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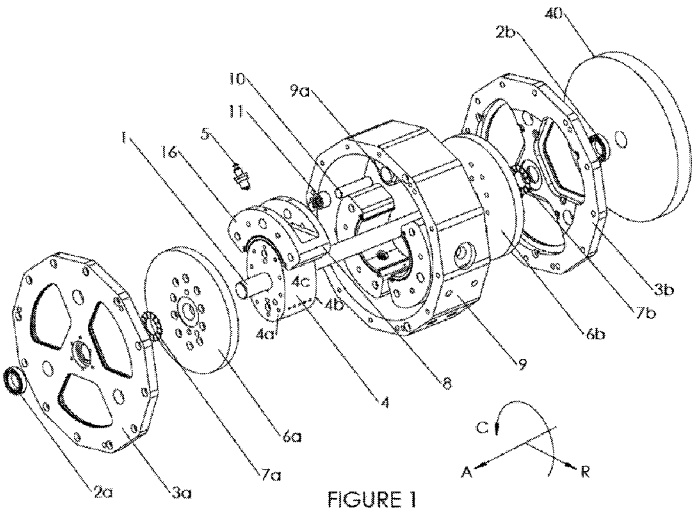

FIGURE 1

(57) Abstract: The disclosure provides engines or pumps that includes a rotatable shaft defining a central axis A, the shaft having a first end and a second end. The shaft can have an elongate first island disposed thereon. The first island can have a body with a volume generally defined between front and rear surfaces that are spaced apart. The front and rear surfaces can lie in a plane parallel to a radial axis R. The perimeters of the front and rear surfaces can define a curved perimeter surface therebetween. The engine or pump can further include a front side plate disposed adjacent to the front surface of the first island, and a rear side plate disposed adjacent to the rear surface of the first island. The engine or pump also includes a first contour assembly disposed between the front side plate and the rear side plate.

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IDAR-ACE INVERSE DISPLACEMENT ASYMMETRIC ROTATING ALTERNATIVE CORE ENGINE

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit of priority to U.S. Provisional Patent Application Serial No. 61/697,481, filed September 6, 2012, and U.S. Provisional Patent Application Serial No. 61/610,781, filed March 14, 2012. Each of the aforementioned patent applications are incorporated by reference herein in their entirety for any purpose whatsoever.

BACKGROUND

U.S. Patent No. 6,758,188, entitled "Continuous Torque Inverse Displacement Asymmetric Rotary Engine", the disclosure of which is incorporated herein by reference in its entirety, discloses an Inverse Displacement Asymmetric Rotary (IDAR) engine. The engine includes an inner chamber wall, an outer chamber wall, and a movable contour. U.S. Patent Application Serial No. 12/732, 160, filed March 25, 2010, which is also incorporated by reference herein in its entirety, presents improved embodiments vis-à-vis the embodiments of U.S. Patent No. 6,758,188. The present disclosure provides significant improvements over these embodiments, as described herein.

SUMMARY

The disclosed embodiments improve upon the common reciprocating piston engine and rotary engine. Improvements over such common engines include at least:

A higher power density;

A flexible working volume that enables high Atkinson Ratio cycles;

A two-dimensional design that enables practical use of low wear materials;

Two, three or more times as many power strokes per revolution;

An increased mechanical transfer efficiency;

Reduced engine case vibrations; and

Reduced number of parts.

The disclosed embodiments describe a machine used to combust fuel-air mixtures thereby converting chemical energy to rotational kinetic energy. An important feature of the disclosed embodiments is a formation of a working volume by the interaction of a convex surface of a non-round, symmetric or asymmetric rotating cylinder or “island”, a reciprocating concave part or “contour,” and front and rear side plates.

Thus, in one embodiment, the disclosure provides an engine or pump that includes a rotatable shaft defining a central axis A, the shaft having a first end and a second end. The shaft can have an elongate first island disposed thereon. The first island can have a body with a volume generally defined between front and rear surfaces that are spaced apart along the rotatable shaft. The front and rear surfaces can lie in a plane parallel to a radial axis R. The front and rear surfaces can have a rounded, non-circular shape. The perimeters of the front and rear surfaces can define a curved perimeter surface therebetween. The engine or pump can further include a front side plate disposed adjacent to the front surface of the first island, and a rear side plate disposed adjacent to the rear surface of the first island. The engine or pump can still further include a first contour assembly disposed between the front side plate and the rear side plate. The first contour assembly is defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface. The concave inwardly facing surface of the contour assembly faces the curved perimeter surface of the first island. The concave inwardly facing surface and the curved perimeter surface of the island and the front side plate and rear side plate cooperate to form a working volume. The rotatable shaft and first island, or at least the first island are preferably configured to rotate with respect to the first contour assembly.

If desired, the contour assembly can define an opening therein for receiving a spark plug. The first contour assembly can be coupled to a stationary housing. The first contour assembly can be mounted to a stationary wrist pin, such that the first contour assembly oscillates about the wrist pin as the first island and rotatable shaft rotate about the central axis A. The wrist pin is preferably generally parallel to the central axis A. The contour can include a first apex point disposed proximate to a first end of the concave inwardly facing surface of the contour assembly and a second apex point disposed proximate to a second end of the concave inwardly facing surface of the contour assembly. The apex points are preferably disposed in a gap defined between the concave inwardly facing surface of the contour assembly and the curved perimeter surface of the first island. The apex points help to define the working volume. If desired, the apex points can be disposed within recesses defined in the contour assembly. The contour assembly can further include at least one preloading spring disposed proximate to each of the apex points, the at least one preloading spring can be adapted to urge the apex points against the first island.

The gap between the contour assembly and first island that is covered by the apex seals can be less than about 0.10 inches, less than about 0.010 inches, less than about 0.0010 inches, less than about 0.00010 inches, or less than about 0.000010 inches, as desired. The contour can include a first corner seal disposed proximate to the front face of the contour assembly and a second corner seal disposed proximate to the rear face of the contour assembly, the corner seals being disposed in a gap defined between the front and rear faces of the contour assembly and the front and rear side plates, the corner seals helping to define the working volume.

In some implementations, the corner seals can be disposed within recesses defined in the front and rear faces of the contour assembly. The contour assembly can further include corner seal preloading springs disposed proximate to each of the corner seals. The corner seal preloading springs can be adapted to urge the corner seals against the front and rear side plates. The contour assembly can further include a plurality of floating side seals embedded in arcuate grooves defined in the pair of opposed outwardly facing arcuately shaped front and rear surfaces of the contour assembly. The arcuate grooves can be generally coincident with the arcuate extent of the concave inner surface, and intersect with the grooves configured to receive the apex seals. Each of the side seals can sit on top of at least one preloading springs for maintaining stability and orientation of the side seals in the arcuate grooves. Preferably, the corner seals and apex points substantially coincide to help define the working volume. In various implementations, the front and rear side plates can rotate with the rotatable shaft and the island.

In accordance with further implementations, the front and rear side plates can have a center of rotation that substantially matches a geometric center of the front and rear side plates. Alternatively, the front and rear side plates can have a center of rotation that do not substantially match a geometric center of the front and rear side plates. If desired, the engine or pump can further include a front thrust bearing disposed proximate to the front plate and a rear thrust bearing disposed proximate to the rear plate to maintain the first island and side plates at a substantially fixed axial location. In various embodiments, the island can be generally elliptical, generally oval, or generally dumbbell-shaped, among other possible shapes.

If desired, at least one of the front and rear side plates can include ports defined therein for directing working fluids passing through the device. If desired, the first island can include at least one port defined therein for directing working fluids passing through the device. The at least one port can be formed through the curved perimeter surface of the first island. The at least one port can include a first portion that is generally parallel to the radial axis R and a second portion in fluid communication with the first portion that is generally parallel to the central axis A. The second portion of the at least one port can be configured to align with a port defined in at least one of the front and rear side plates.

In some implementations, at least two ports can be formed through the curved perimeter surface of the first island. The at least two ports can include a first port and a second port that are displaced from each other about the curved perimeter surface of the first island along a circumferential axis C that is orthogonal to the central axis A and the radial axis R. The first port can be configured to function as an intake port to direct working fluid into the working volume, and the second port can be configured to function as an exhaust port to direct working fluid out of the working volume. In some implementations, at least one port can include a valve for controlling the flow of fluid therethrough. The valve can be passively or actively actuated.

In further accordance with the disclosure, the engine or pump can further include a second contour assembly disposed between the front side plate and the rear side plate. The second contour assembly can be defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface. The concave inwardly facing surface of the second contour assembly can face the curved perimeter surface of the first island. The concave inwardly facing surface and the curved perimeter surface of the first island and the front side plate and rear side plate can cooperate to form a second working volume. The rotatable shaft and first island are preferably configured to rotate with respect to the second contour assembly.

The second contour assembly can be angularly displaced from the first contour assembly about the central axis along a circumferential axis by a first angular increment. For example, the first angular increment can be about 180 degrees, about 120 degrees or about 90 degrees.

In a further implementation, the engine or pump can further include a third contour assembly disposed between the front side plate and the rear side plate. The third contour assembly can be defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface. The concave inwardly facing surface of the third contour assembly can face the curved perimeter surface of the first island. The concave inwardly facing surface and the curved perimeter surface of the first island and the front side plate and rear side plate can cooperate to form a third working volume. The rotatable shaft and first island can be configured to rotate with respect to the third contour assembly.

In some implementations, the first, second and third contour assemblies can be angularly displaced from each other about the central axis along a circumferential axis by a second angular increment. The second angular increment can be about 120 degrees or about 90 degrees.

In further implementations, the engine or pump can further include a fourth contour assembly disposed between the front side plate and the rear side plate. The fourth contour assembly can be defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface. The concave inwardly facing surface of the fourth contour assembly can face the curved perimeter surface of the first island. The concave inwardly facing surface and the curved perimeter surface of the first island and the front side plate and rear side plate can cooperate to form a fourth working volume. The rotatable shaft and first island can be configured to rotate with respect to the fourth contour assembly.

In further implementations, the first, second, third and fourth contour assemblies can be angularly displaced from each other about the central axis along a circumferential axis by a third angular increment. For example, the fourth angular increment can be about 90 degrees. In various implementations, the engine or pump can further include a housing for containing at least a portion of the rotatable shaft, the first island, and the front and back side plates.

In some implementations, the rotatable shaft can include a second elongate island disposed thereon. The second island is preferably axially displaced along the shaft from the first island, the second island has a body with a volume generally defined between front and rear surfaces that are spaced apart along the rotatable shaft. The front and rear surfaces preferably lie in a plane parallel to the radial axis R. The front and rear surfaces preferably have a rounded, non-circular shape. The perimeters of the front and rear surfaces define a second curved perimeter surface therebetween. The engine or pump can further include a second front side plate disposed adjacent to the front surface of the second island, a second rear side plate disposed adjacent to the rear surface of the second island, and a second contour assembly disposed between the second front side plate and the second rear side plate. The second contour assembly can be defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a second concave inwardly facing surface. The second concave inwardly facing surface of the contour assembly can face the second curved perimeter surface of the second island. The second concave inwardly facing surface and the second curved perimeter surface of the second island and the second front side plate and second rear side plate can cooperate to form a second working volume. The rotatable shaft and second island are preferably configured to rotate with respect to the second contour assembly. If desired, at least one of the second front or rear side plate can be integral with the front or rear side plate that is associated with the first island.

In some implementations, the engine or pump can further include at least one cam follower operably coupled with the first contour assembly. The at least one cam follower can be adapted to roll along an edge surface of at least one of the front side plate and rear side plate. The at least one cam follower can be mounted on a lever arm that is coupled with the first contour assembly.

In accordance with further aspects, the engine or pump device can be used as a pump or compressor. For example, the device can be an air conditioning compressor configured to compress refrigerant. In another embodiment, the engine or pump can be a steam driven engine, or an engine driven by compressed air. Such an engine can be connected to an input shaft of a device such as a generator or pump, or other device, as desired.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and are intended to provide further explanation of the embodiments disclosed herein.

The accompanying drawings, which are incorporated in and constitute part of this specification, are included to illustrate and provide a further understanding of the methods and systems of the disclosure. Together with the description, the drawings serve to explain the principles of the disclosed embodiments.

BRIEF DESCRIPTION OF DRAWINGS

Accompanying the description are plural images illustrating the disclosed embodiments, which represent non-limiting examples and in which:

Fig. 1 illustrates an exploded, isometric view of a first embodiment in accordance with the present disclosure;

Fig. 2 illustrates mechanical detail of a portion of the embodiment of Fig. 1;

Fig. 3 illustrates mechanical motion of a portion of the embodiment of Fig. 1;

Fig. 4 illustrates aspects of a contour portion of the embodiment of Fig. 1;

Fig. 5. presents illustrative side plate porting for a C.E.(Combustion Engine) in accordance with the embodiment of Fig. 1;

Fig. 6 presents illustrative porting of the island for a C.E. in accordance with the embodiment of Fig. 1;

Figs. 7a-8d illustrate various operations of a C.E./pump in accordance with the embodiment of Fig. 1;

Fig. 9 illustrates a side view of a first example of an engine using three spaced apart islands, wherein successive islands are spaced apart from each other 40 degrees;

Fig. 10 illustrates a variety of different islands that can be used for the island of the embodiment of Fig. 1;

Fig. 11 illustrates an exploded, isometric view of a second embodiment in accordance with the disclosure;

Fig. 12 illustrates a mechanical transfer detail of the embodiment of Fig. 11;

Fig. 13 illustrates contour parts of the embodiment of Fig. 11;

Fig. 14 illustrates rotating side plates of the embodiment of Fig. 11;

Fig. 15 illustrates a lever arm and compliant axle of the embodiment of Fig. 11;

Fig. 16 illustrates porting for a C.E.(Combustion Engine)/pump for the embodiment of Fig. 11;

Figs. 17-24b illustrate various operations of the C.E./pump of Fig. 11.

Fig. 25 illustrates an example of an engine design having four contours spaced apart ninety degrees.

Fig. 26 illustrates an example of a two island engine wherein the islands are spaced apart by sixty degrees.

DETAILED DESCRIPTION

Referring to Fig. 1, components are illustrated which form embodiments of the disclosure. In addition, a coordinate system is illustrated which will be utilized for discussing the disclosed embodiments. This coordinate system is a cylindrical, three dimensional system, including axial (A), radial (R) and circumferential (C) axes. As illustrated in Figure 1, a rotatable shaft 1 is held by a pair of front 2a and rear 2b radial frictionless, oil film or plain bearings. The bearings are supported by a pair of front 3a and rear 3b stationary case end plates.

The rotatable shaft 1 is affixed to, or has integrated in it, a cylindrical-like shaped structure 4 or "island". The Island 4, is sufficiently thick having two parallel flat surfaces 4a and 4b and a perimeter surface 4c which is curved and may be any suitable shape, such as elliptical, oval and the like, as discussed in further detail below.

As illustrated in Fig. 1, mechanically fastened to or integrated in front 4a and rear 4b flat ends of the island 4 are a pair of generally circular front 6a and rear 6b side plates having a generally uniform thickness, such that a substantially gas-tight or fully gas tight seal is formed between the island and the end plates, as well as between the contour portions 8 and the end plates such that a substantially or fully gas-tight chamber can be defined by an outer surface of the island 4, the inner faces of the side plates 6, and an inner face of the contour assembly(ies) 8. The side plates 6a, 6b rotate with the shaft 1 as depicted but may or may not have a center of rotation that matches a geometric center of the side plates 6a, 6b and island 4 combination. Non-coincident rotating and geometric centers can produce the desirable effect of asymmetric working volume dynamic changes. A pair of front 7a and rear 7b thrust bearings are used to keep the island - side plate combination at a fixed axial location.

A concave-shaped part or “contour assembly” 8 is depicted in the figures, having a pair of opposed outwardly facing arcuate surfaces that cooperate with and are connected by a concave inwardly facing surface that faces the island 4. The contour assembly 8 also can have an opening (if desired) for receiving a spark plug 5 or other similar device. The contour assembly 8 is inserted between plates 6a and 6b such that the inner concave face is facing the island 4 forming a working volume 5’ (see Fig.2) there between. A pair of first 15a and second 15b apex points (Fig. 2), contact the convex surface of the island 4 and the parallel surfaces of the side plates 6a, 6b to help define working volume 5’ that can act as a combustion chamber when the disclosed embodiments act as an internal combustion engine, rather than a pump or compressor (in which case the engine will be driven by driving pressurized fluid into the working volume, e.g., via a port in a location generally coinciding with the spark plug port), as alternatively discussed herein. The thickness or depth of the island 4 and corresponding parts of the engine (e.g., contours 8 and housing 9) can be increased or decreased to correspondingly provide an engine having a relatively larger or smaller working volume 5'. The size of the working volume can additionally or alternatively be scaled by increasing or decreasing the diameter of the engine and altering the curvature of the inner arcuate surfaces of the contours 8.

Outer housing 9 has at least one or up to N appendages or anchor points 9a-n, which point inwardly toward the island 4 separated from each other by about 120 degrees (in the case that N=3) of circumferential extent. This exemplary embodiment shows a quantity of three anchor points (9a, 9b and 9c of Fig. 2). Outer housing 9, is attached to both stationary case end plates 3a and 3b. In an alternative embodiment, housing 9 can be made in two castings or a single casting and an endplate that use a single seal, rather than having a cylindrical housing with two end plates. For purposes of illustration only, consecutive islands and housings can be stacked serially and be discrete as illustrated in Figs. 9(a)-9(b) and in Fig. 26. It should be noted that not all details of the engine are present in the aforementioned illustrations. If desired, the housings can be combined into the same structural unit wherein the housings are integrated (e.g., into the same casting). For example, two adjacent cylindrical cavities, each containing an island, can be formed integrally having a cover portion covering each end of the casting to complete two cylindrical cavities.

With further reference to the Figures, wrist pins 10, are disposed in a double shear mode that enables high rigidity in the structure. Side plates 6a, 6b rotate inside of outer housing 9. Lubricant (e.g., ordinary or synthetic motor oil) can be disposed in the lower portion of outer housing 9. As side plates 6a, 6b rotate, they pass through the lubricant and help distribute it over the parts of the engine inside of housing 9. If desired, end plates 6a, 6b can be provided with an irregular or textured (e.g., embossed/grooved) surface to facilitate the uptake and distribution of lubricant.

The parts as arranged in Figure 3 create the motion of the contour assembly 8. Specifically, the contour assembly 8 is connected to an appendage 9a on outer housing 9 by use of wrist pin 10. While the planform area of housing 9 is generally round in shape (see, e.g., Fig. 2), any suitable shape can be used. The connection via pin 10 allows the contour assembly 8 to pivot or oscillate in the plane as viewed in Figure 3 about the center of 10. Alternatively, wrist pin 10 may also contain one or more frictionless bearings 11 shown in figure 1. It will also be appreciated by those of skill in the art that while three contours are presented in the first illustrated embodiment, any suitable number of circumferentially spaced contours riding on pivots (e.g., wrist pins 10) can be used, such as one, two, four, five, or more contours.

To describe the motion of contour assembly 8 two conventions are made herein: 1.) The apex seal 15a, which rides over the outer surface of the island 4c that, until immediately before reaching the seal, is not within a combustion chamber, is called the "leading" seal. 2.) the apex seal 15b, which rides over island surface that, until immediately before reaching the seal, is only inside a combustion chamber is called the "trailing" seal. This is the case in Figure 3 where the island 4, is shown rotating in the clockwise direction.

In the case where the island 4 is rotating clockwise, should the contour require to pivot in the clockwise direction, the leading apex seal 15a, would be subject to a contact force and hence force a clockwise rotation. Should the contour require a counter clockwise rotation, the trailing apex seal 15b, would be subject to contact force.

