in the function of the turbines of hydroelectric plants; act as an engine when a source of steam or pressurized gases is coupled to one of the collectors; this engine being used separately or as part of more complex systems such as automobiles, industrial machines and aircraft.

9. "Internal spring pumping system", **characterized by** pumping gases, acting as a compressor; being used in refrigeration systems as a compressor and or as an air feeder, supercharger in combustion engines of industrial machines, cars, trucks or aircraft.

10. "Internal spring pumping system, **characterized by** acting as a vacuum pump.

Amended claims under Art. 19.1 PCT

1. "Internal spring pumping system", a positive displacement pump **characterized in that** it is equipped with a set of pumping chambers consisting of grooves "groove spiral" (10) that describe a trajectory defined by a toroidal thread "with one or more entries of grooves spirals present on the inner surface of the " spiral housings"(1); inserted in the so-called "spiral grooves" are the "lobes" (9) present in the "lobular gears" (4); the "lobular gears" being housed in the "radial slots" (8) present in an internal rotor (25), being integral or consisting of 2 parts, one of the parts of the rotor, the "axle rotor" (6), and the another part of the rotor made up of the "solidarity rotor" (7).

2. "Internal spring pumping system", according to claim 1, **characterized by** establishing a configuration with "spiral grooves" (10) in the "surrounding groove" model.

3. "Internal spring pumping system", according to claim 1, **characterized by** establishing a "smooth housing" (2) configuration, and only one of the housings has "spiral grooves" with 2 or more lobe gears, each lobe gear having 5 lobes or more, in which these 2 parameters are defined according to the geometry of the "internal spiral pumping system", proportions between parts, pressure and flow capacities.

4. "Internal spring pumping system", according to claim 1 is **characterized by** presenting in a configuration, "the pump with rectangular spirals" the lobes in rectangular or trapezoidal shape, the so-called "rectangular gear" (19) that acts in the "grooves rectangular spirals" (20).

5. "Internal spring pumping system", according to claim 1, is **characterized by** presenting a configuration with lobular gears arranged obliquely, that is, not parallel to the axis of rotation.

6. "Internal spring pumping system", according to claim 1 is **characterized by** having, in one of the configurations, an electric motor (21) installed inside the rotor.

7. "Internal spring pumping system", according to claims 1 to 6, **characterized by** exercising the function of a hydraulic pump, acting in the pumping of clean water or with particulates, food pump, pump for more viscous fluids, sanitary pump, pump of Oil, fuel pump, hydraulic fluid pump, hemodialysis pump, cardiac pump for internal or external use to act as an auxiliary or main pump replacing a heart performing the function of an artificial heart; use separately or as part of other systems such as combustion engines, jet turbines and rockets performing the function of oil and/or fuel pump and or in the role of supplying hydraulic power to a separate hydraulic motor or hydraulic piston or to a hydraulic component of a machine such as a tractor, crane, excavator, industrial press, aircraft or vehicle.

8. "Internal spring pumping system", according to claims 1 to 6, **characterized in that** it performs the function of an engine when a source of pressurized fluid is coupled to one of the collectors; acting the "hydraulic motor of internal turns" in the function of the turbines of hydroelectric plants; act as an engine when a source of steam or pressurized gases is coupled to one of the collectors; this engine being used separately or as part of more complex systems such as automobiles, industrial machines and aircraft.

9. "Internal spring pumping system", according to claims 1 to 6, **characterized by** pumping gases, acting as a compressor; being used in refrigeration systems as a compressor and or as an air feeder, supercharger in combustion engines of industrial machines, cars, trucks or aircraft.

10. "Internal spring pumping system", according to claims 1 to 6, **characterized by** acting as a vacuum pump.