The shape of the outer surface 4c of the island 4 and the geometry of contour assembly 8, together with the pivot location 10, minimize the free play between the motions of increasing and decreasing the working volume 5'. The curvature of the surface of the island 4 can be a continuous geometric shape and follow the profile of a known shape (e.g., ellipse) or may deviate from such a uniform shape along its circumferential path, such as by having one or more irregularities (e.g., concavities or convexities) that fall outside the uniform shape, such as those illustrated in Figs. 10(a)-10(d). The contour of the external surface of the island 4 is preferably adapted and configured to maintain a substantially uniform gap between the locations of the contours having apex seals to permit a relatively small amount of seal travel to extend seal life and engine durability. For example, the gap covered by the apex seals can be less than about 0.10 inches, less than about 0.010 inches, less than about 0.0010 inches, less than about 0.00010 inches, and less than about 0.000010 inches, in any desired increment of about 0.0000010 inches. The preferred shape of the island and the gap is affected by a variety of geometric factors including the size, shape and number of contours, (e.g., 1, 2, 3, 4, 5 or more contours), the size of the engine, and the like.

The contour assembly 8 as shown in Figure 4, includes a main body 16 and additional parts (e.g., springs, apex seals, other seals and the like), discussed below, to prevent leakage of the working fluids (in the case of an engine) or the fluids being worked (in the case of a pump or compressor) from the working volume. The assembly can include a spark plug 5 as illustrated in Figure 4 and described in the related text, below in the case of an internal combustion engine.

The main body 16 of contour assembly 8 is preferably narrower than the thickness of the island 4 and can be made of materials not conducive to wear. For example, main body 16 can be made from aluminum or other light weight materials; as well it could be made from cast iron or forged steel. Moreover, ceramic coatings or inserts can also be applied disposed on the inner concave face of the contour assembly for improved thermal and combustion behavior. A gap, which is to be sealed, is defined between the main body 16 of the contour assembly 8 (Fig. 1) and the adjacent side plates 6a, 6b. To bridge this gap and keep gases/fluids in the working volume 5', as illustrated, floating side seals 17a, 17b can be provided (Fig. 4) that are embedded in arcuate grooves formed in the outer arcuate surfaces of the main body 16. As illustrated, the arcuate grooves are generally coincident with the arcuate extent of the concave inner surface of the main body 16, and can intersect with grooves 23a, 23b that are adapted and configured to receive the apex seals 15a, 15b. Other embodiments can employ additional channels to further reduce leakage, and/or single-piece floating side seals in which 17a and 17b are merged into one part.

To prevent gases from leaking out via the apex points (Fig. 3) floating apex seals 15a, 15b of Fig. 4 are inserted into transverse, axially extending, matching channels 8e and 8f in the contour 8. The apex seals 15a, 15b contact the surface 4c of island 4 as shown in Fig. 3. The seals 15a/b and matching channels 8e/f are dimensioned to minimize leakage over the top and around 15a/b but still allow some movement of the floating seal as discussed above. Channels 8e, f, as illustrated, are oriented generally orthogonally with respect to the arcuate grooves that receive side seals 17a, b in opposing flat faces 8c, 8d of the contour 8. The side seals 17a, 17b sit atop preloading springs 18a, 18b which have a wavy contour to maintain stability and orientation of the seals 17a,b in the arcuate grooves. As is further evident from the inset of Figure 4 illustrating the “reverse view”, contour portion 8 further includes a hollowed portion on its outwardly facing arcuate surface that is defined by two radially extending and inwardly facing walls having an outer arcuate edge that joins a generally straight inner edge. The generally straight inner edges of the inwardly facing walls help to define a generally planar surface that faces radially outwardly, in which the spark plug 5 is received.

Preloading springs 20a, 20b (Fig. 4) maintain a nominal seal contact force of the apex seals 15a, 15b. For enhancing seal contact force, internal gas pressure "P" (Fig. 3) within working volume 5’ creates an unbalanced load on the seals, thus increasing the seal contact force at 15a and 15b proportionally to the internal pressure of the working volume 5’. Preloading springs, 20a and 20b furthermore assist in correcting for differences in the motion and wear at the contact points of 15a, 15b. To further enhance sealing, corner seals 21a, 21b, 21c and 21d with one each respectively preload springs 22a, 22b, 22c and 22d installed inwardly of the corner seals are installed in matching pockets 23a, 23b, 23c and 23d formed adjacent each end of channels 8e, 8f.

In a typical application, one to multiple copies of the contour assembly 8 shown in Figure 4 may be used. For purposes of illustration only, as illustrated in Figure 2, the depicted embodiment uses three of the same sub assemblies 100, 102, each including contour assemblies and related parts identified in figure 4. The sub assemblies 100, 102 are rotationally separated by N/360° degrees around the island 4, where N is the number of subassemblies. In this case it is 120°.

In the case when the disclosed embodiment is used as an internal combustion engine, an ignition spark plug 5 is provided, and is preferably, but not necessarily, located as centrally as practicable in the contour 8 as shown in Fig. 4. A high voltage electrical spark is transferred to the center electrode of the sparkplug through a high voltage wire, spring or other mechanism not shown. The high voltage electrical pulse is created in a magneto, electronic ignition coil or other conventional components not shown, and timed to the rotational position of the shaft. It will be appreciated that the subject embodiments can also be used as a pump or compressor as discussed elsewhere herein.

Working gases such as fresh air-fuel mixtures or exhaust are conveyed into and out of the working volume 5' with ports located in the side plates 6a and 6b or island 4. The ports may include, but are not limited to, those illustrated in Figure 5 and 6.

Side plate ports: In the case of side plate porting, side plates 6a/b have specially shaped through-openings 24a, 24b, which as the island 4 and side plates 6a, 6b assembly rotates, come into view of the working volume 5'. Such openings 24a/b were described in USPA 12/732,160 for an INVERSE DISPLACEMENT ASYMMETRIC ROTARY (IDAR) ENGINE, filed on March 25, 2010 incorporated herein by reference in its entirety (for any purpose whatsoever) in which the contours 8 revolved around the fixed island 4. As indicated, while the island 4 revolves in the embodiment disclosed herein, the covering and exposing ports is still accomplished by the movement of the contour(s) 8. The shapes of the openings 24a, 24b are optimized to enhance flow timing, seals traversing over ports and minimize parasitic losses.

Island based ports: Alternatively, Figure 6 shows an embodiment where the working gases enter and or exit through the island 4. Such intake and exhaust ports may have devices that control the back flow of gases (e.g., check valves or active valves). As depicted, intake gases flow through one or more ports 25a and exhaust gases flow through one or more ports 25b formed at angularly displaced, generally opposing portions of the outer peripheral face of the island 4.

Ports 25a, 25b begin at the surface 4c of the island 4, and extend generally radially inwardly until they intersect and are in fluid communication with corresponding passages 26a and 26b, which allow gases to enter or exit axially from the rotating parts. As illustrated, passages 26a, 26b are oriented generally orthogonally with respect to passages 25a, 25b, and are oriented generally parallel with respect to the shaft 1 of the engine.

As further illustrated in Fig. 6, the central bore of the island can have a slot portion for mating with a corresponding key portion on the crankshaft. In the alternative, the island can be formed integrally with the shaft 1, via techniques such as forging and the like.

In the case of either porting configuration, the island and side plates preferably includes rotary seals (not shown) to interface the intake and exhaust manifolds with the rotating ports. This prevents the gases from mixing with the inner space contained by the engine case 3a, 9 and 3b and directs gases to the outside of the engine.

WHEN USED AS AN INTERNAL COMBUSTION (I.C.) ENGINE

When used to convert chemical energy to rotational kinetic energy, a four stroke cycle is used, and one complete cycle is performed in one shaft revolution. If three contour assemblies 8, 100 and 102 are used as shown in Fig. 2, a total of three complete cycles are performed in one revolution. Flywheel 40 illustrated in Fig. 1 is also added to store rotational energy. This flywheel can be optionally omitted in larger scale designs where the rotating island-sideplate assembly is able to store substantial rotational energy.

For valving, side plates 6a, 6b, may typically have single port openings respectively 24a and 24b as shown in Figures 5a/b. Another embodiment shown in Figure 6 may have both ports 25a/b in the island which are fed by passage ways 26a/b. The angular locations of each port with respect to a single common indicia on the shaft 1, and the locations of the contour assemblies 8, determine the function of each port. The angular location = 0 degrees will be set at the start of combustion for these discussions. This position is commonly called Top Dead

Center (TDC). A negative angle is considered before TDC and a positive is after TDC.

Intake stroke: Figures 7 and 8 show various points in rotation where the working volume is explained. On or before Crank Angle = -180°, Figure 7a, a port designated as the intake port, for example, Port 25a, starts to become exposed in the rotating Island 4 (note arrow for rotation direction) to the working volume 5'. Passage way 26a is externally connected to a fresh air source to which a means to inject or induce fuel, such as gasoline, propane or methane gas into such air stream. This allows the combustible mixture of fuel and air to be suctioned into the working volume 5' (Figure 7b-c), which is increasing at the same time.

It will be appreciated by those of skill in the art that any suitable combustible fuel can be used, such as hydrogen, diesel, kerosene, natural gas, ethanol (and other alcohols), and the like. By way of further example, in another aspect, an embodiment of the disclosed engine is attached to an electrical generator for power generation that can use combustible fuels, as well as other types of working fluids having relatively high pressure energy with respect to the environment in which the engine is situated, such as steam, water, compressed air, combustion products, other gases, and the like. For example, a disclosed engine/generator combination could be coupled to a boiler used to generate steam that is heated by combustion or other (e.g., nuclear) power. The energized fluid can cause the engine to rotate, thus driving the generator. As such, embodiments of the disclosed engine can be used in any suitable application where fluid driven turbines are used. Such a combination can also be used to be driven by a pressurized liquid and act as a hydraulic motor, such as in the case of hydroelectric power or could be used in a hydraulic drivetrain for power generation or propulsion purposes.

The island 4 continues to rotate as shown in Figure 7c, Crank Angle = -90°. At this point, intake port 25a, which is circumferentially trailing in the direction of motion, is now aligned with the contacting edge of apex seal 15b, so as to close the intake port 25a. At this point, intake charge compression begins.

Compression Stroke: As the cycle continues from Crank Angle = -90° to Crank Angle = 0°, shown in Figure 7d the fuel - air charge is compressed into a gradually decreasing working volume. Stored rotational energy from a flywheel 40 of Figure 1 forces the continued rotation of the island 4 and forces contour assembly 8 to constrict the working volume 5'. This compresses the gas mixture. Due to continued relative movement of the island 4 and contour assembly 8, compression continues until a minimum void exists between the island facing surface of the contour assembly 8 and the contour facing surface of the island 4c, until the working volume 5' reaches its minimum volume shown in Figure 7d. This is the compression stroke.

<u>Power stroke</u>: When the working volume 5' is near or at TDC (Fig. 8a), the spark plug 5 is energized from an external high voltage coil and the fuel - air mixture is ignited. All ports remain closed at this time. The rapidly burning, expanding gases begin pushing the contour 8 outward and island 4 clockwise.

<u>Power stroke kinematics</u>: Figure 3 shows the island Crank Angle = +45 degrees of the power stroke. The force created by gas pressure "P" of Figure 3, representing in this case that from burning gases, is constrained by wrist pin 10, and applied to surface 4c of the island. The effective area of the gas force is developed by a rectangle formed by chord line 12 between apex seals 15a/b, and extruded by the thickness of the island. The total force developed by the working volume on the island is equal to this effective area multiplied by the chamber pressure. The force is driven perpendicular to the effective area, shown as direction 13, and applied to the moment arm line 14 to generate torque and useful rotational power. The power stroke continues until +90° after TDC.

<u>Exhaust stroke</u>: After the working volume 5' reaches its maximum at +90° as shown in Figure 8b, exhaust port 25b begins to be exposed to the working volume 5' due to relative movement of the island 4 and the contour assembly 8. Positive power transmission ceases. Port 25b gradually then fully opens as shown in Figure 8c, and the spent gases are pushed out port 25b and into the exhaust system to atmosphere, as the working volume 5' decreases.

Exhausting continues to occur through to the beginning of the intake cycle, at which point ports 25a, 25b are both within the working volume 5'. At the point when the working volume 5' can get no smaller, the cycle is repeated with the intake stroke as shown in Figure 7a and repeated in the related text.

In similar fashion but +120 degrees out of phase for a three-contour engine, contour assembly 100 is repeating the above 4 stroke cycle using the same ports that were used for assembly 8.

In similar fashion but -120 degrees out of phase for a three-contour engine, contour assembly 102 is repeating the above 4 stroke cycle using the same ports that were used for assembly 8.

The shape of the island 4 can be chosen to modify the variation in working volume over the engine cycle so as to exhibit a power stroke maximum volume which is larger than the intake stroke maximum volume. Additionally, the length and closing point of intake port 24a can be modified to simulate a smaller intake stroke volume. When the expansion volume is larger than the intake volume, it is said to be an "Atkinson Cycle". The ratio of the expansion volume over the intake volume is known as Atkinson ratio. Ratios significantly greater than 1.0 can produce higher fuel efficiency combustion engines. Particular geometry details of the invention can be easily modified to boost the Atkinson ratio well over 1.0.

While the geometry of the three contour island is illustrated showing three contours in place, it is also within the scope of the disclosure to provide only one or two contours in the three contour geometry. The three contour geometry is capable of operating as an internal combustion engine with only one contour installed. Thus, the disclosure also provides an engine with a single contour. As such, an internal combustion engine is disclosed having only two moving parts – the island and the contour.

Figure 25 illustrates another embodiment of an engine having four contours that are spaced 90 degrees from each other about a rotatable island. The island defines two impressions therein that are spaced apart by 180 degrees for helping to define two parallel combustion chambers with two contours that are spaced 180 degrees apart. Thus, in one revolution the engine of Figure 25 is able to provide four combustion events. As illustrated, as with the other contour assemblies illustrated herein, contours of Figure 25 are defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface. The concave inwardly facing surface of the contour assemblies face the curved perimeter surface of the island.

Figures 11-24b provide illustrations of a further embodiment of a device in accordance with the disclosure.

Referring to Fig. 11, components are illustrated forming another embodiment of a IDAR engine. A coordinate system is also illustrated which will be utilized for discussing the disclosed embodiment. This coordinate system is a cylindrical, three dimensional system, consisting of axial (A), radial (R) and circumferential (C) axes. As illustrated in the Figure, a rotatable shaft 201 is held by a pair of front 202a and rear 202b radial frictionless/substantially frictionless, oil film or plain bearings. The bearings are supported by a pair of front 203a and rear 203b stationary case end plates.

The rotating shaft 201 is affixed to, or has integrated in it, a cylindrical-like shaped structure 204 or "island". The island, 204, is substantially thick and has two parallel flat surfaces 204a and 204b, as well as a perimeter surface 204c which is not round. The non-round shape surface, 204c can be elliptical, oval, egg like or a combination of curves and splines that form a closed, smooth convex path, such as disclosed herein with respect to the embodiment of Figs. 1-10. This shape (i.e., the profile or planform projection of the island 204) can be symmetric or asymmetric in shape with respect to either a vertical or horizontal axis when viewed directly upon either flat surface. (See Fig. 12).

As further illustrated in Fig. 11, mechanically fastened to or integrated in front 204a and rear 204b flat ends or faces of the island 204 are a pair of front 206a and rear 206b side plates, such that a gas-tight seal is formed. The side plates 206a, 206b rotate with the shaft 201 but may or may not have a center of rotation that matches a geometric center of the side plates 206a, 206b and island 204 combination. Non-coincident rotating and geometric centers can produce the desirable effect of asymmetric working volume dynamic changes.

A pair of front 207a and rear 207b thrust bearings can be used to keep the island - side plate combination at a fixed axial location.

A concave-shaped part or “contour assembly” 208 is disposed between plates 206a and 206b such that the concave opening is facing the island 204 forming a working volume 205 therebetween. A pair of first 215a and second

215b apex points (Fig. 12), contact the convex surface of the island 204 and the parallel surfaces of the side plates 206a, 206b.

The parts illustrated in Figure 12 define the motion of the contour assembly 208. The contour assembly 208 is operably connected to a lever 209, illustrated as being “L”-shaped (see Fig. 15), by use of a wrist pin 210. This connection allows the contour assembly 208 to pivot in the plane as viewed in Figure 12 about the center 210a.

As further illustrated, lever 209 is attached to a fixed bracket 211 by way of a second wrist pin 212. Wrist pins 210 and 212 are disposed in a double shear mode that enables high rigidity in the structure.

Bracket 211 can be fastened to, or can be one and the same as, both of the stationary case end plates 203a, 203b. The second wrist pin 212 also only allows the lever 209 to pivot or rock in the plane as viewed in Figure 12 about center 212a.

Continuing down the lever 209, the assembly further includes a pair of first 213a and second 213b (Fig. 1) cam followers, one for each side plate 206a, 206b. The cam followers 213a, 213b may be rotating bearings or sliding shoes. Cam follower bearings 213a and 213b, if so chosen, are allowed to rotate about an axle pin 214 (Fig. 12) and can be held on by clips or other structure. The cam followers 213a, 213b contact and thus follow the complex profile of the outer edge 206c, 206d of the side plates 206a, 206b (Fig. 11).

The motion of the contour assembly 208 is determined by two different mechanisms. To move the contour assembly 208 to the center, thereby reducing the working volume 205, the side plates 206a, 206b exert outward force 230 on the cam followers 213a and 213b. Through the fulcrum point 212a created at wrist pin 212, the outward cam force 230 is then translated to an inward force 231 at wrist pin 210, thus pushing the contour assembly 208 toward the center of the island 204.

To increase the working volume 205, the pair of first 215a and second 215b contact points of the contour assembly 208 are pushed outward in the direction 232a and 232b of Fig. 14, by the rotational motion of the island 204.

The shape of the outer edges 206c and 206d of the side plates 206a, 206b, the shape of the outer surface 204c of the island 204 and the geometry of the lever 209 and contour assembly 208, together, minimize the free play between the motions of increasing and decreasing the working volume 205.

The contour assembly 208 as shown in Figure 13, includes a main body 16 and additional parts, discussed below, to substantially prevent leakage of the working gases from the working volume defined between the island, the contour and the faces of the front and rear end plates. As illustrated, the assembly can include a spark plug 221 as shown in Figure 13 and as described in the related text, below.

The main body 216 of the contour assembly 208 is narrower than the thickness of the island 204 and can be made of materials not conducive to wear. For example, main body 216 can be made from aluminum or other light weight materials. If desired, it could also be made from cast iron or forged steel. A gap, which can be sealed, is defined between the main body 216 of the contour assembly 208 (Fig. 1) and the adjacent side plates 206a, 206b. To bridge this gap and in order to substantially maintain gases within the working volume 205, the floating side seals 217a, 217b (Figure 13) are imbedded in opposing flat faces 208c, 208d of the contour 208. The side seals 217a, 217b sit atop the preloading wavy springs 218a, 218b.

To prevent gases from leaking out the apex points 215a, 215b (Fig. 12), rotatable seals 219a, 219b as illustrated in Fig. 13 can be inserted into transverse, axially extending, matching channels 208e and 208f in the contour 208. The apex points 215a, 215b of the seals 219a, 219b contact the surface 204c of island 204 as shown in Fig. 12. The seals 219a/b and matching channels 208e/f are shaped to provide the seals 219a/b with a circumferential range of motion about pivot points 219e/f, as discussed below and as shown in Figure 204.

For example, fulcrums 219e, 219f, can be created near the center of the seals 219a, 219b by convex arcs 219g, 219h that are concentric with second arcs 208 g/h formed into each transverse cut 208e and 208f of the contour. This geometry allows the seals 219a, 219b to circumferentially rotate when viewed from the end as shown in Figure 204. Furthermore, the distance between the fulcrum point 219e or 219f and apex points 2215a or 15b is substantially shorter than the distance between the fulcrum and the radiused ends 219g and 19h of the seals 219a and 219b.

Radially outwardly extending, preloading springs 220a, 220b (Fig. 13) preferably maintain a nominal seal contact force of the rotatable seals 219a, 219b at contact points 215a and 215b. For enhancing seal contact force, internal gas pressure P (Fig. 14) within working volume 205 creates an unbalanced load on the rotatable seals, thus increasing the seal contact force at 215a and 215b proportionally to the ratio of the above noted distances and the internal pressure P of the working volume 205.

Preloading springs, 220a and 220b furthermore assist in correcting for differences in the motion and wear at contact points 215a, 215b.

Additional springs 235, shown in Figure 15, contact with axle 214 to prevent "slapping" of the side plate surfaces 206c and 206d against cam follower bearings 213a and 213b that may be the result of motion error or wear. Springs 235 are held in place with retainer plate 236 and screws 237.

In a typical application, one to multiple copies of the sub assembly 300 shown in Figure 11 may be used. As illustrated in Figure 11, the disclosed embodiment uses two of the same sub assemblies 300, 302, each including contour assemblies 208a, 208b levers 209a, 209b and related parts identified above. The sub assemblies 300, 302 are rotationally separated by 180 degrees around the island 204. This symmetric construction dampens vibrations in the case and motor mounts.

In the case when the disclosed embodiment is used as an internal combustion engine, the ignition spark plug 221, located as centrally as possible in the contour 208 as shown in Fig. 13. A high voltage electrical spark is transferred to the center electrode of the sparkplug through a high voltage wire or other mechanism not shown. The high voltage electrical pulse is created in a magneto, electronic ignition coil or other conventional components not shown, and timed to the rotational position of the shaft.

Working gases such as fresh air-fuel mixtures or exhaust are conveyed into and out of the working volume 205 with ports located in the side plates 206a and

206b. The ports may include, but are not limited to, those illustrated in Figure 16. Side plate 206a, 206b have specially shaped through-openings 222a, 222b, which as the island 204 and side plates 206a, 206b assembly rotates, come into view of the working volume 205. Such openings 222 were described in United States Patent Application Serial No. 12/732,160, filed on March 25, 2010 incorporated herein by reference in its entirety in which the contours 208 revolved around the fixed island 204. As indicated, while the island 204 revolves in the embodiment disclosed herein, the covering and exposing ports is still accomplished by the movement of the contour(s) 208. The shapes of the openings 222a, 222b are optimized to enhance flow timing, seals traversing over ports and parasitic losses.

Incidentally, smaller through-hole openings in Figure 16 are mounting openings as discussed in the '160 application.

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When the embodiment of Figs. 11 et seq. is used to convert chemical energy to rotational kinetic energy, a four stroke cycle is preferably used, and one complete cycle can be performed in one shaft revolution. If two contour assemblies 300 and 302 are used as shown in Fig. 11, a total of two complete cycles can be performed in one revolution. Flywheel 240 illustrated in Fig. 11 is also added to store rotational energy.

Side plates 206a, 206b, may have typically single port openings 222a or 222b. The angular locations of each port with respect to a single common indicia on the shaft 201, and the locations of the contour assemblies 208, determine the function of each port. The angular location = 0 degrees will be set at the start of the intake stroke for these discussions.

Intake stroke: Figure 17 shows the point in rotation where the working volume is at a minimum. A port designated as the intake port, for example, port 222a, starts to become exposed in the rotating side plate 206a (note arrow for rotation direction) when viewed to the relative movement of the island 204 and the contour assembly 208 to the working volume 205. Port 222a is externally connected to a fresh air source to which a means to inject or induce fuel, such as gasoline, propane or methane (or natural) gas into such air stream. This allows the combustible mixture of fuel and air to be suctioned into the working volume 205, which is increasing at the same time.

The island 204 continues to rotate as shown in Figure 18A. At this point, the radially inner edge 222c of exhaust port 222b, which is circumferentially trailing in the direction of motion, is now aligned with the radially inner edge of the contour 208, so as to close exhaust port 222b. In addition, the radially outermost edge 222d of the port 222a, which is the circumferentially trailing direction of motion, becomes aligned with the radially inner edge of the contour 8, maximizing the opening of the port 222a though the cycle.

Figure 18B shows the rotation at 45 degrees and indicates that the intake port 222a is fully engaged in allowing air and fuel to enter the working volume.

Progressing further to 90 degrees, the radially inner edge 222e of intake port 222a, which is in the circumferentially trailing direction of motion, becomes aligned with the radially inner edge of the contour 208 as illustrated in Figure 209, closing the intake port. Figure 209 shows the maximum volume point for the working volume 205. The maximum volume results when, due to relative movement of the island 204 and the contour assembly 208, a maximum void exists between the island facing surface of the contour assembly 208f of Figure 18 and the contour facing surface of the island 204c. Coincidently, the port 222a is no longer open to the working volume due to the rotation of the island-side plate assembly and the movement of the contour assembly.

<u>Compression stroke</u>: Figure 20 shows the intake port 222a rotated beyond the working volume, i.e., closed. Stored rotational energy from a flywheel 240 of Figure 11 forces the continued rotation of the island 204 and forces contour assembly 208 to constrict the working volume 205 though the side plate, cam follower and lever mechanism. This compresses the gas mixture. Due to continued relative movement of the island 204 and contour assembly 208, compression continues until a minimum void exists between the island facing surface of the contour assembly 8f and the contour facing surface of the island 204c, until the working volume 205 reaches its minimum volume shown in Figure 21.

Power stroke: When the working volume 205 is near or at a minimum (Fig. 21), the spark plug 221 is energized from an external high voltage coil and the fuel - air mixture is ignited. All ports remain closed at this time. The rapidly burning, expanding gases begin pushing the contour 208 outward as shown in Figure 22. The force is transmitted through the wrist pin 20, and into lever 209. Lever 209 rotates about wrist pin 212 and imparts the force onto cam follower wheels 213. The cam action pushes the side plates 206a, 206b in a rotary motion and the shaft 201 turns thus creating useful rotational power.

Exhaust stroke: After the working volume 205 reaches its maximum as shown in Figure 23, the radially inner edge 222f of exhaust port 222b, which is in the leading direction of motion, and which is located on side plate 206b, begins to be exposed to the working volume 205 due to relative movement of the island 204 and the contour assembly 208. Positive power transmission ceases. Port 222b gradually then fully opens as shown in Figure 24A due relative movement of the island 204 and the contour assembly 208, and the spent gases are pushed out port 222b and into the exhaust system to atmosphere, as the working volume 205 decreases.

Figure 24B shows the radially outer edge 222g of the port 222b is shaped to provide for maximum opening as the contour 208 moves against the island 204 during the later part of the exhaust stage. Exhaustion continues to occur through to the beginning of the intakes cycle, when both ports 222a, 222b are not within the working volume 205. At the point when the working volume 205 can get no smaller, the cycle is repeated with the intake stroke as shown in Figure 17 and repeated in the related text.

In similar fashion but approximately 180 degrees out of phase, contour assembly 302 is repeating the above four stroke cycle using the same ports that were used for assembly 300.

The shape of the island 204 can be chosen to modify the variation in working volume over the engine cycle so as to exhibit a power stroke maximum volume which is larger than the intake stroke maximum volume. Additionally, the length and closing point of intake port 222a can be modified to simulate a smaller intake stroke volume. When the expansion volume is larger than the intake volume, it is said to be an "Atkinson Cycle". The ratio of the expansion volume over the intake volume is known as Atkinson ratio. Ratios significantly greater than 1.0 can produce higher fuel efficiency combustion engines. Particular geometry details of the invention can be easily modified to boost the Atkinson ratio well over 1.0.

Although the present disclosure herein has been described with reference to particular preferred embodiments thereof, it is to be understood that these embodiments are merely illustrative of the principles and applications of the disclosure. Therefore, modifications may be made to these embodiments and other arrangements may be devised without departing from the spirit and scope of the disclosure.

CLAIMS

What is claimed is:

1. An engine or pump, comprising:

a) a rotatable shaft defining a central axis A, the shaft having a first end and a second end, the shaft having an elongate first island disposed thereon, the first island having a body with a volume generally defined between front and rear surfaces that are spaced apart along the rotatable shaft, the front and rear surfaces lying in a plane parallel to a radial axis R, the front and rear surfaces having a rounded, non-circular shape, the perimeters of the front and rear surfaces defining a curved perimeter surface therebetween;

b) a front side plate disposed adjacent to the front surface of the first island;

c) a rear side plate disposed adjacent to the rear surface of the first island; and

d) a first contour assembly disposed between the front side plate and the rear side plate, the first contour assembly being defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface, the concave inwardly facing surface of the contour assembly facing the curved perimeter surface of the first island, the concave inwardly facing surface and the curved perimeter surface of the island and the front side plate and rear side plate cooperating to form a working volume, the rotatable shaft and first island being configured to rotate with respect to the first contour assembly.

2. The engine or pump of Claim 1, wherein the contour assembly defines an opening therein for receiving a spark plug.

3. The engine or pump of Claim 1, wherein the first contour assembly is coupled to a stationary housing.

4. The engine or pump of Claim 1, wherein the first contour assembly is mounted to a stationary wrist pin, the first contour assembly being able to oscillate about the wrist pin as the first island and rotatable shaft rotate about the central axis A, the wrist pin being generally parallel to the central axis A.

5. The engine or pump of Claim 1, wherein the contour includes a first apex point disposed proximate to a first end of the concave inwardly facing surface of the contour assembly and a second apex point disposed proximate to a second end of the concave inwardly facing surface of the contour assembly, the apex points being disposed in a gap defined between the concave inwardly facing surface of the contour assembly and the curved perimeter surface of the first island, the apex points helping to define the working volume.

6. The engine or pump of Claim 5, wherein the apex points are disposed within recesses defined in the contour assembly.

7. The engine or pump of Claim 6, wherein the contour assembly further includes at least one preloading spring disposed proximate to each of the apex points, the at least one preloading spring being adapted to urge the apex points against the first island.

8. The engine or pump of Claim 7, wherein the gap between the contour assembly and first island that is covered by the apex seals is less than about 0.10 inches, less than about 0.010 inches, less than about 0.0010 inches, less than about 0.00010 inches, or less than about 0.000010 inches.

9. The engine or pump of Claim 5, wherein the contour includes a first corner seal disposed proximate to the front face of the contour assembly and a second corner seal disposed proximate to the rear face of the contour assembly, the corner seals being disposed in a gap defined between the front and rear faces of the contour assembly and the front and rear side plates, the corner seals helping to define the working volume.

10. The engine or pump of Claim 9, wherein the corner seals are disposed within recesses defined in the front and rear faces of the contour assembly.

11. The engine or pump of Claim 10, wherein the contour assembly further includes corner seal preloading springs disposed proximate to each of the corner seals, the corner seal preloading springs being adapted to urge the corner seals against the front and rear side plates.

12. The engine or pump of Claim 6, wherein the contour assembly further includes a plurality of floating side seals embedded in arcuate grooves defined in the pair of opposed outwardly facing arcuately shaped front and rear surfaces of the contour assembly.

13. The engine or pump of Claim 12, wherein the arcuate grooves are generally coincident with the arcuate extent of the concave inner surface, and intersect with the grooves configured to receive the apex seals.

14. The engine or pump of Claim 12, wherein each of the side seals sits on top of at least one preloading springs for maintaining stability and orientation of the side seals in the arcuate grooves.

15. The engine or pump of Claim 9, wherein the corner seals and apex points substantially coincide to help define the working volume.

16. The engine or pump of Claim 1, wherein the front and rear side plates rotate with the rotatable shaft.

17. The engine or pump of Claim 16, wherein the front and rear side plates have a center of rotation that substantially matches a geometric center of the front and rear side plates.

18. The engine or pump of Claim 16, wherein the front and rear side plates have a center of rotation that do not substantially match a geometric center of the front and rear side plates.

19. The engine or pump of Claim 16, further comprising a front thrust bearing disposed proximate to the front plate and a rear thrust bearing disposed proximate to the rear plate to maintain the first island and side plates at a substantially fixed axial location.

20. The engine or pump of Claim 1, wherein the front of the island is one of (i) generally elliptical, (ii) generally oval and (iii) generally dumbbell-shaped.

21. The engine or pump of Claim 16, wherein at least one of the front and rear side plates includes ports defined therein for directing working fluids passing through the device.

22. The engine or pump of Claim 1, wherein the first island includes at least one port defined therein for directing working fluids passing through the device.

23. The engine or pump of Claim 22, wherein the at least one port is formed through the curved perimeter surface of the first island.

24. The engine or pump of Claim 23, wherein the at least one port includes a first portion that is generally parallel to the radial axis R and a second portion in fluid communication with the first portion that is generally parallel to the central axis A.

25. The engine or pump of Claim 24, wherein the second portion of the at least one port is configured to align with a port defined in at least one of the front and rear side plates.

26. The engine or pump of Claim 24, wherein at least two ports are formed through the curved perimeter surface of the first island, the at least two ports including a first port and a second port that are displaced from each other about the curved perimeter surface of the first island along a circumferential axis C that is orthogonal to the central axis A and the radial axis R.

27. The engine or pump of Claim 24, wherein the first port is configured to function as an intake port to direct working fluid into the working volume, and further wherein the second port is configured to function as an exhaust port to direct working fluid out of the working volume.

28. The engine or pump of Claim 19, wherein the at least one port includes a valve for controlling the flow of fluid therethrough.

29. The engine or pump of Claim 28, wherein the valve is passively actuated.

30. The engine or pump of Claim 28, wherein the valve is actively actuated.

31. The engine or pump of Claim 1, further comprising a second contour assembly disposed between the front side plate and the rear side plate, the second contour assembly being defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface, the concave inwardly facing surface of the second contour assembly facing the curved perimeter surface of the first island, the concave inwardly facing surface and the curved perimeter surface of the first island and the front side plate and rear side plate cooperating to form a second working volume, the rotatable shaft and first island being configured to rotate with respect to the second contour assembly.

32. The engine or pump of Claim 31, wherein the second contour assembly is angularly displaced from the first contour assembly about the central axis along a circumferential axis by a first angular increment.

33. The engine or pump of Claim 31, wherein the first angular increment is about 180 degrees, about 120 degrees or about 90 degrees.

34. The engine or pump of Claim 31, further comprising a third contour assembly disposed between the front side plate and the rear side plate, the third contour assembly being defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface, the concave inwardly facing surface of the third contour assembly facing the curved perimeter surface of the first island, the concave inwardly facing surface and the curved perimeter surface of the first island and the front side plate and rear side plate cooperating to form a third working volume, the rotatable shaft and first island being configured to rotate with respect to the third contour assembly.

35. The engine or pump of Claim 34, wherein the first, second and third contour assemblies are angularly displaced from each other about the central axis along a circumferential axis by a second angular increment.

36. The engine or pump of Claim 32, wherein the second angular increment is about 120 degrees or about 90 degrees.

37. The engine or pump of Claim 35, further comprising a fourth contour assembly disposed between the front side plate and the rear side plate, the fourth contour assembly being defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a concave inwardly facing surface, the concave inwardly facing surface of the fourth contour assembly facing the curved perimeter surface of the first island, the concave inwardly facing surface and the curved perimeter surface of the first island and the front side plate and rear side plate cooperating to form a fourth working volume, the rotatable shaft and first island being configured to rotate with respect to the fourth contour assembly.

38. The engine or pump of Claim 37, wherein the first, second, third and fourth contour assemblies are angularly displaced from each other about the central axis along a circumferential axis by a third angular increment.

39. The engine or pump of Claim 38, wherein the fourth angular increment is about 90 degrees.

40. The engine or pump of Claim 1, further comprising a housing for containing at least a portion of the rotatable shaft, the first island, and the front and back side plates.

41. The engine or pump of Claim 1, wherein the rotatable shaft includes a second elongate island disposed thereon, the second island being axially displaced along the shaft from the first island, the second island having a body with a volume generally defined between front and rear surfaces that are spaced apart along the rotatable shaft, the front and rear surfaces lying in a plane parallel to the radial axis R, the front and rear surfaces having a rounded, non-circular shape, the perimeters of the front and rear surfaces defining a second curved perimeter surface therebetween, the engine or pump further including:

a) a second front side plate disposed adjacent to the front surface of the second island;

b) a second rear side plate disposed adjacent to the rear surface of the second island; and

d) a second contour assembly disposed between the second front side plate and the second rear side plate, the second contour assembly being defined by a pair of opposed outwardly facing arcuately shaped front and rear surfaces that are connected by a second concave inwardly facing surface, the second concave inwardly facing surface of the contour assembly facing the second curved perimeter surface of the second island, the second concave inwardly facing surface and the second curved perimeter surface of the second island and the second front side plate and second rear side plate cooperating to form a second working volume, the rotatable shaft and second island being configured to rotate with respect to the second contour assembly.

42. The engine or pump of Claim 41, wherein at least one of the second front or rear side plate is integral with the front or rear side plate that is associated with the first island.

43. The engine or pump of Claim 1, further comprising at least one cam follower operably coupled with the first contour assembly, the at least one cam follower being adapted to roll along an edge surface of at least one of the front side plate and rear side plate.

44. The engine or pump of Claim 43, wherein the at least one cam follower is mounted on a lever arm that is coupled with the first contour assembly.

45. The engine or pump of Claim 1, wherein the device is a pump or compressor.

46. The engine or pump of Claim 45, wherein the device is an air conditioning compressor configured to compress refrigerant.