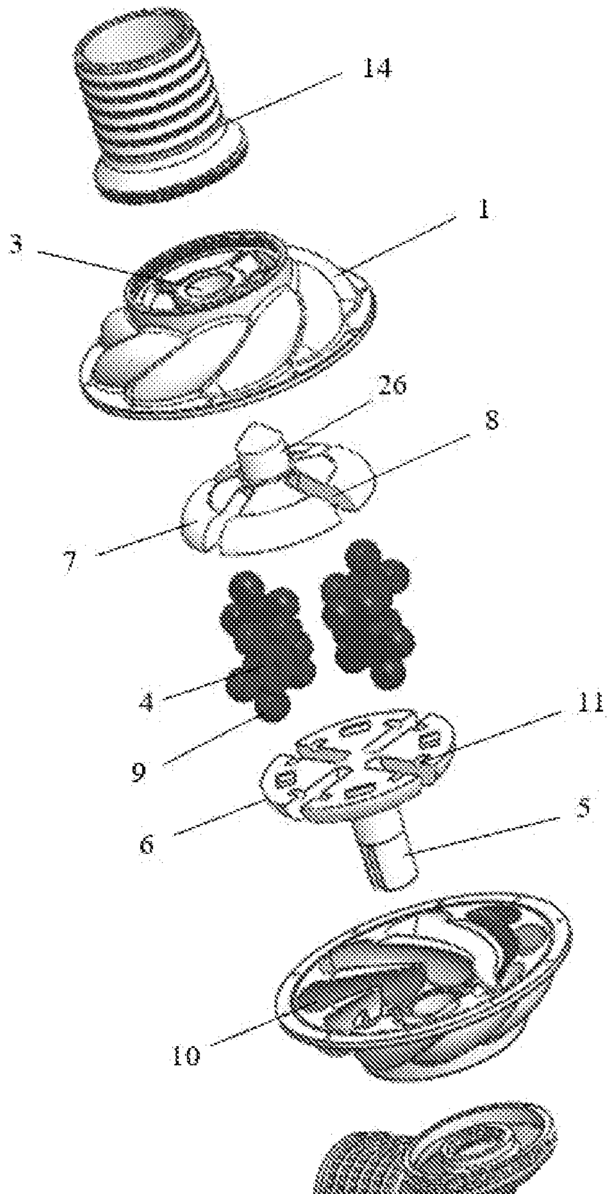


FIG. 1

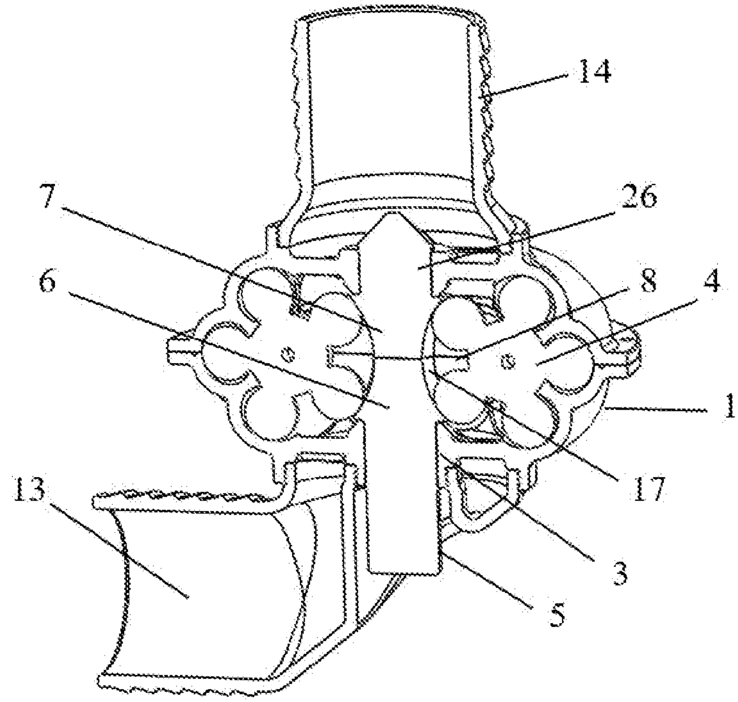
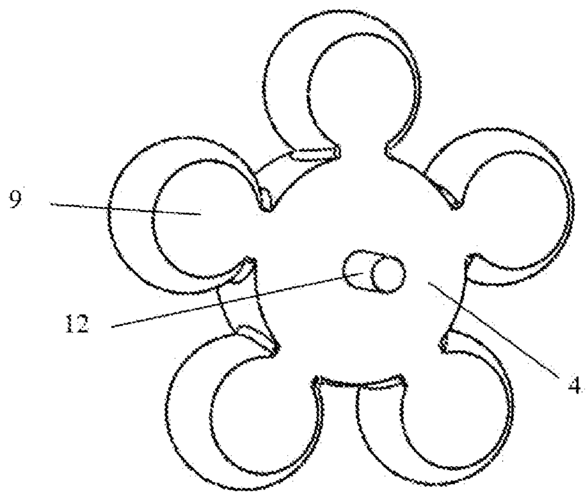


FIG. 2



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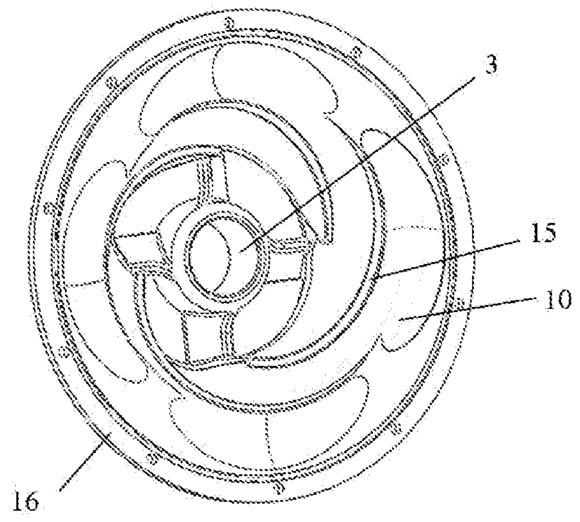

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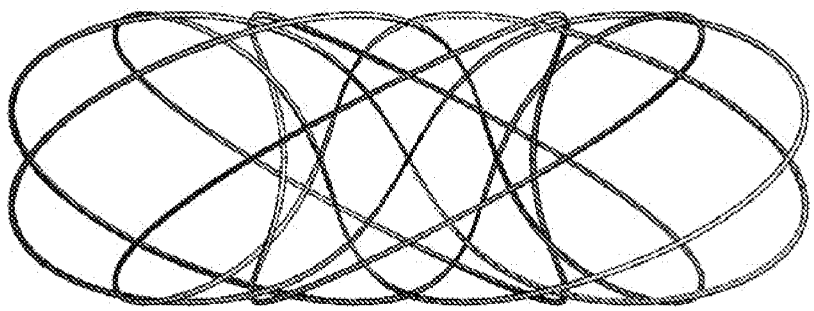
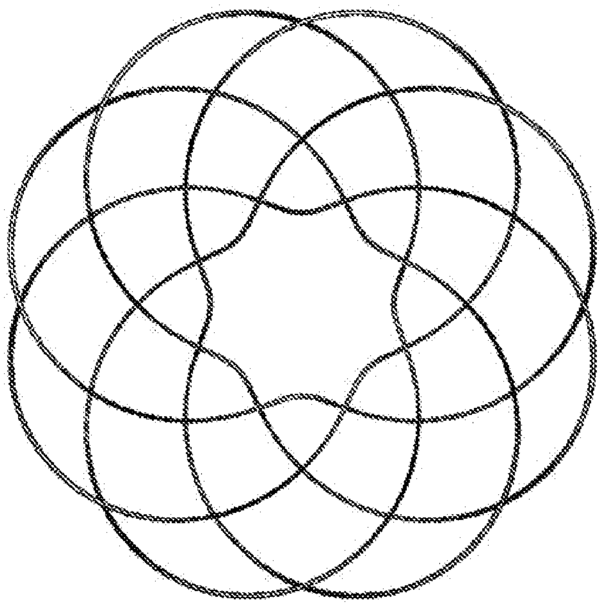