47. The engine or pump of Claim 1, wherein the engine is a steam driven engine.

48. The engine or pump of Claim 1, wherein the engine is an engine driven by compressed air.

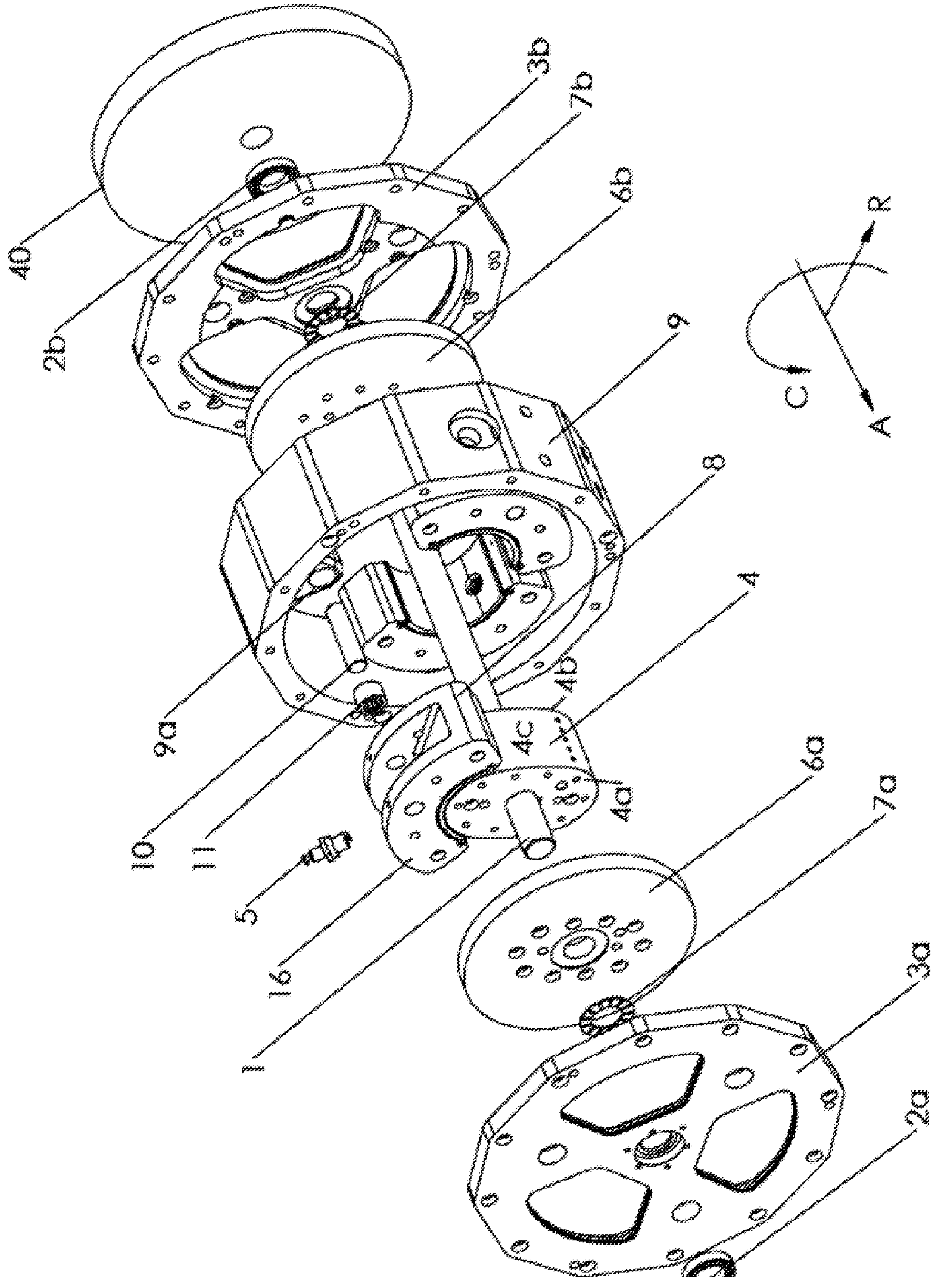


FIGURE 1

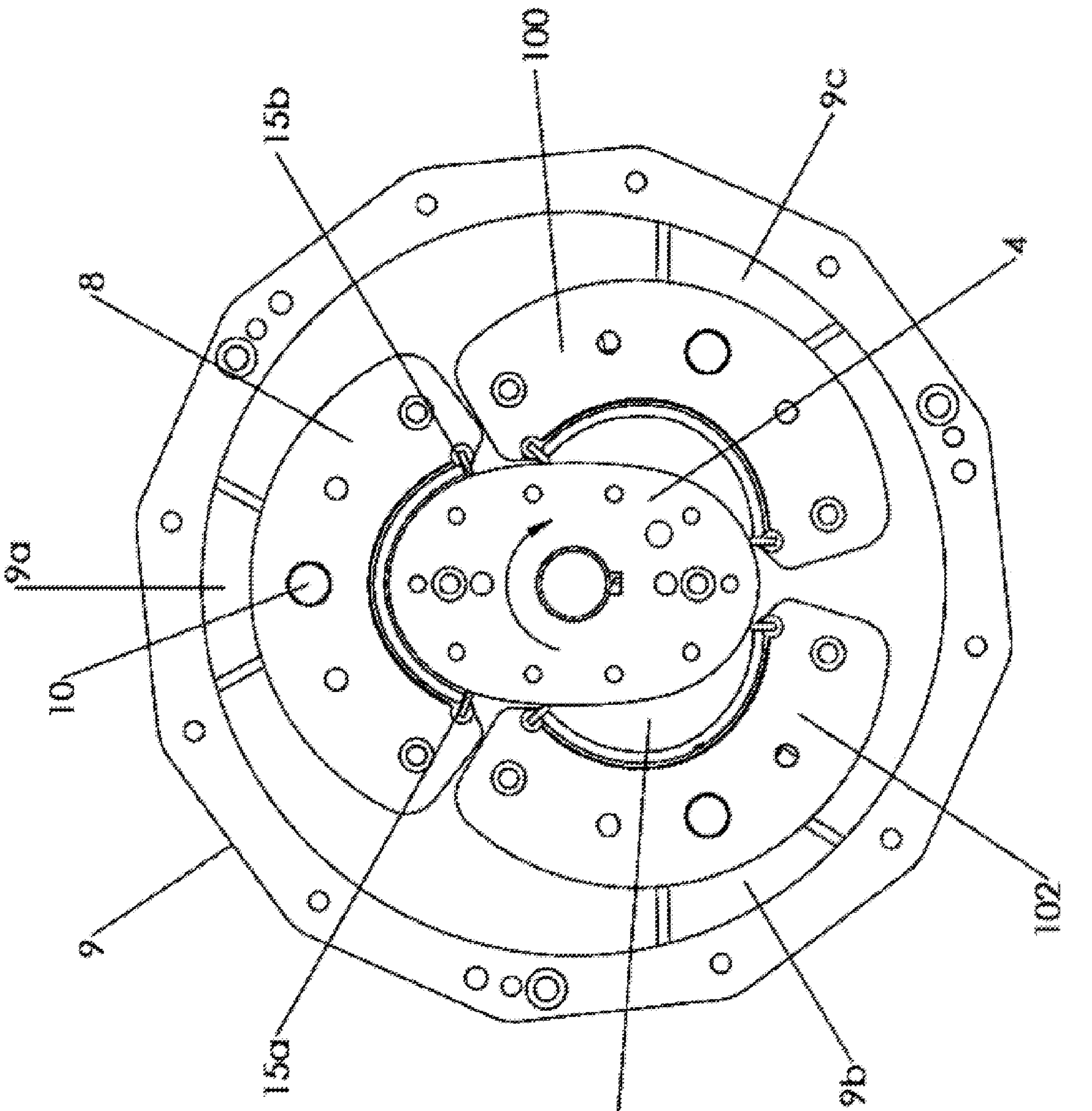
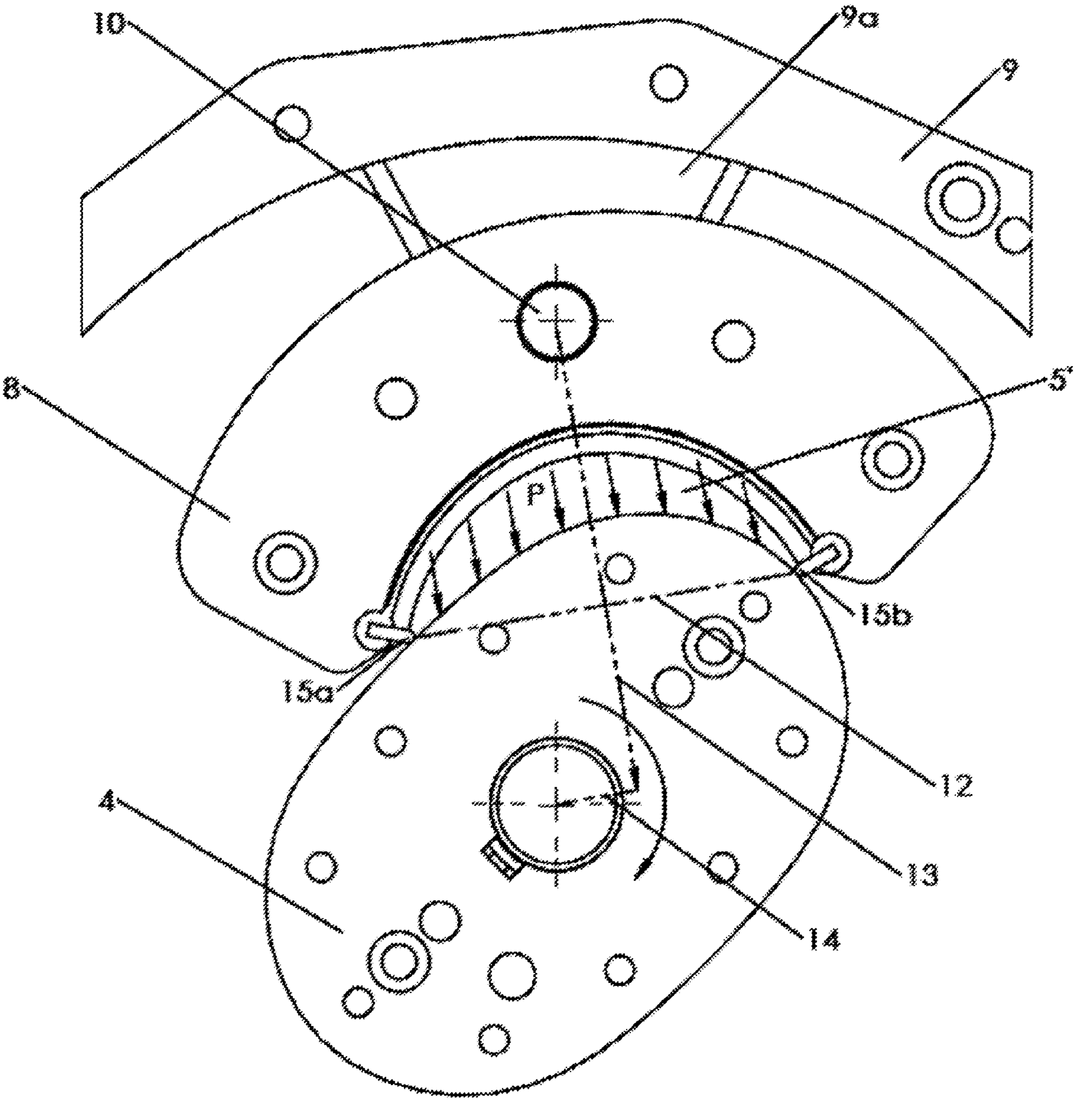


FIGURE 2



CRANK ANGLE = +45°

FIGURE 3

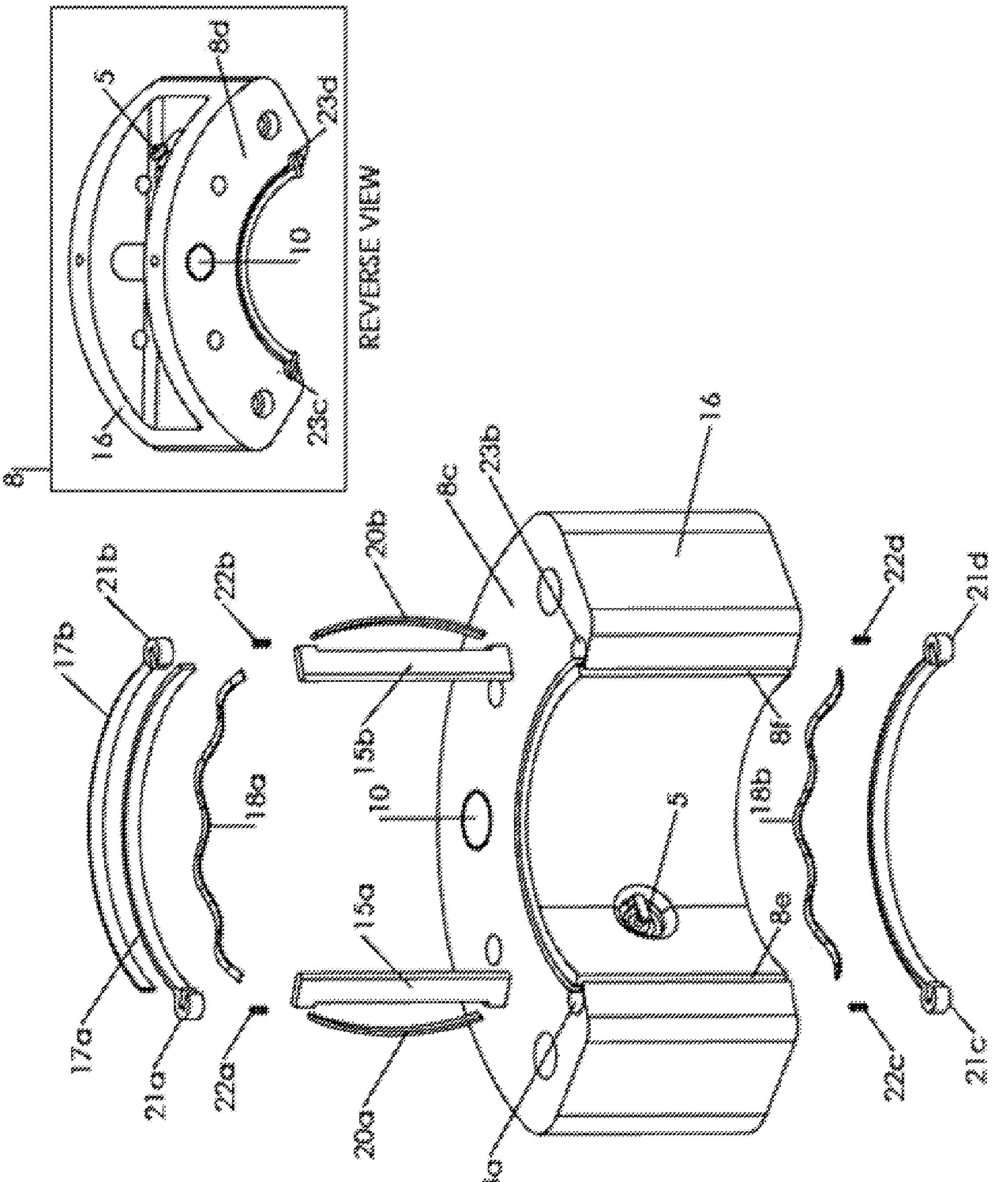

REVERSE VIEW
8
16
5
8d
23d
10
23c
17b
21b
22b
18a
17a
21a
22a
20b
15b
10
15a
20a
8c
23b
16
5
18b
8f
8e
23a
22d
21d
22c
21c

FIGURE 4

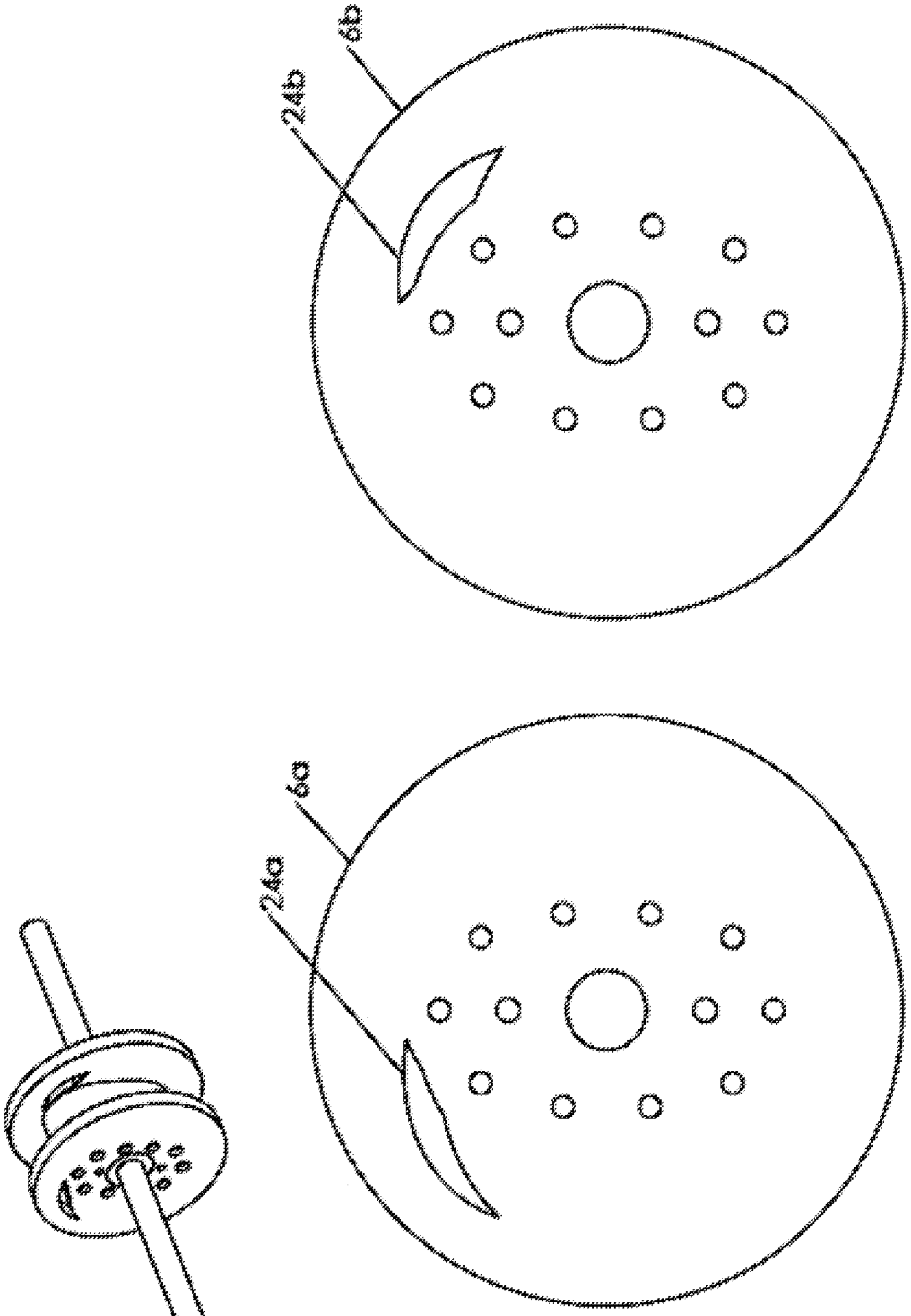


FIGURE 5b

FIGURE 5a

FIGURES 5a-b

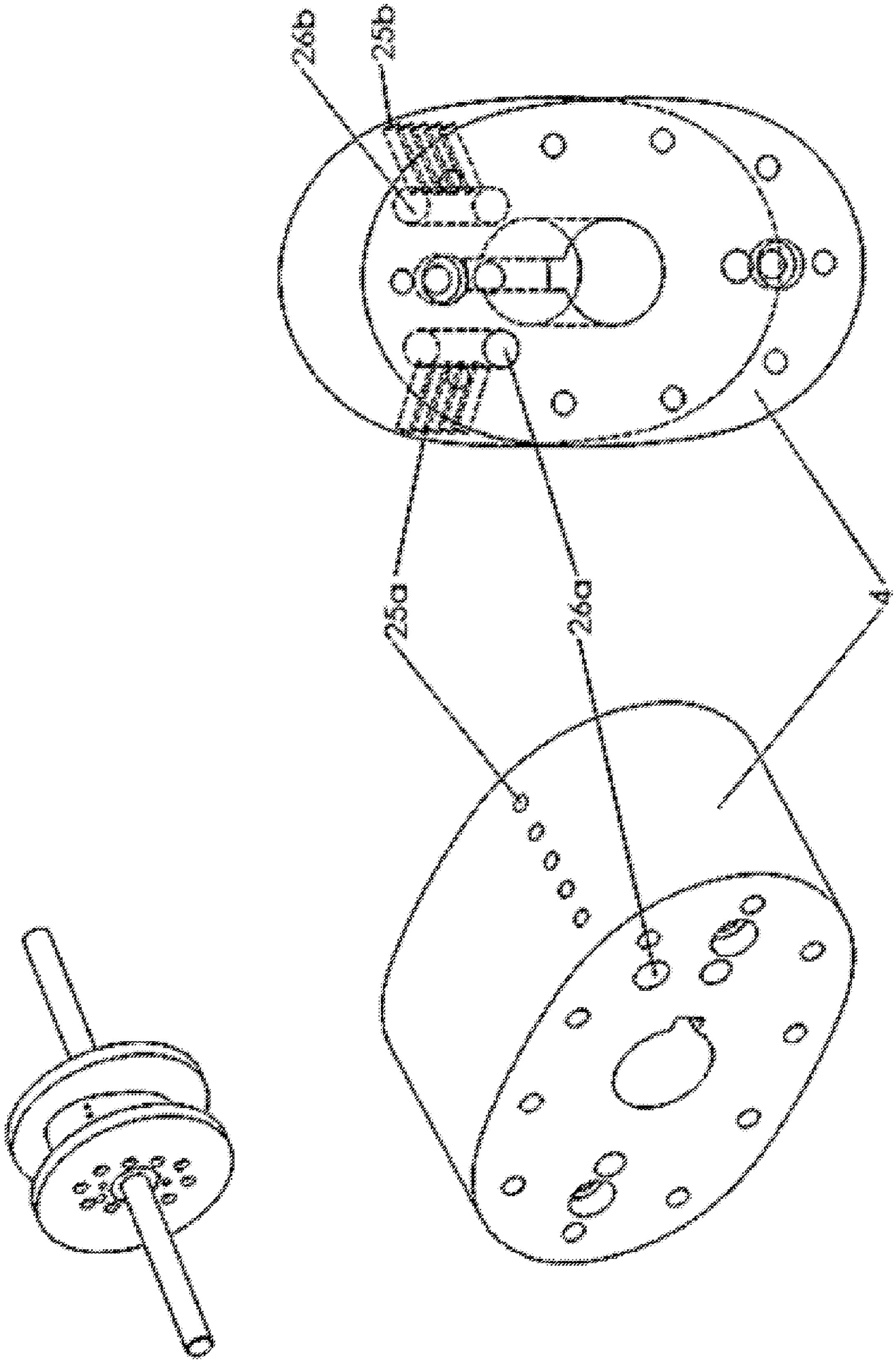
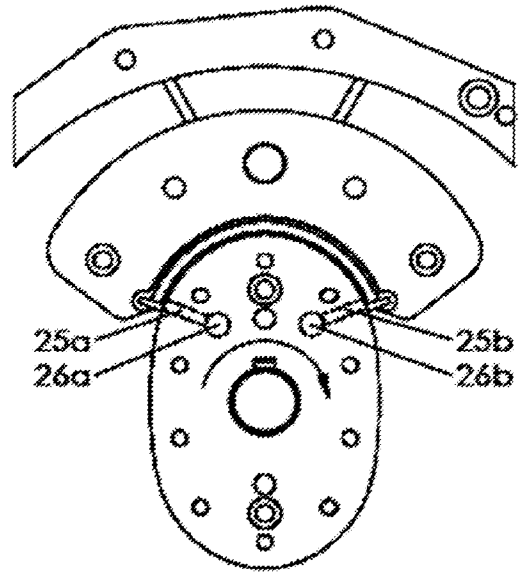
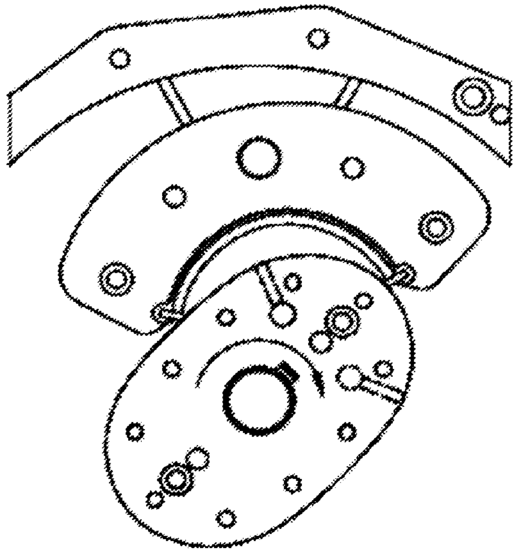
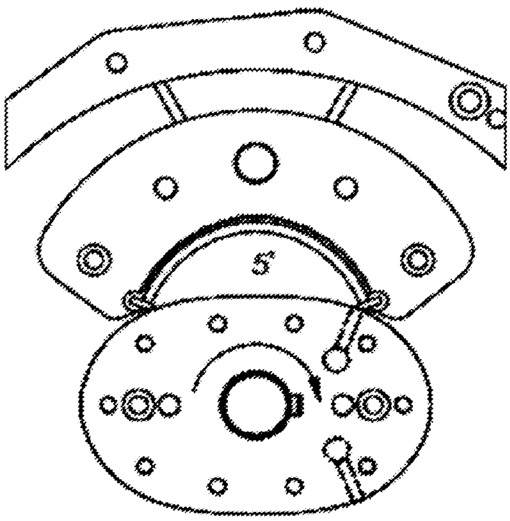


FIGURE 6

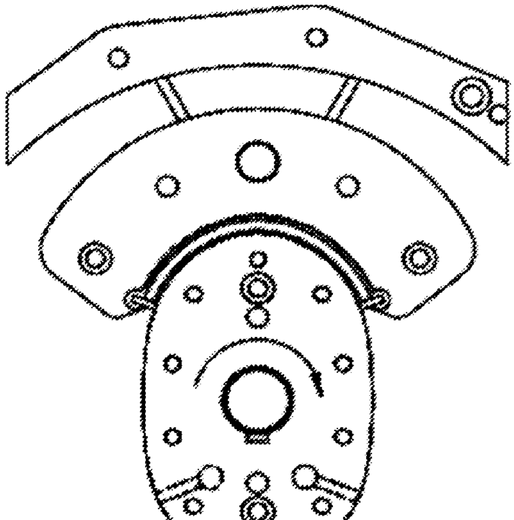


CRANK ANGLE = -180°
FIGURE 7a

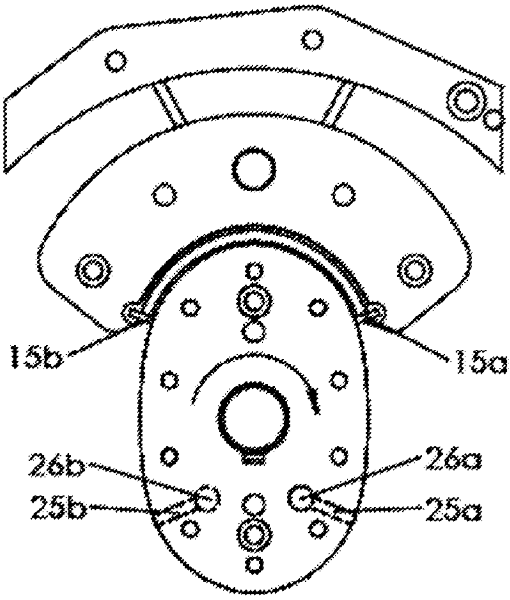

CRANK ANGLE = -135°
FIGURE 7b



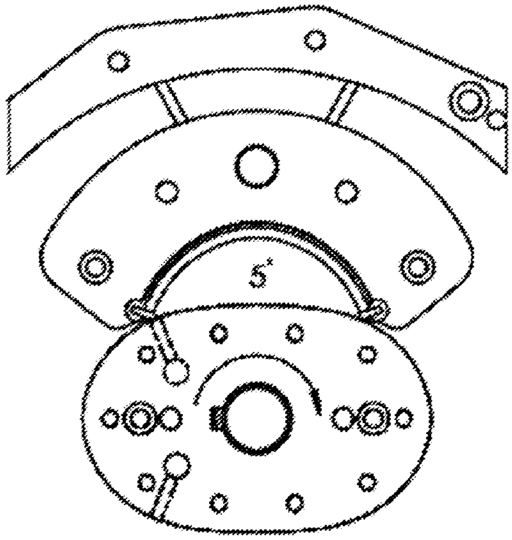
CRANK ANGLE = -90°
FIGURE 7c


CRANK ANGLE = 0°
FIGURE 7d

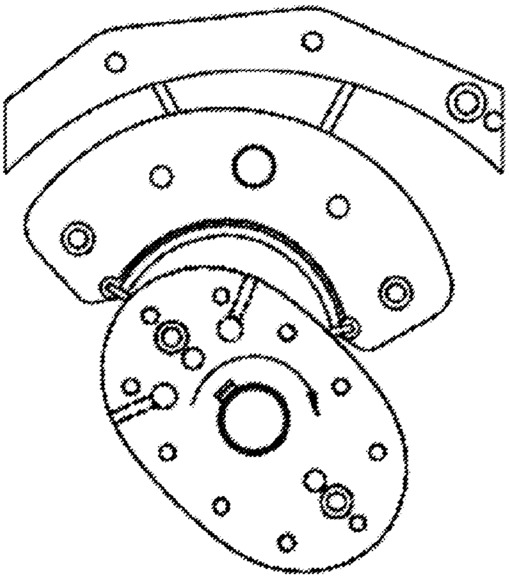
FIGURES 7a-d



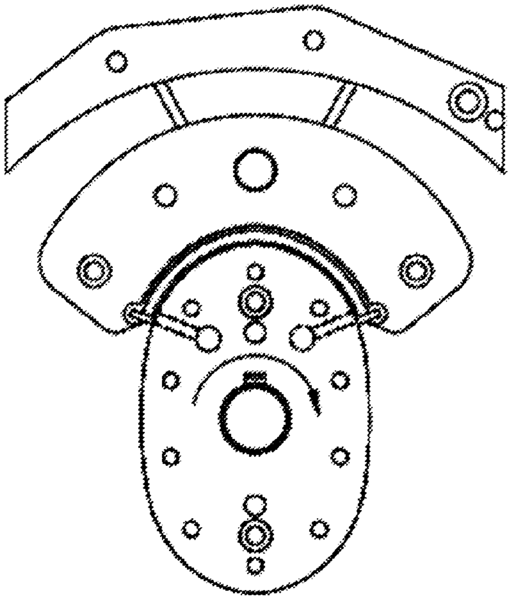
CRANK ANGLE = 0°
FIGURE 8a



CRANK ANGLE = +90°
FIGURE 8b



CRANK ANGLE = +135°
FIGURE 8c



CRANK ANGLE = +180°
FIGURE 8d

FIGURES 8a-d

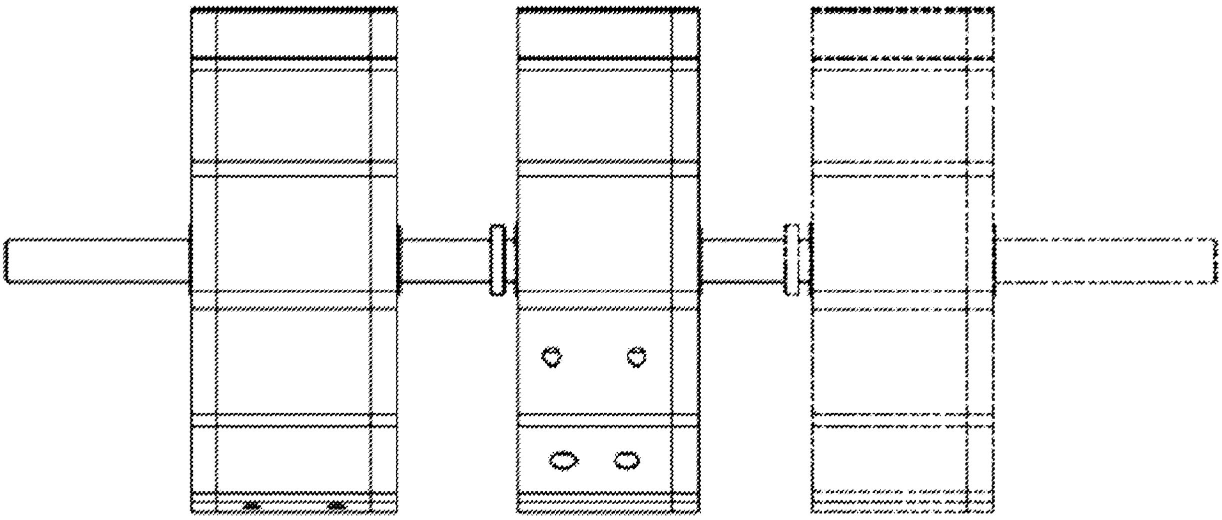


FIGURE 9a

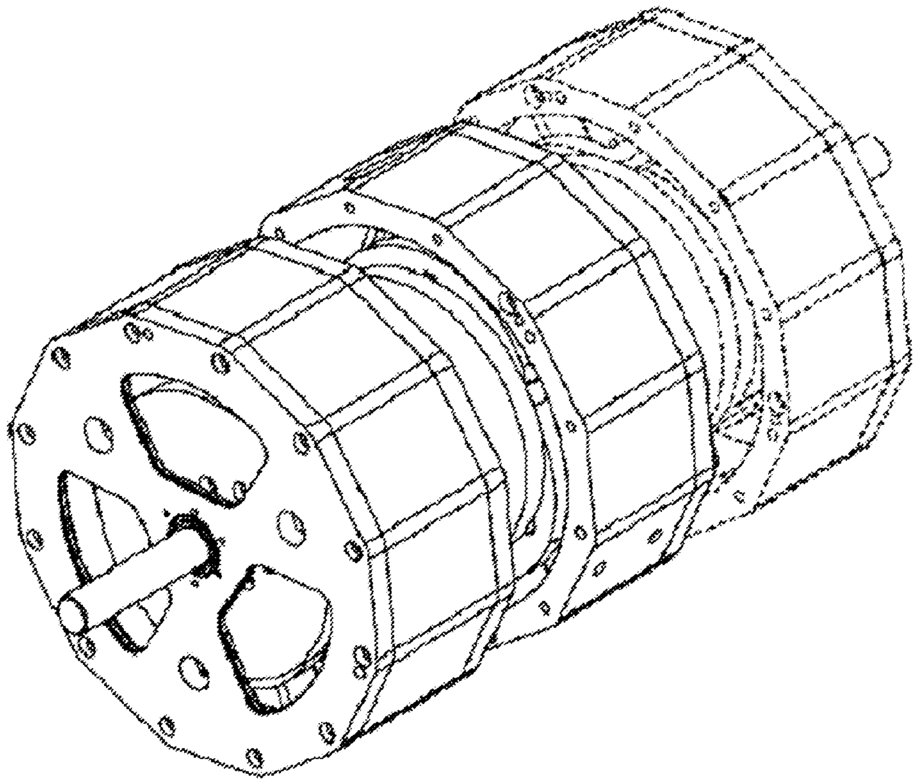


FIGURE 9b

FIGURES 9a-b

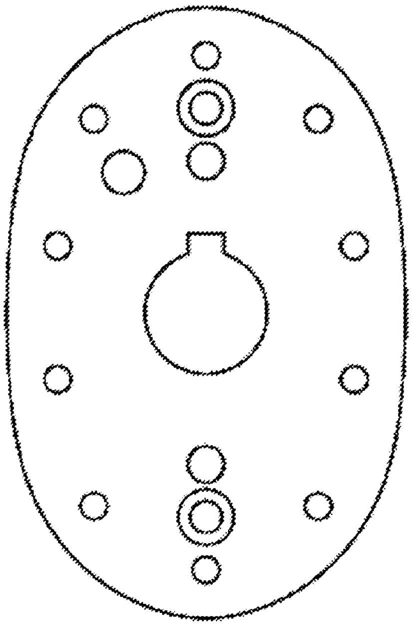


FIGURE 10a

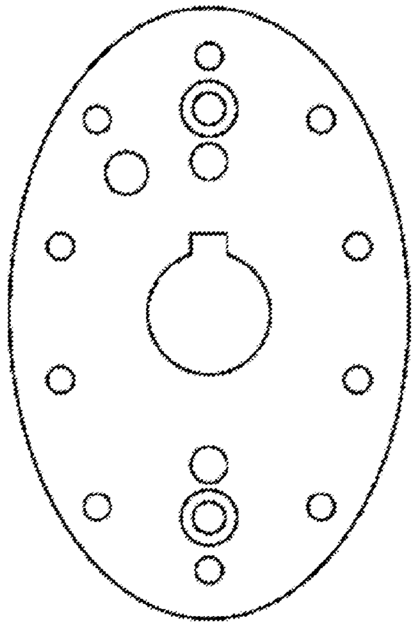


FIGURE 10b

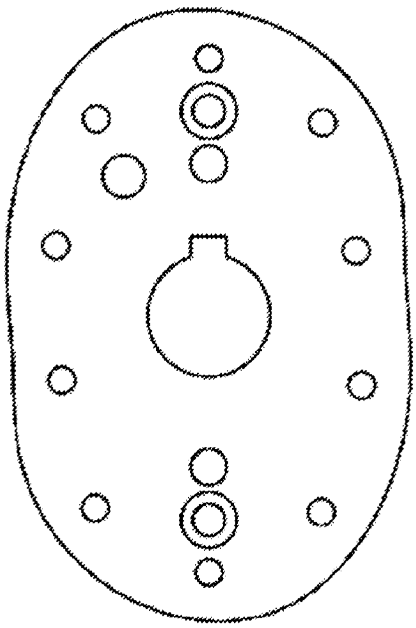


FIGURE 10c

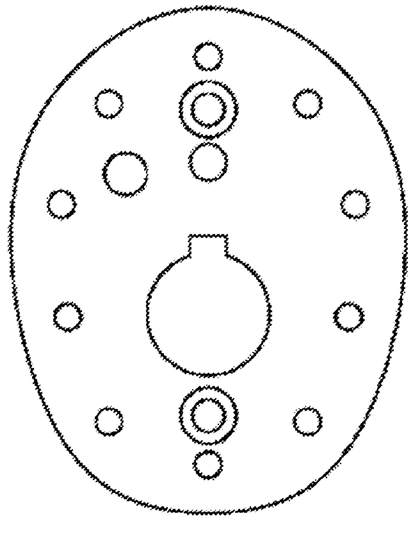


FIGURE 10d

FIGURES 10a-d

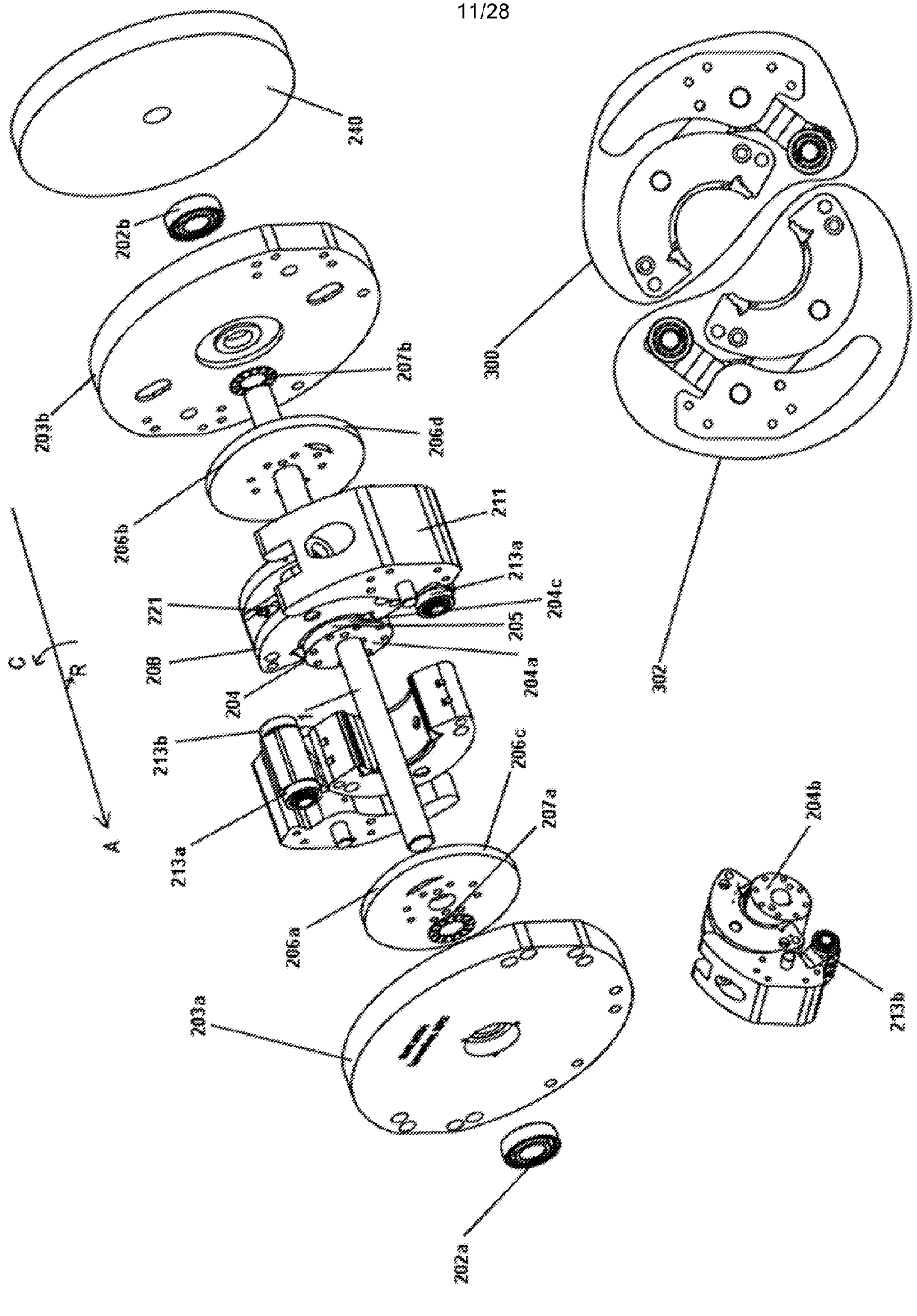

240
202b
203b
207b
206d
206b
211
213a
221
204c
205
208
204a
204
C
R
A
213b
206c
207a
213a
206a
203a
202a
300
302
204b
213b