FIG. 5



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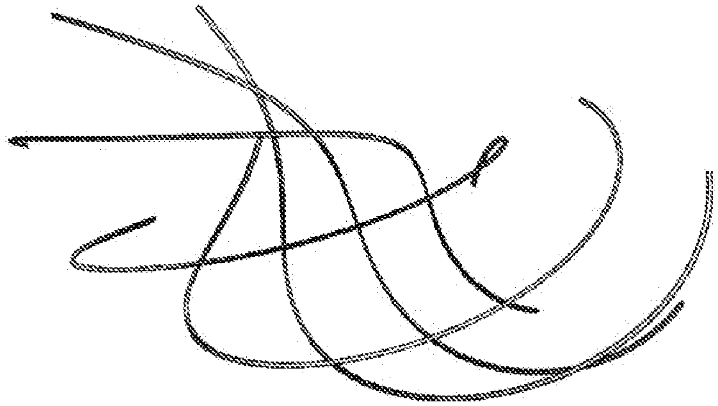


FIG. 7

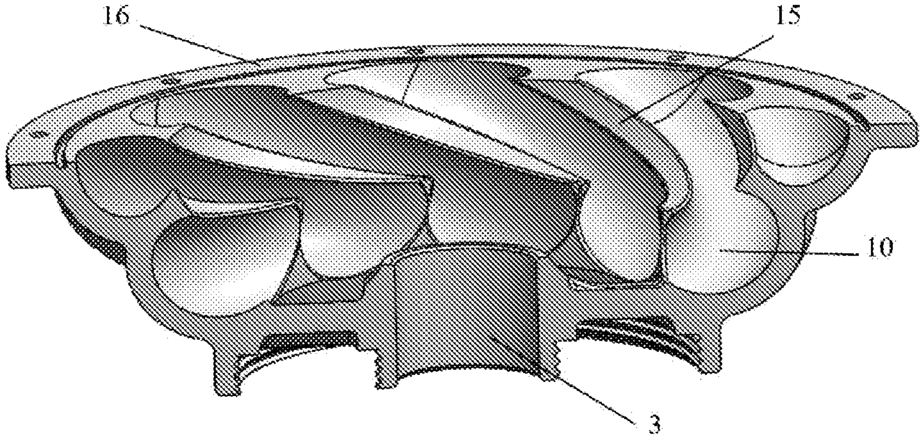


FIG. 8

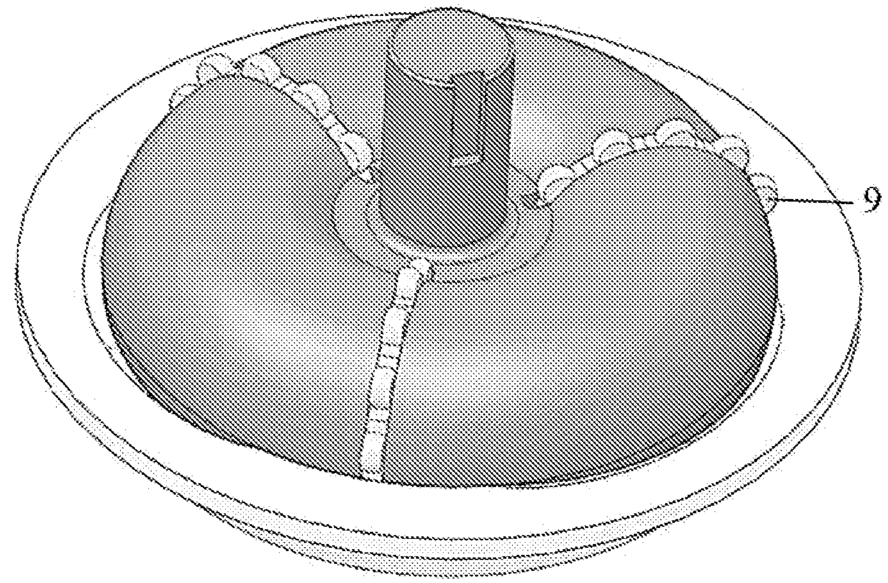


FIG. 9