FIGURE 11

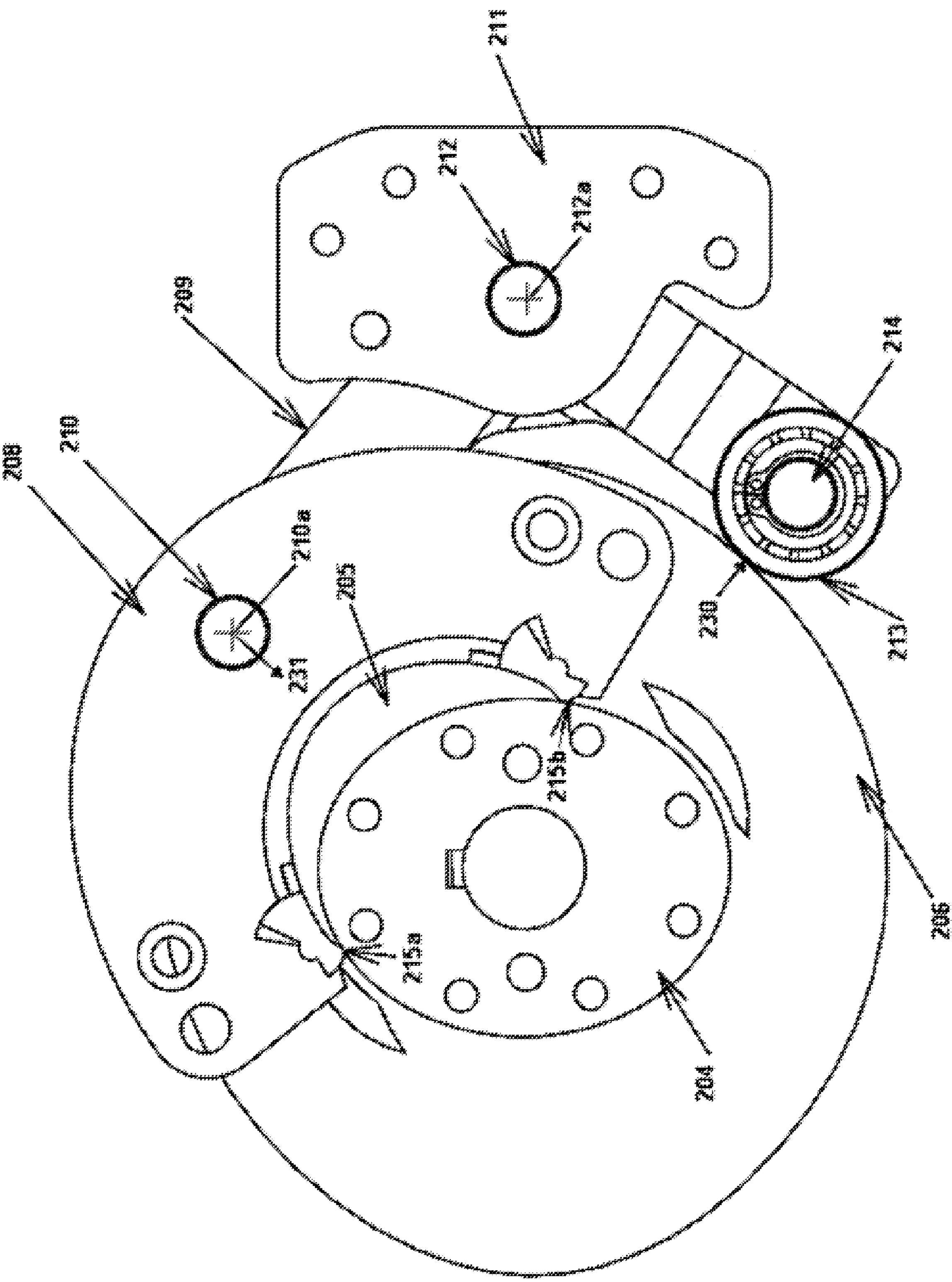

211
212
212a
209
210
208
210a
205
214
230
213
231
215b
215a
204
206

FIGURE 12

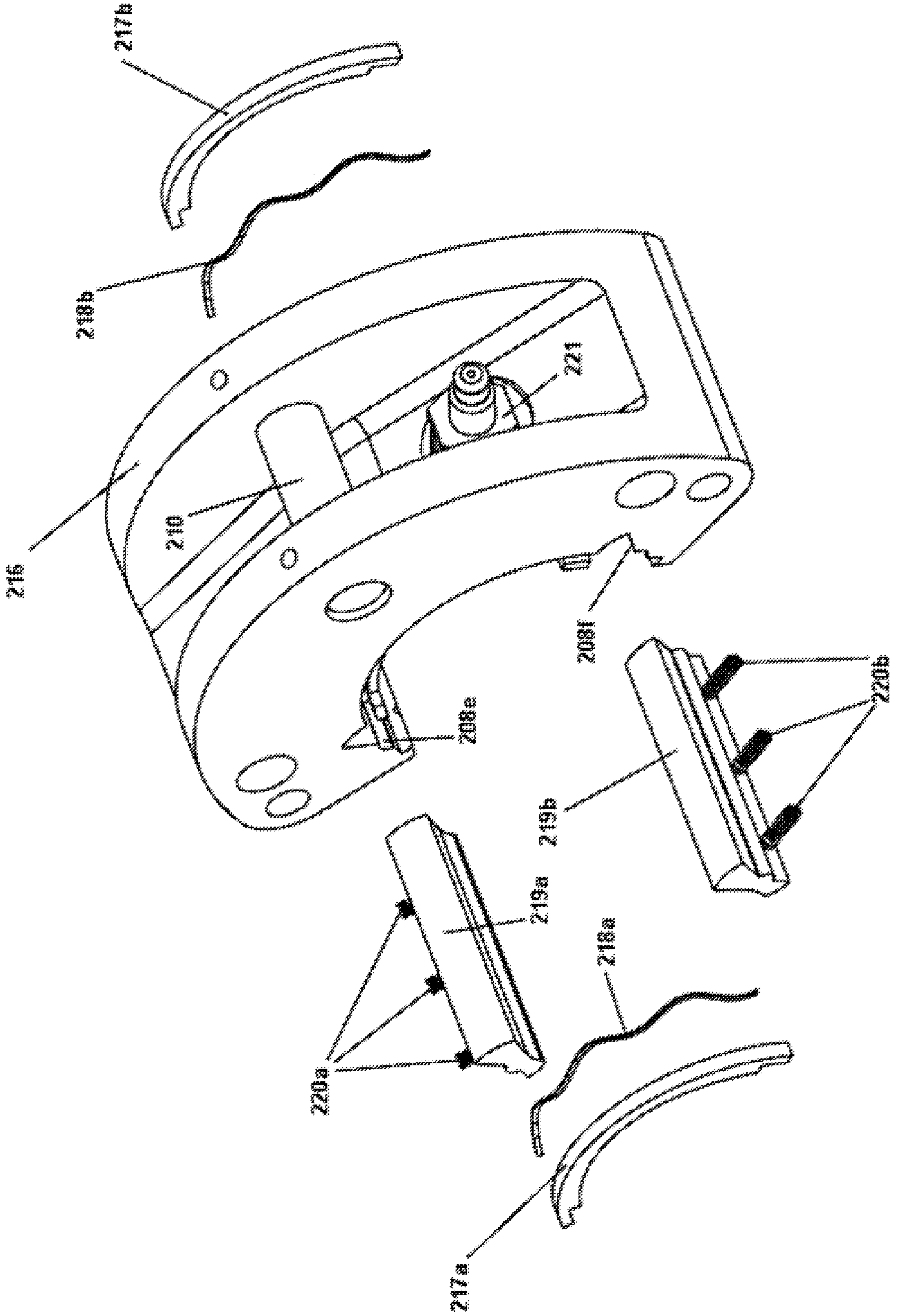


FIGURE 13

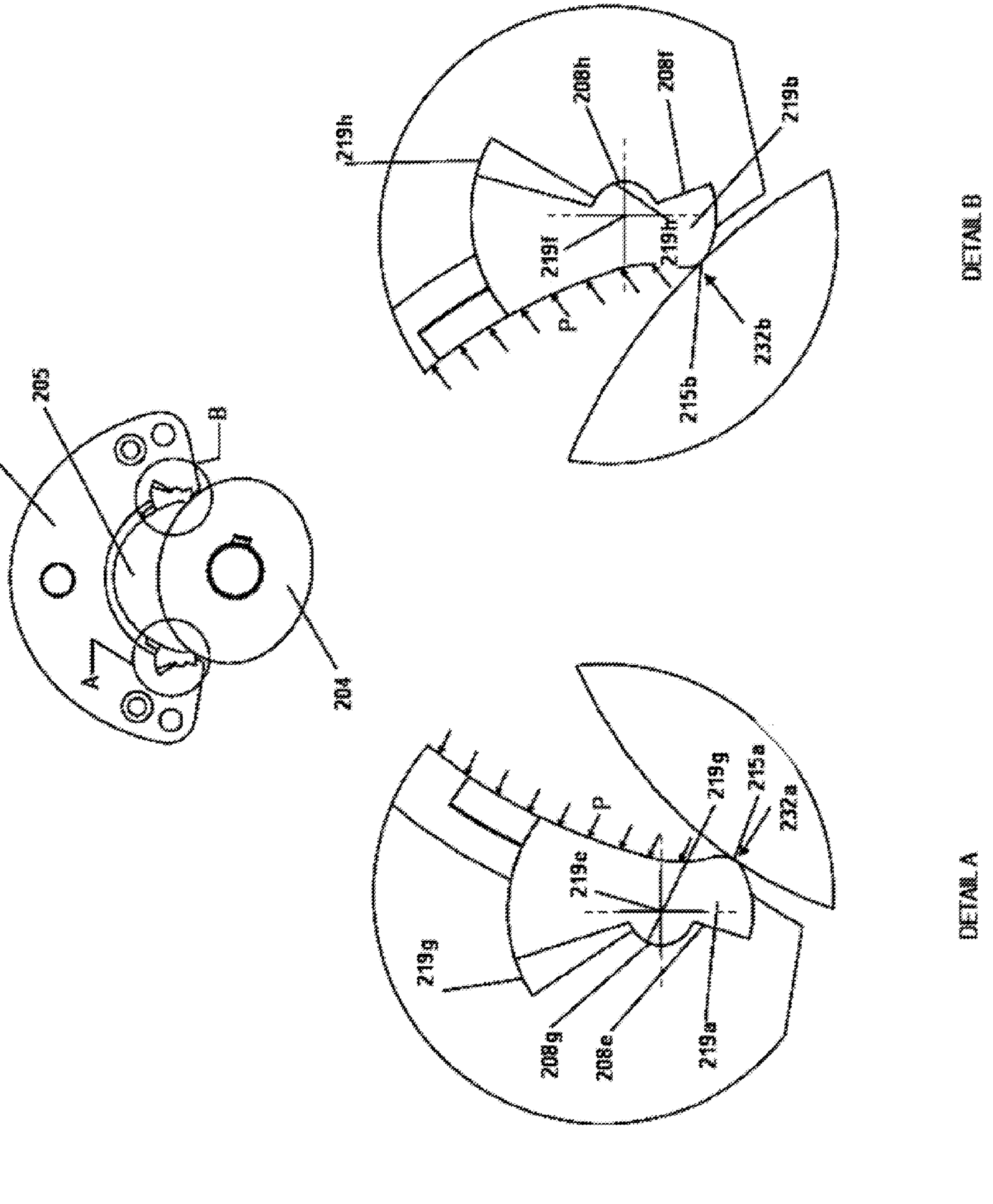

208
205
B
A
204
219h
208h
208f
219b
219f
219h
P
215b
232b
DETAIL B
219g
215a
232a
P
219e
219g
208g
208e
219a
DETAIL A