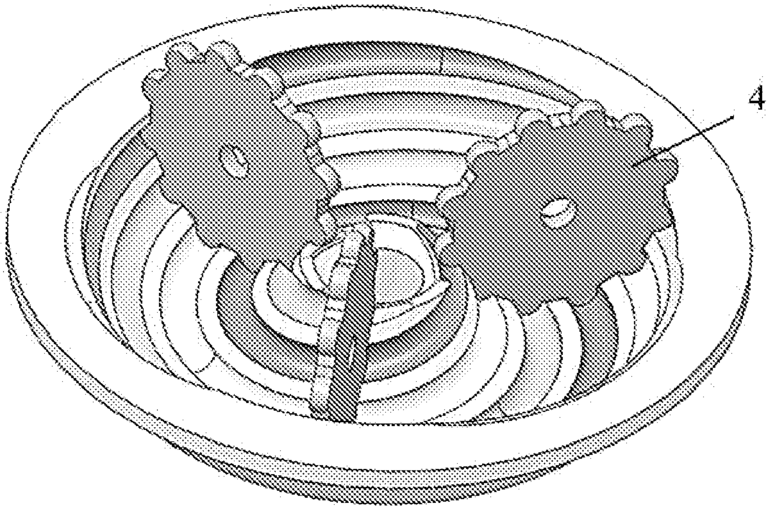


FIG. 10

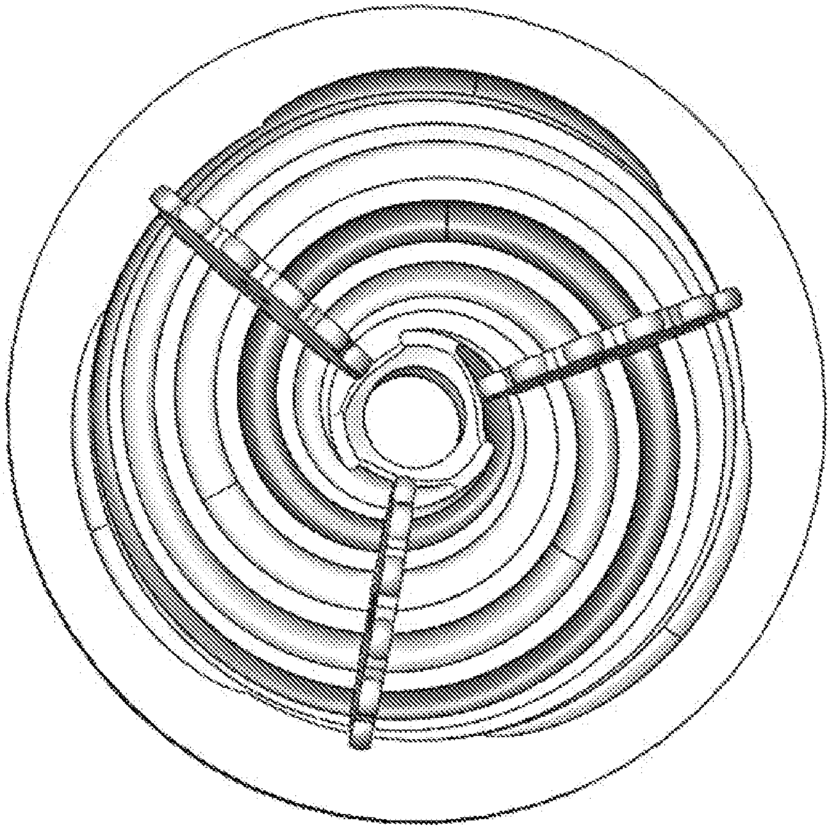
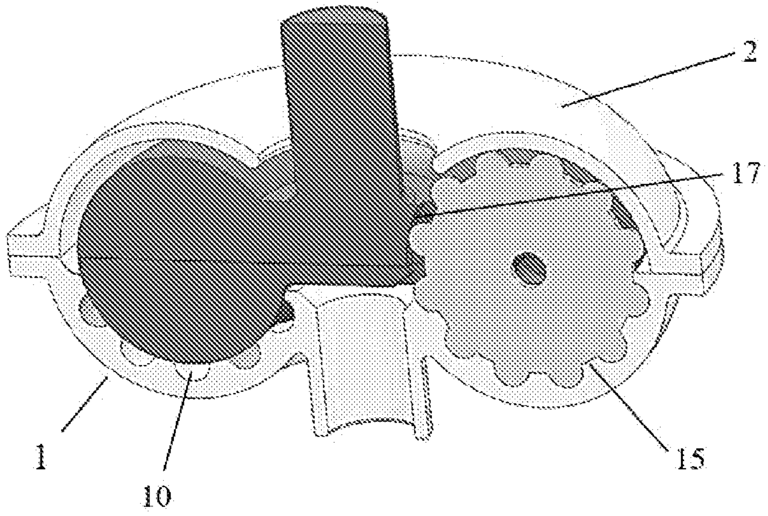


FIG. 11



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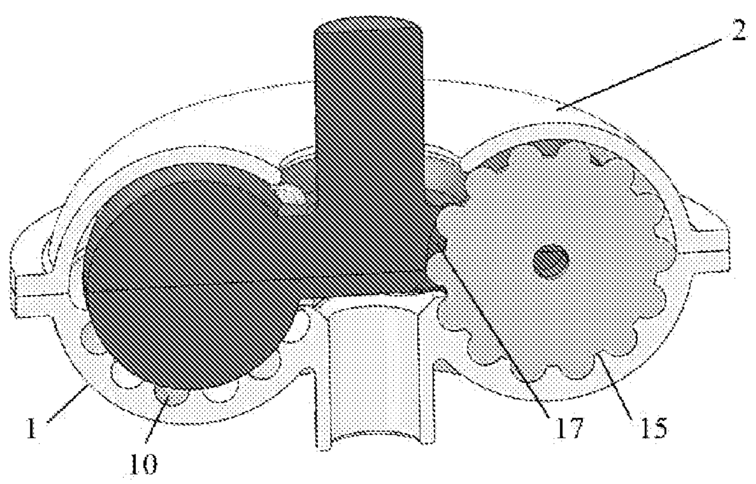