FIGURE 14

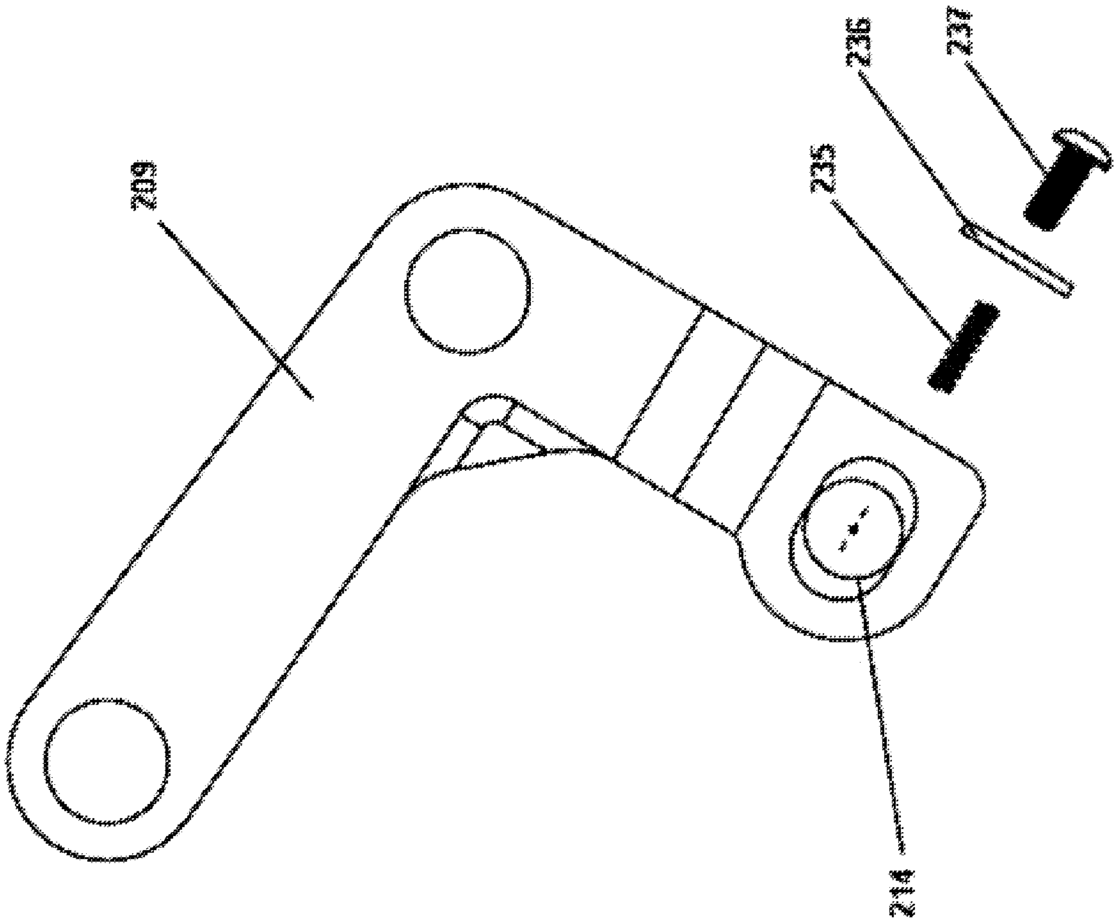


FIGURE 15

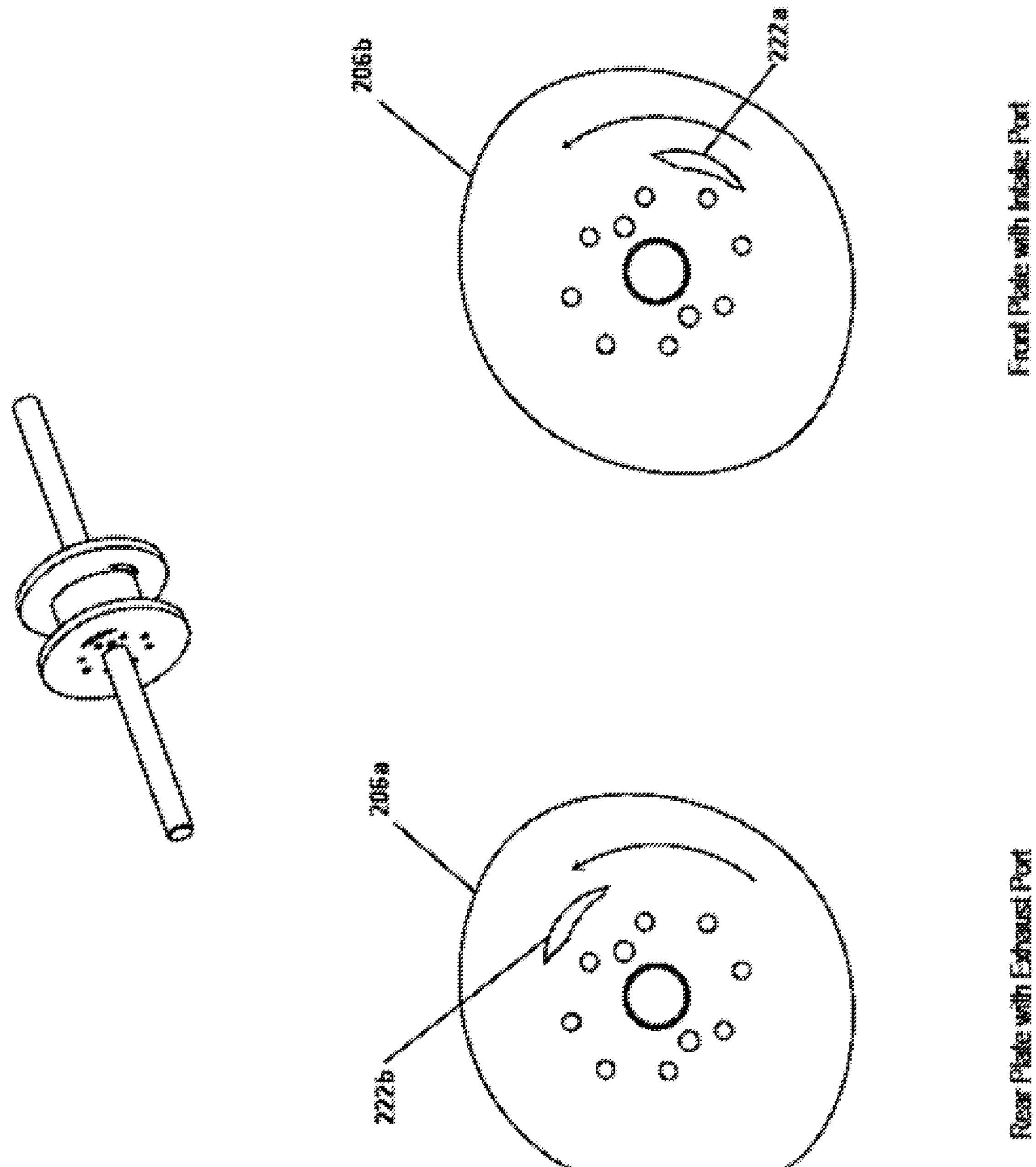
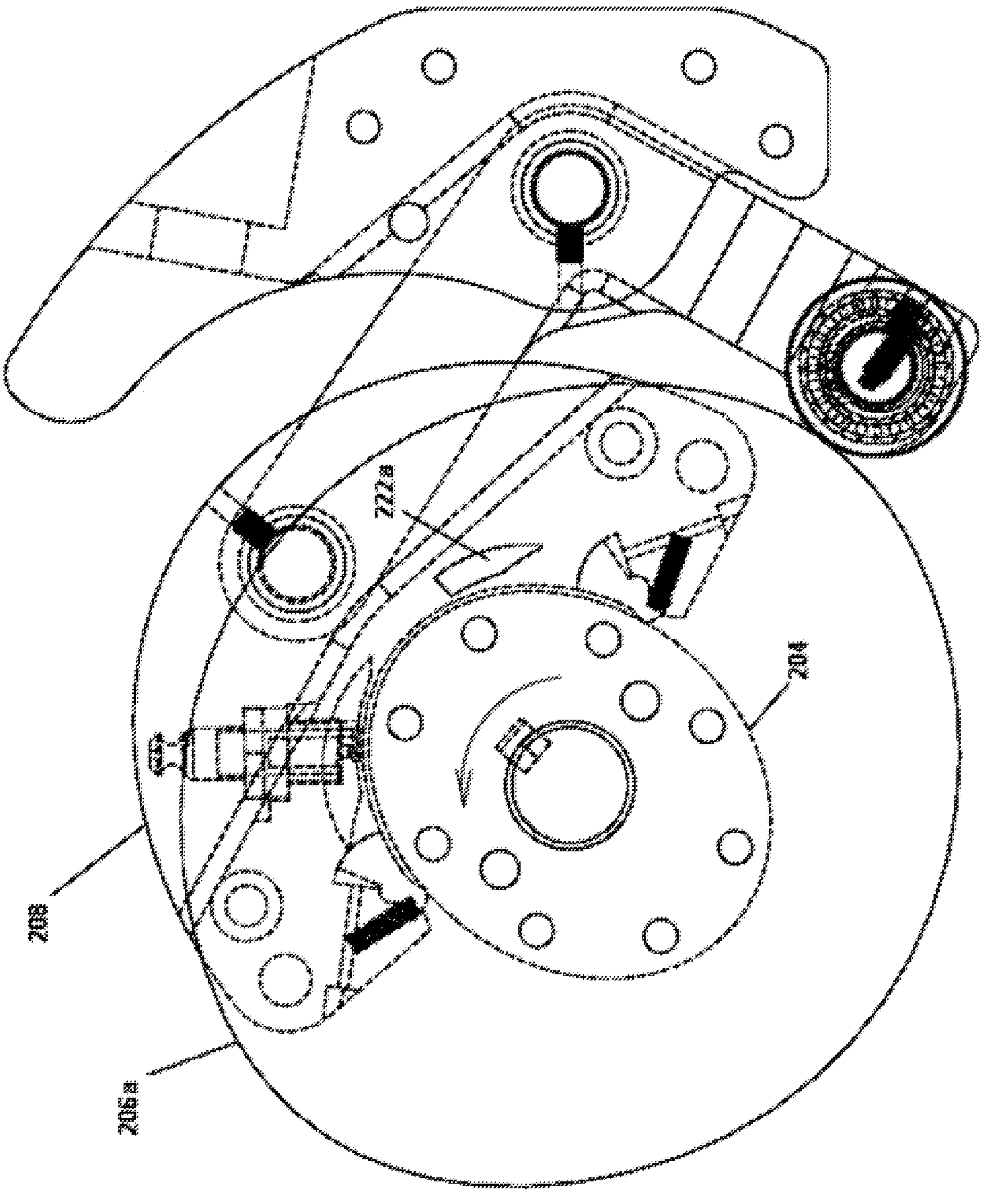

206b
222a
Front Plate with Intake Port
206a
222b
Rear Plate with Exhaust Port

FIGURE 16



START OF INTAKE
CRANK ANGLE = 0 DEG.

FIGURE 17

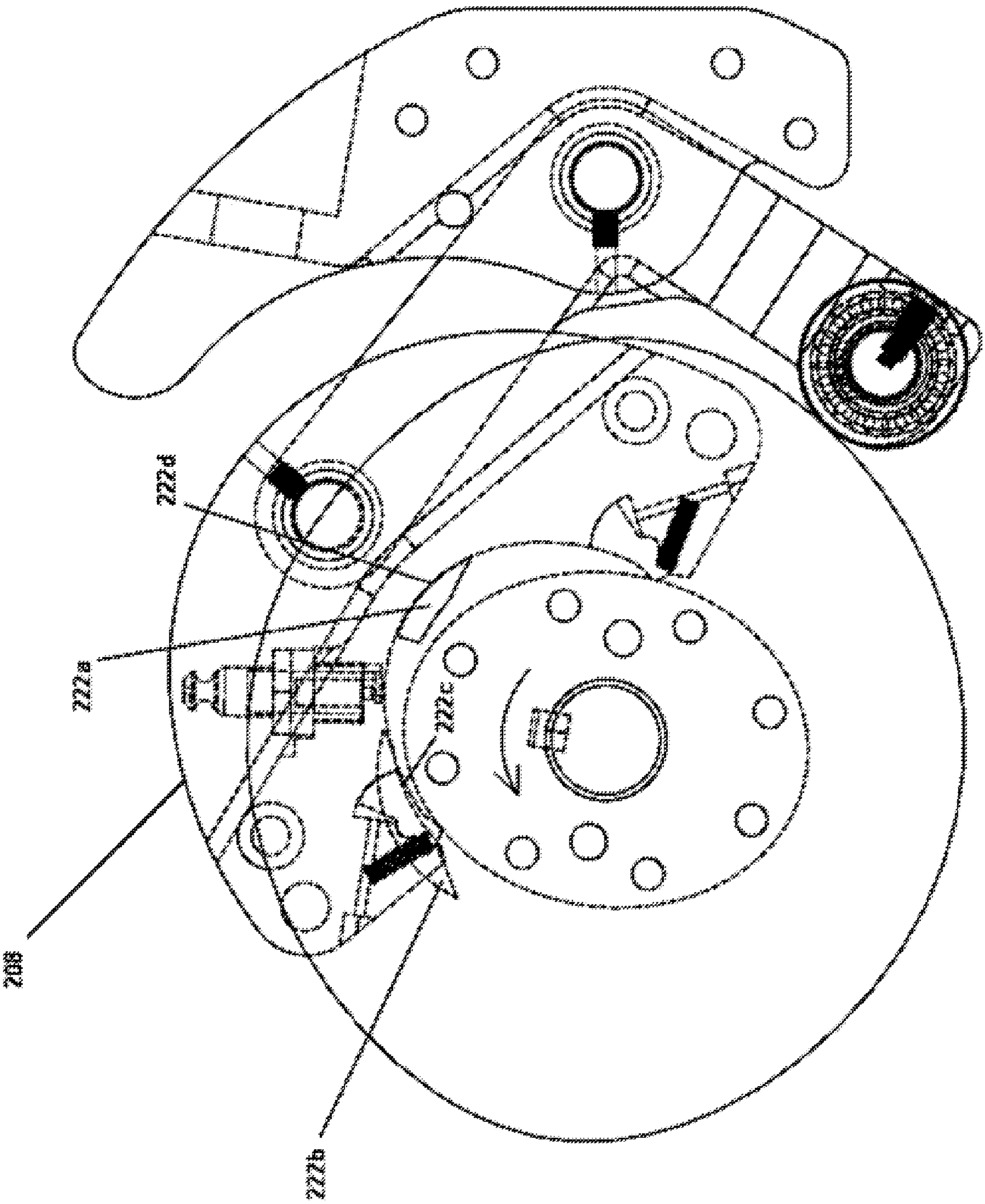
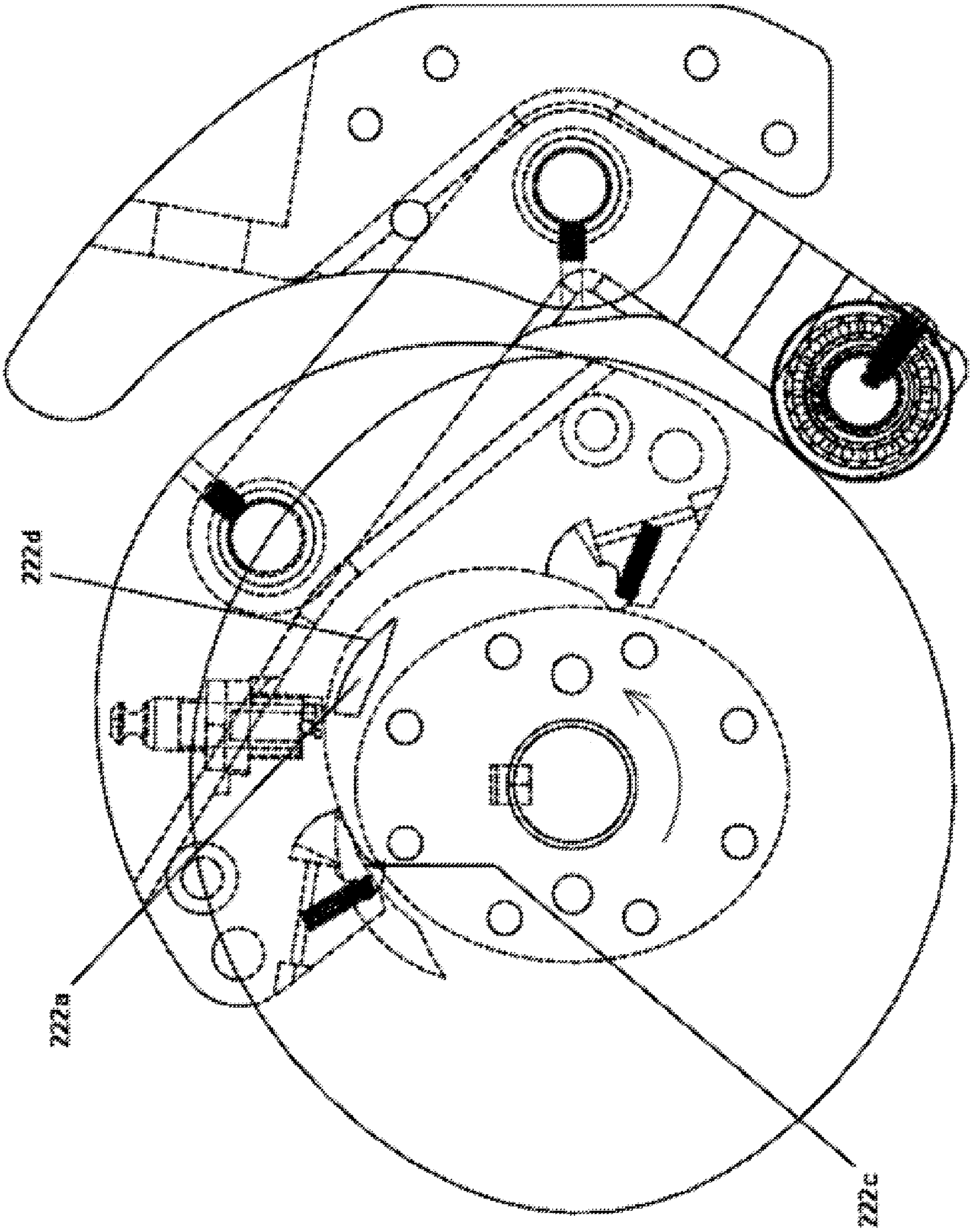


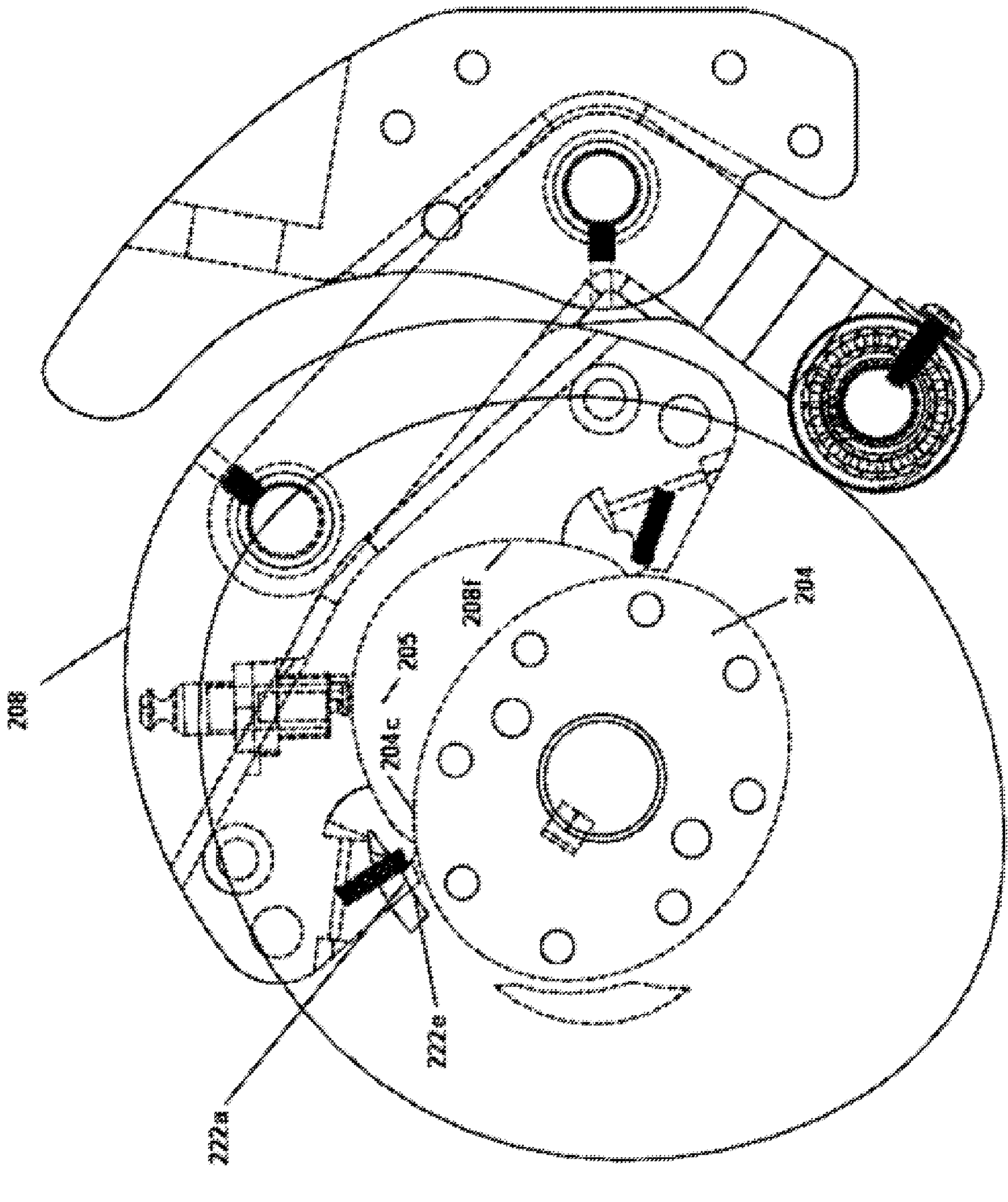
FIGURE 18A

CRANK ANGLE ~30 DEG.



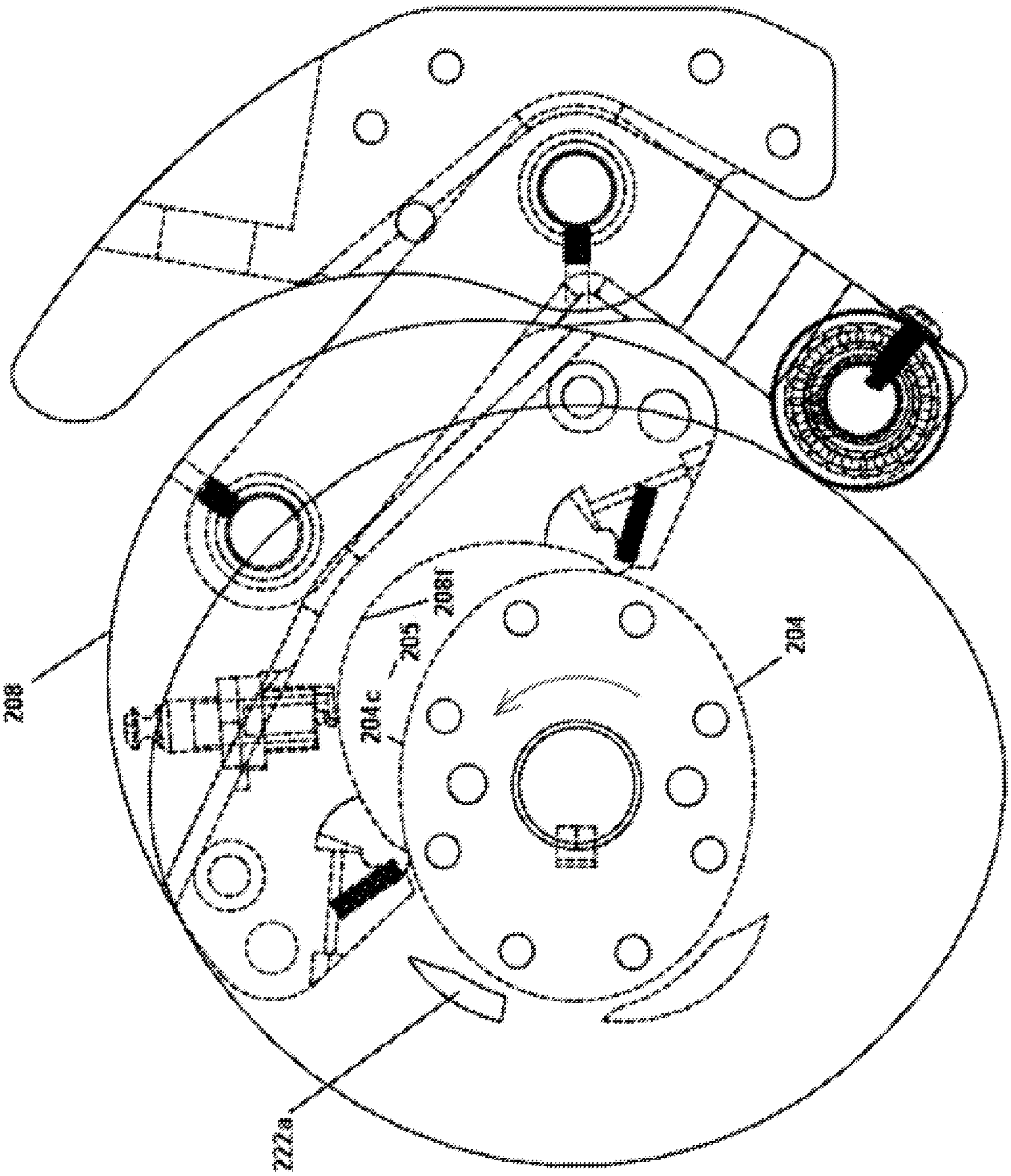
INTAKE
CRANK ANGLE = ~45 DEG.