FIG. 13

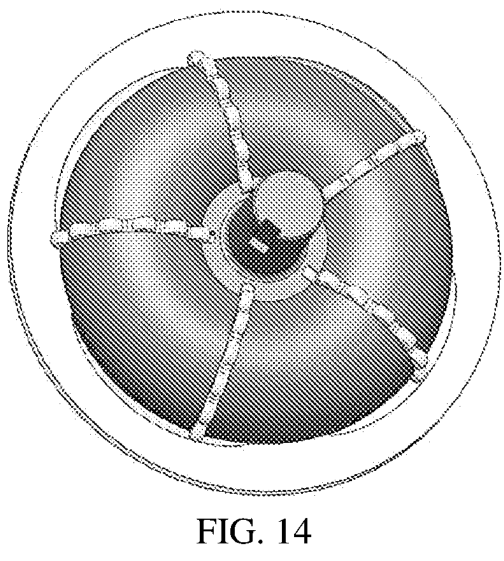

FIG. 14

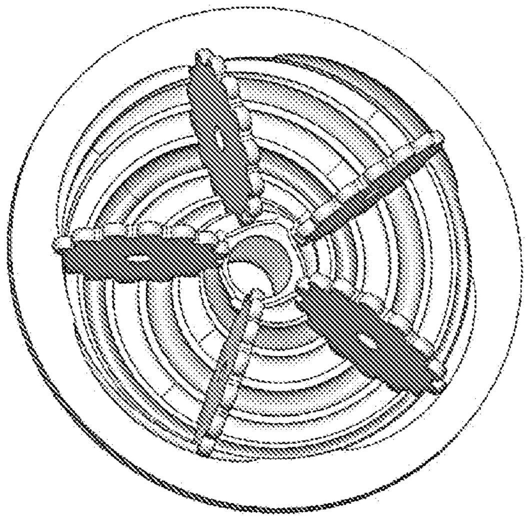

FIG. 15

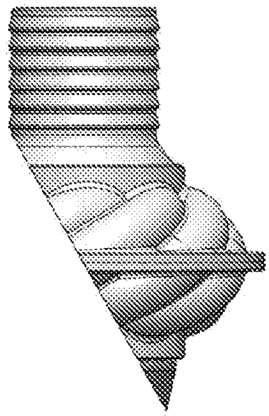

FIG. 16

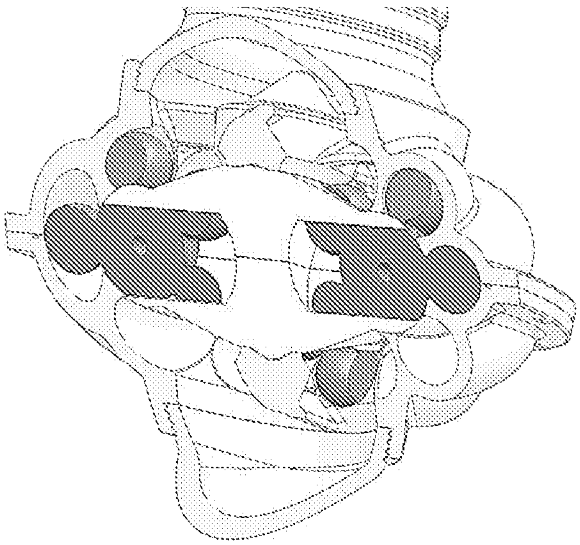

FIG. 17

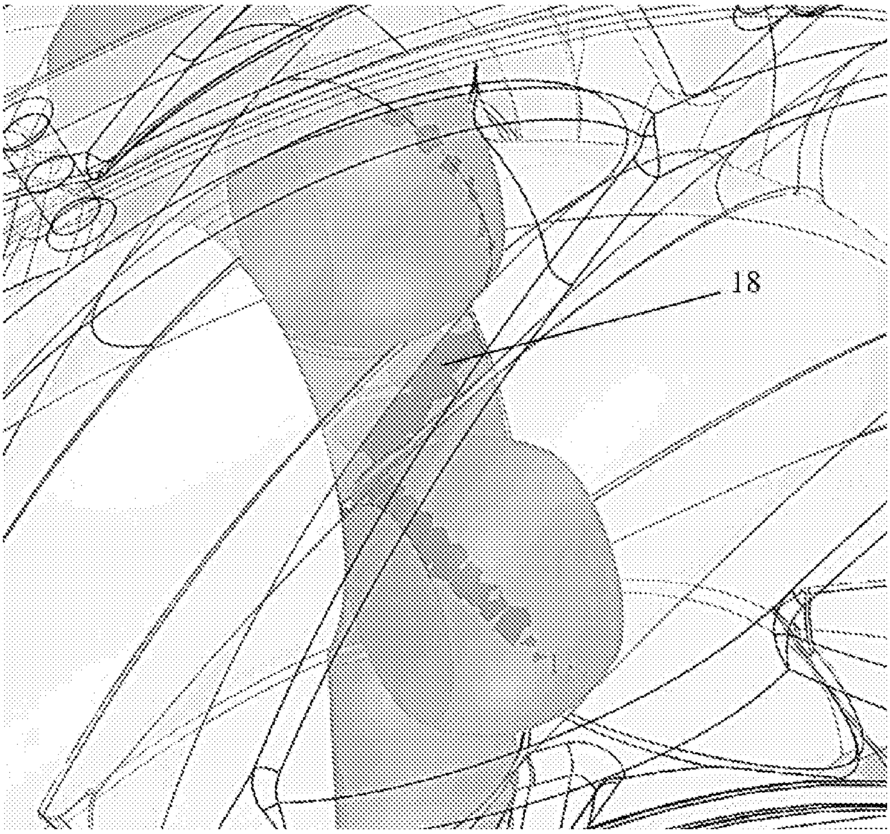

FIG. 18

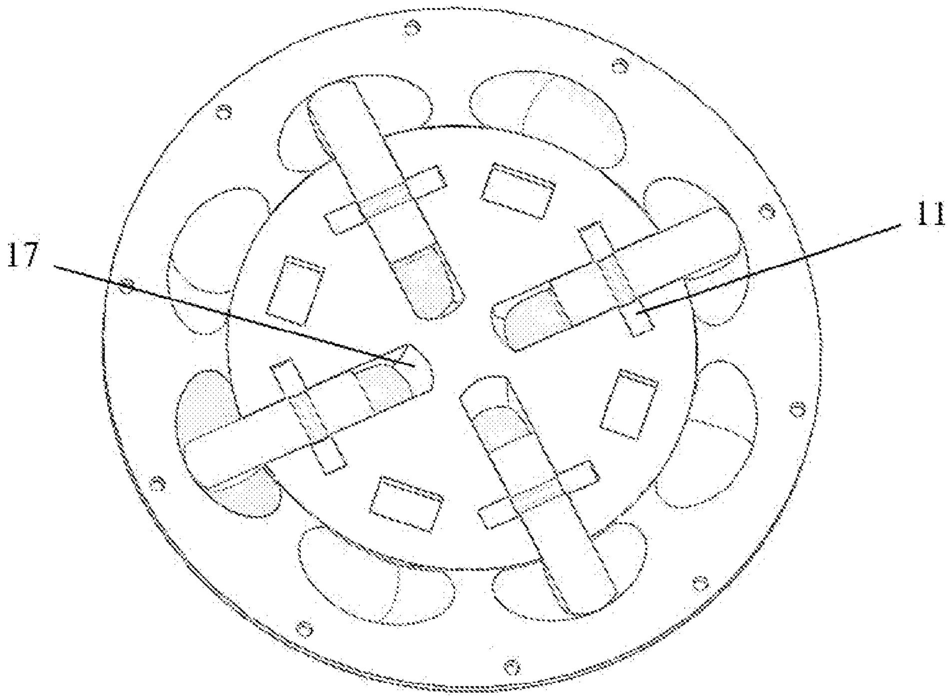

FIG. 19

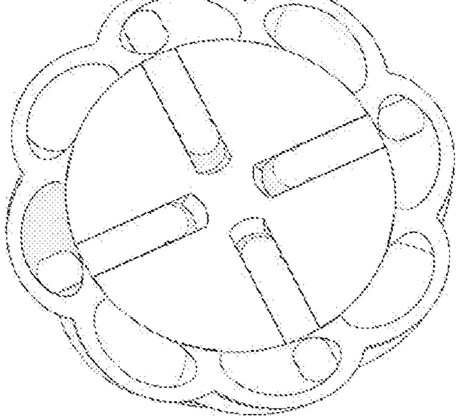

FIG. 20

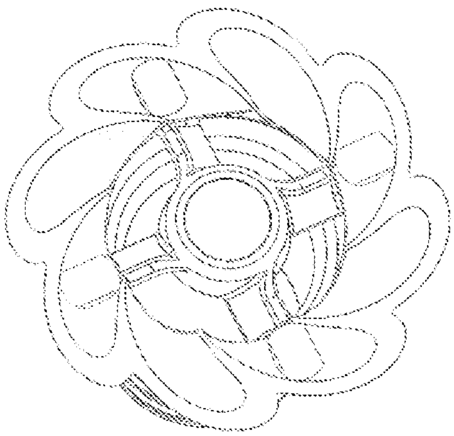

FIG. 21

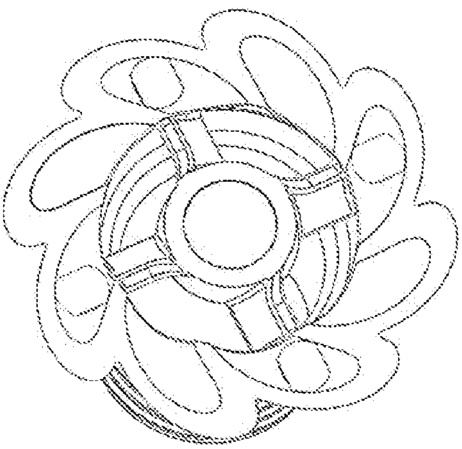

FIG. 22

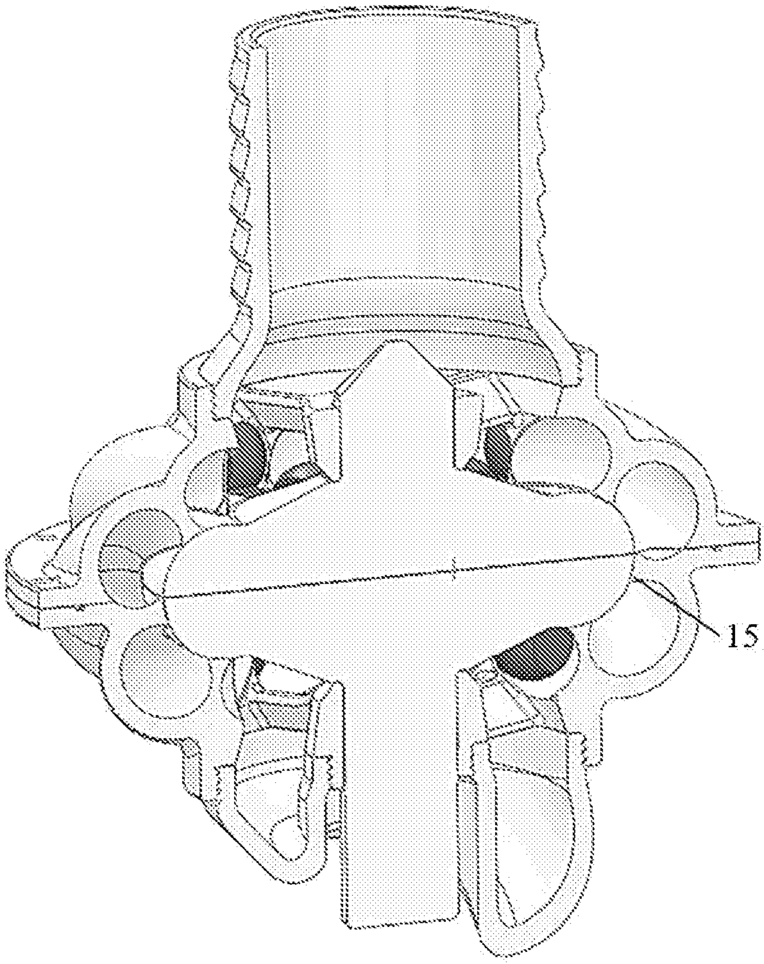

FIG. 23

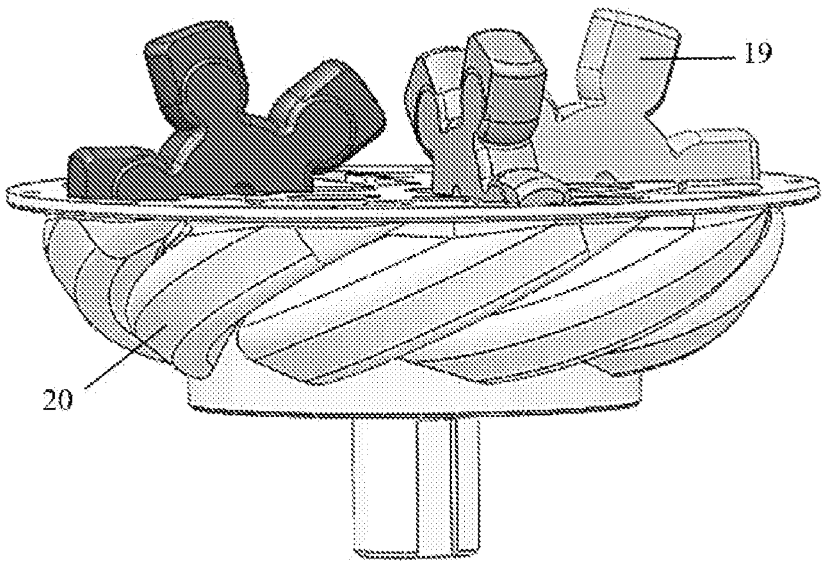

FIG. 24

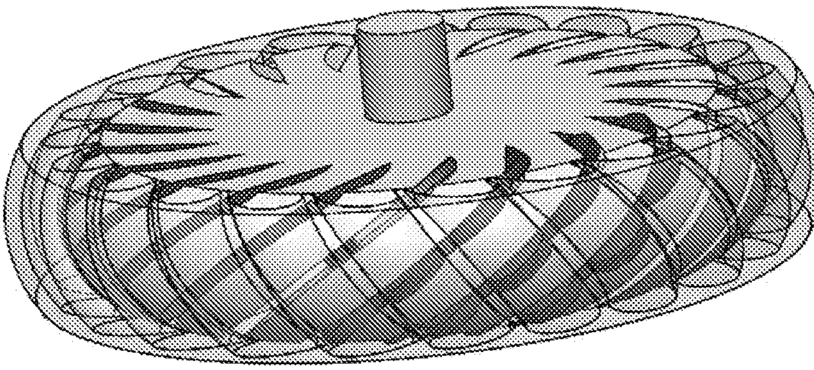

FIG. 25

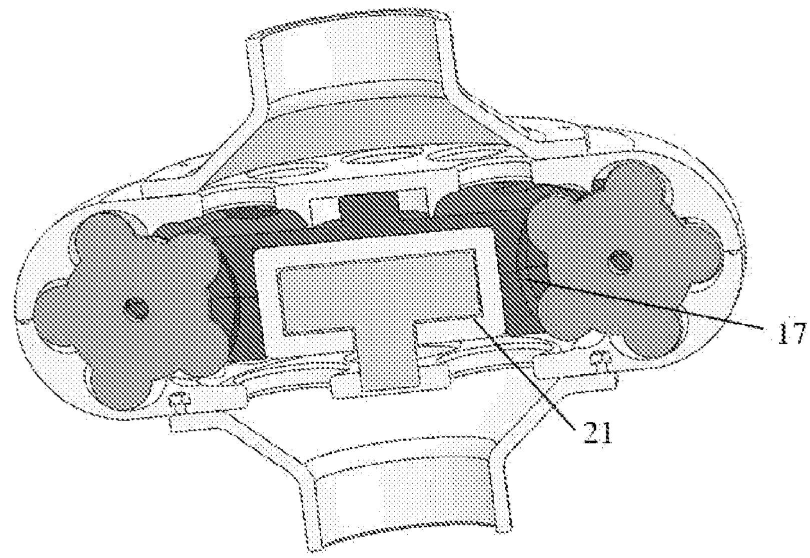

FIG. 26

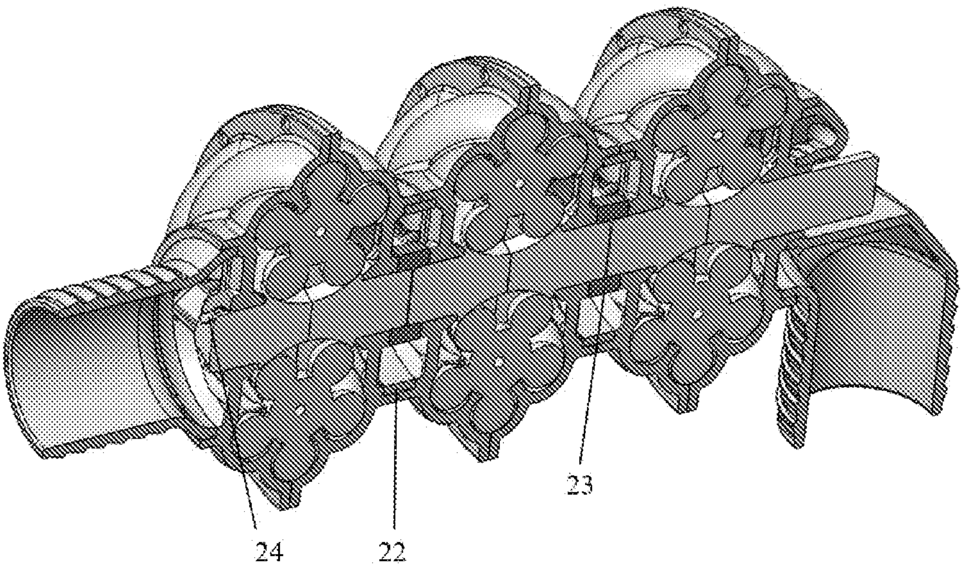

FIG. 27

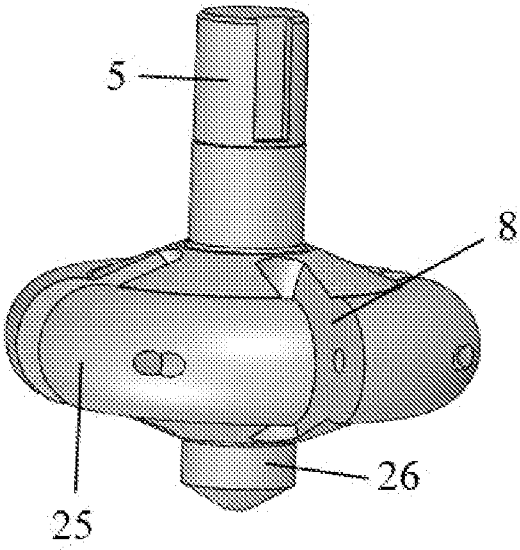

FIG. 28

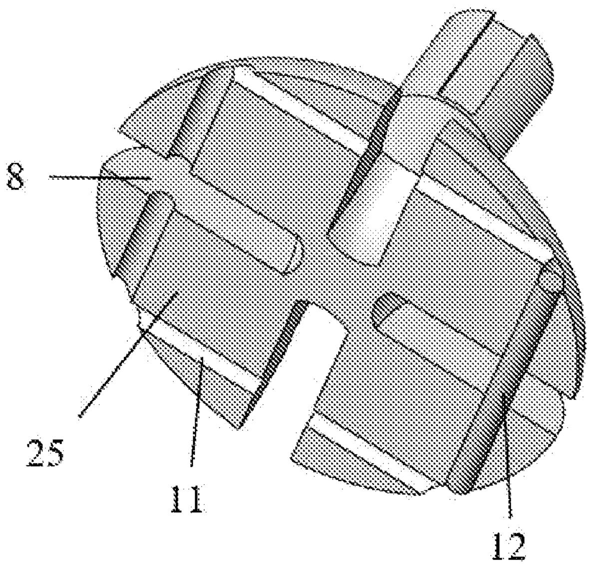

FIG. 29

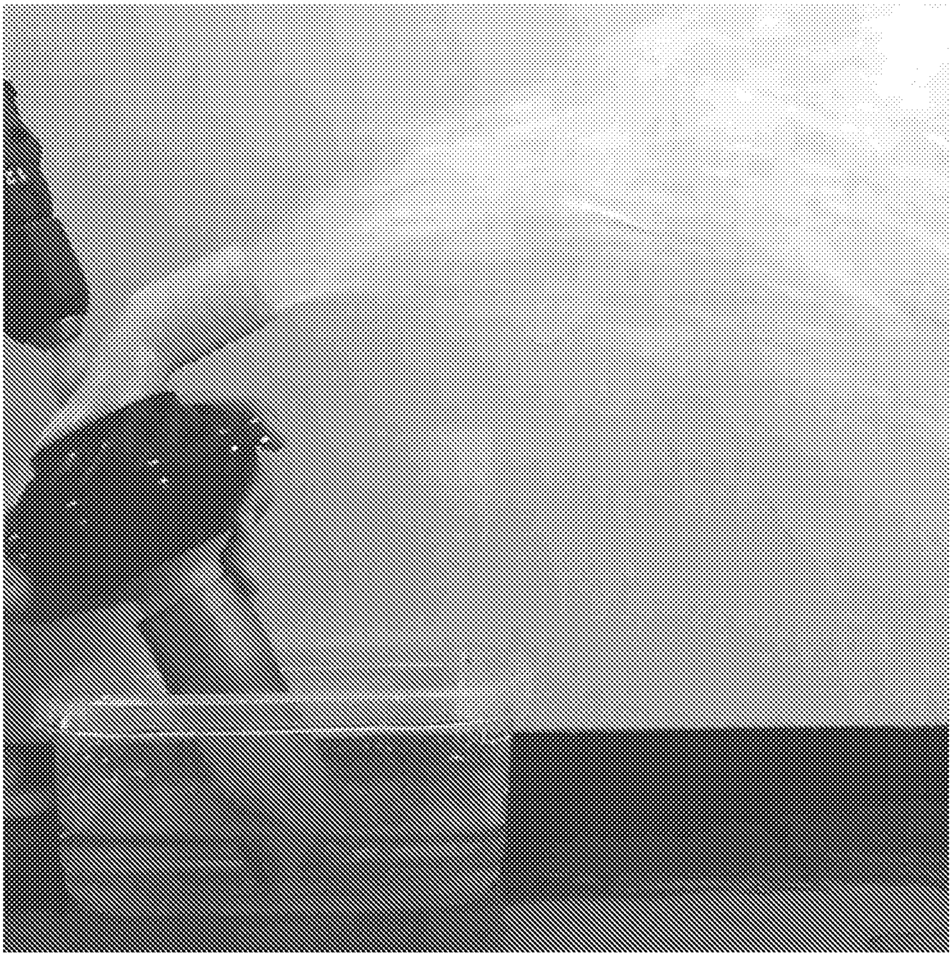

FIG. 30

INTERNATIONAL SEARCH REPORT

International application No. **PCT/BR2022/050067**

A. CLASSIFICATION OF SUBJECT MATTER

IPC: F04B19/20 (2006.01), F04C2/02 (2006.01), F04C18/30 (2006.01), F01C3/02 (2006.01), F04C2/077 (2006.01), F01B23/00 (2006.01).
CPC: F04C2/025, F04C2/102, F04C2/1076.

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)

F04B, F04C, F01C.

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

Banco de patentes do INPI/BR.

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

EPODOC, DERWENT INNOVATION.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7631632 B2 (AROV ANATOLY [CA]) 15 December 2009 (2009-12-15) *The whole documento*	1 to 10
A	US 9719350 B2 (HICKS EDWARD ALAN [US]) 01 August 2017 (2017-08-01) *The whole documento*	1 to 10
A	WO 8606786 AI (SOLTESS HANS [DE]) 20 November 1986 (1986-11-20) *The whole documento*	1 to 10

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 June 2021	30 June 2022
Name and mailing address of the ISA/BR	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/BR2022/050067

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 4636157 A (WERFF JEICHIENUS A V D [NL]) 13 January 1987 (1987-01-13) *The whole document*	1 to 10
A	US 2008251043 AI (LI YAN [US]) 16 October 2008 (2008-10-16) *The whole document*	1 to 10
A	US 4167933 A (SLANHOFF BERTRAM [US]) 18 September 1979 (1979-09-18) *The whole document*	1 to 10
A	WO 2008029426 AI (SPADA EMANUELE [IT]) 13 March 2008 (2008-03-13) *The whole document*	1 to 10

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INTERNATIONAL SEARCH REPORT
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		IT CT20060019 A1	2006-12-07

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