FIGURE 18B



START OF COMPRESSION
CRANK ANGLE = 90 DEG.

FIGURE 19



DURING COMPRESSION
CRANK ANGLE = ~135 DEG.

FIGURE 20

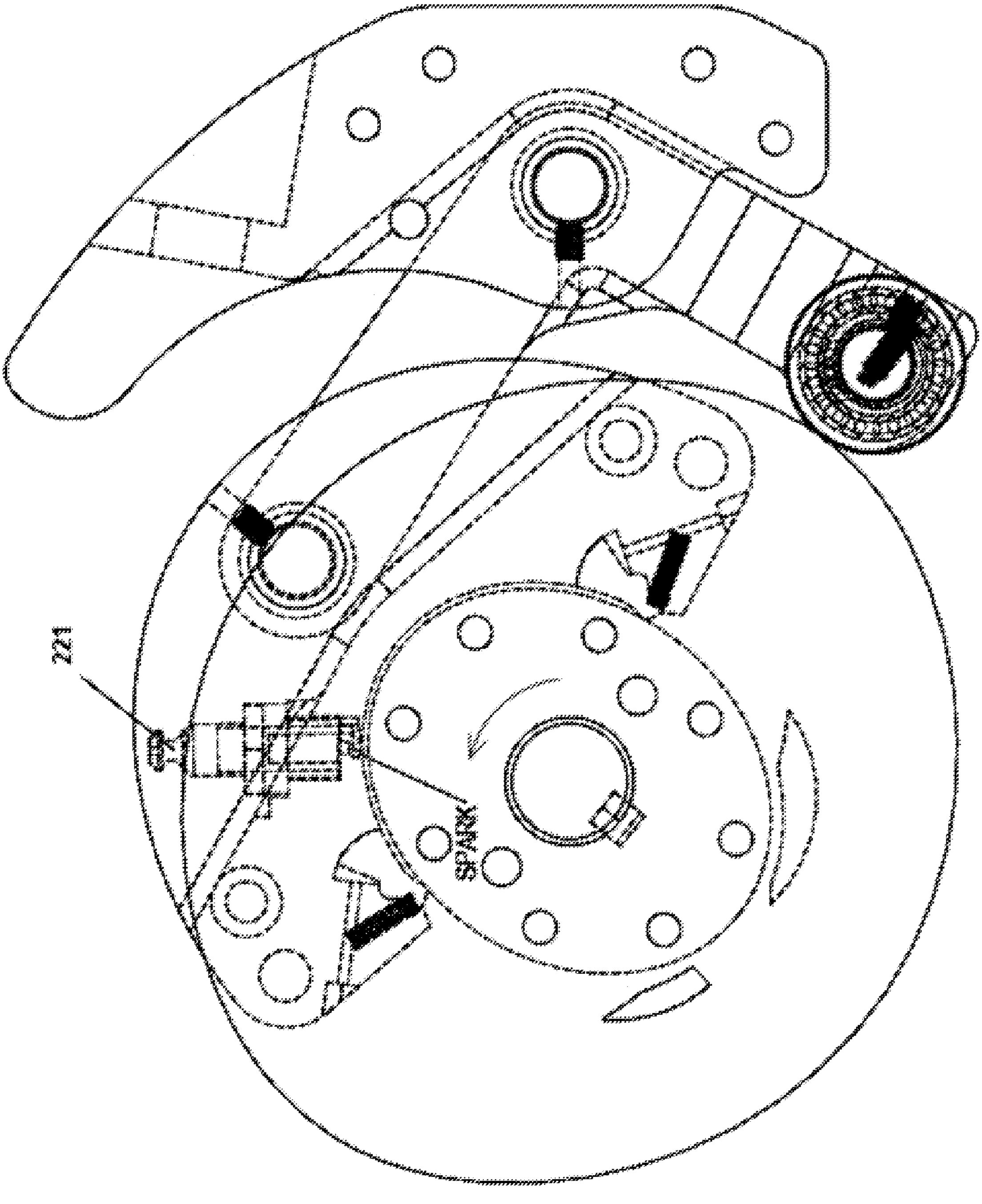
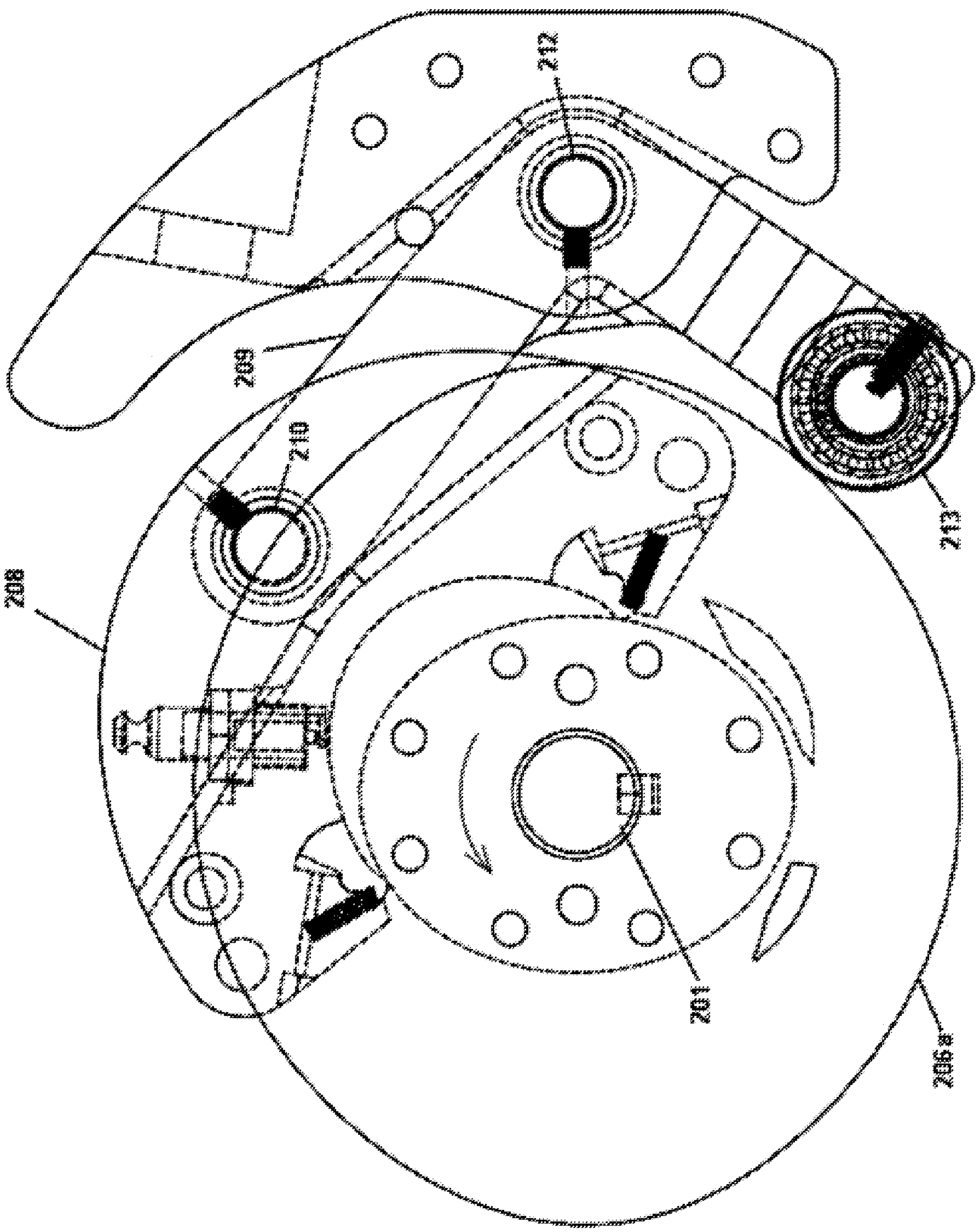
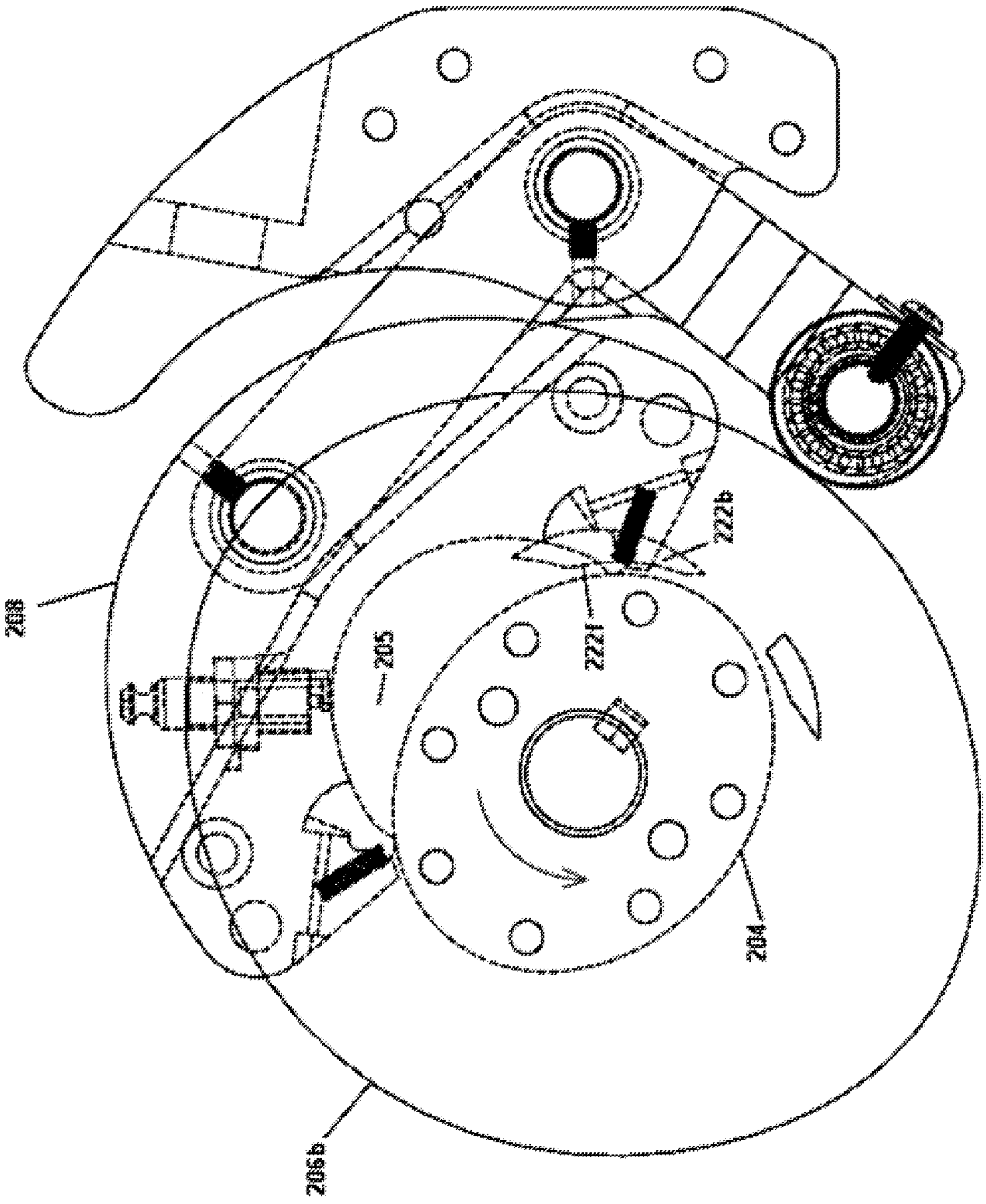


FIGURE 21



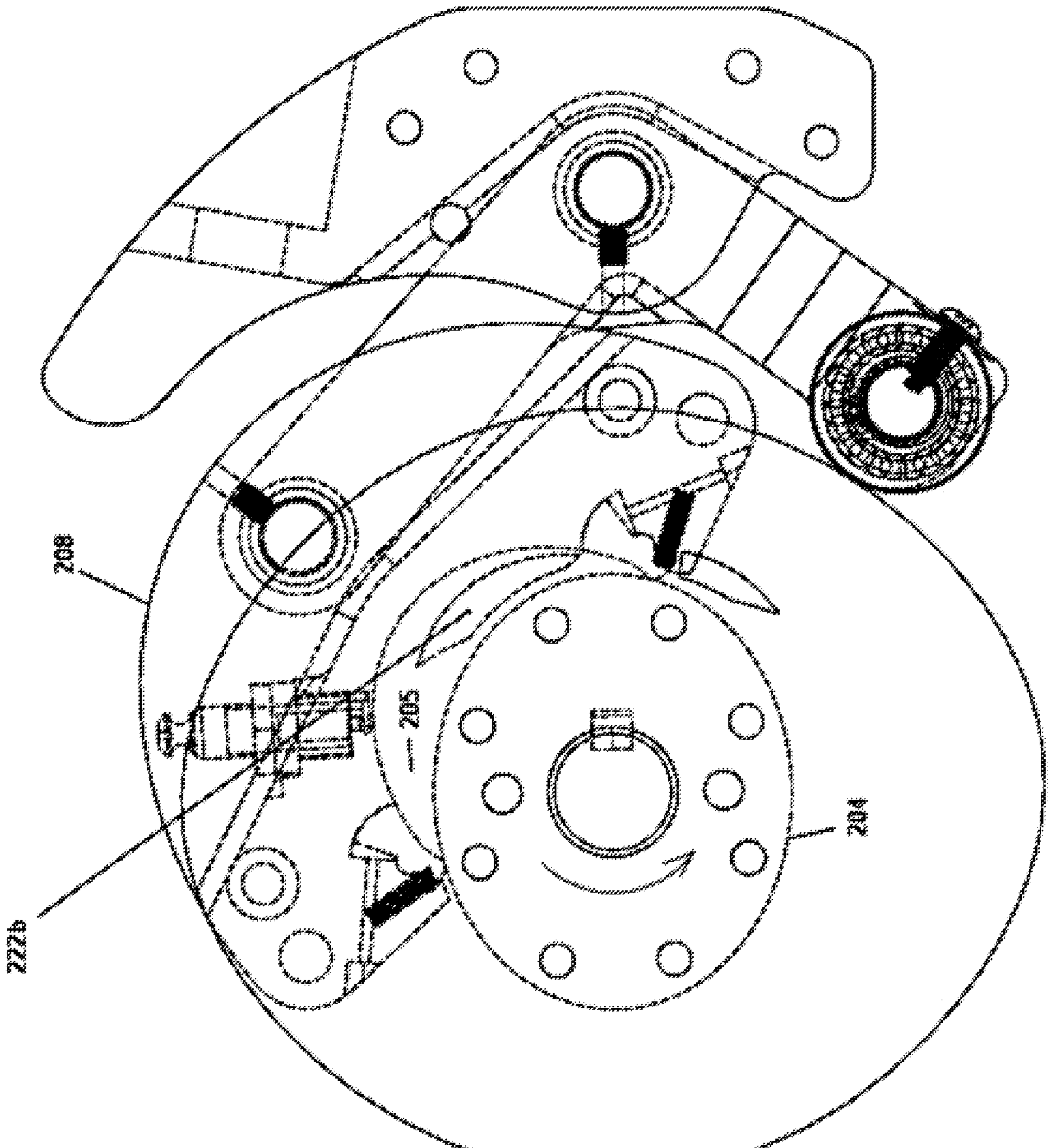
DURING EXPANSION
CRANK ANGLE = ~225 DEG.

FIGURE 22



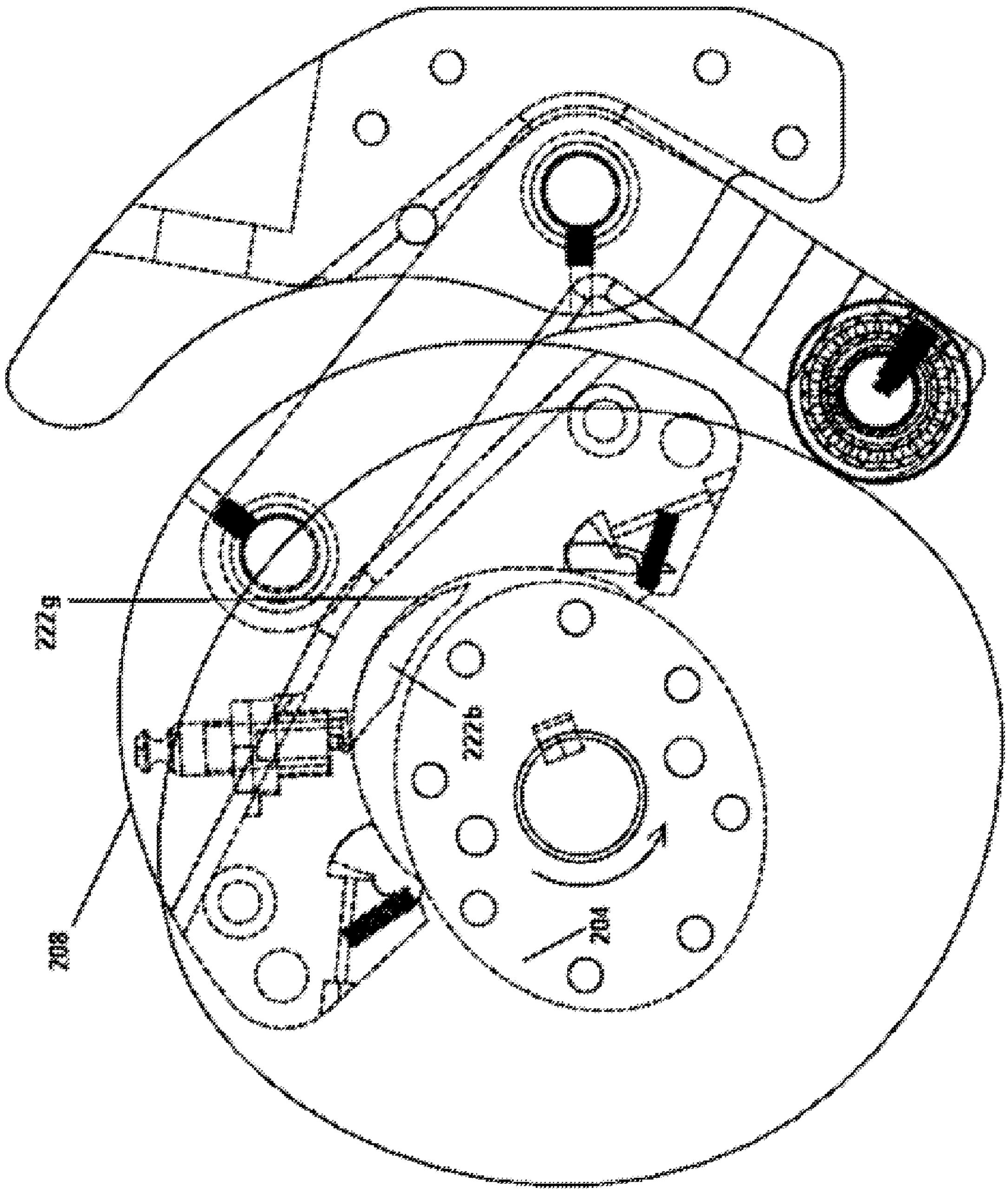
START OF EXHAUST
CRANK ANGLE = 270 DEG.

FIGURE 23



DURING EXHAUST
CRANK ANGLE = ~315 DEG.

FIGURE 24A



CRANK ANGLE ~330 DEG.

FIGURE 24B

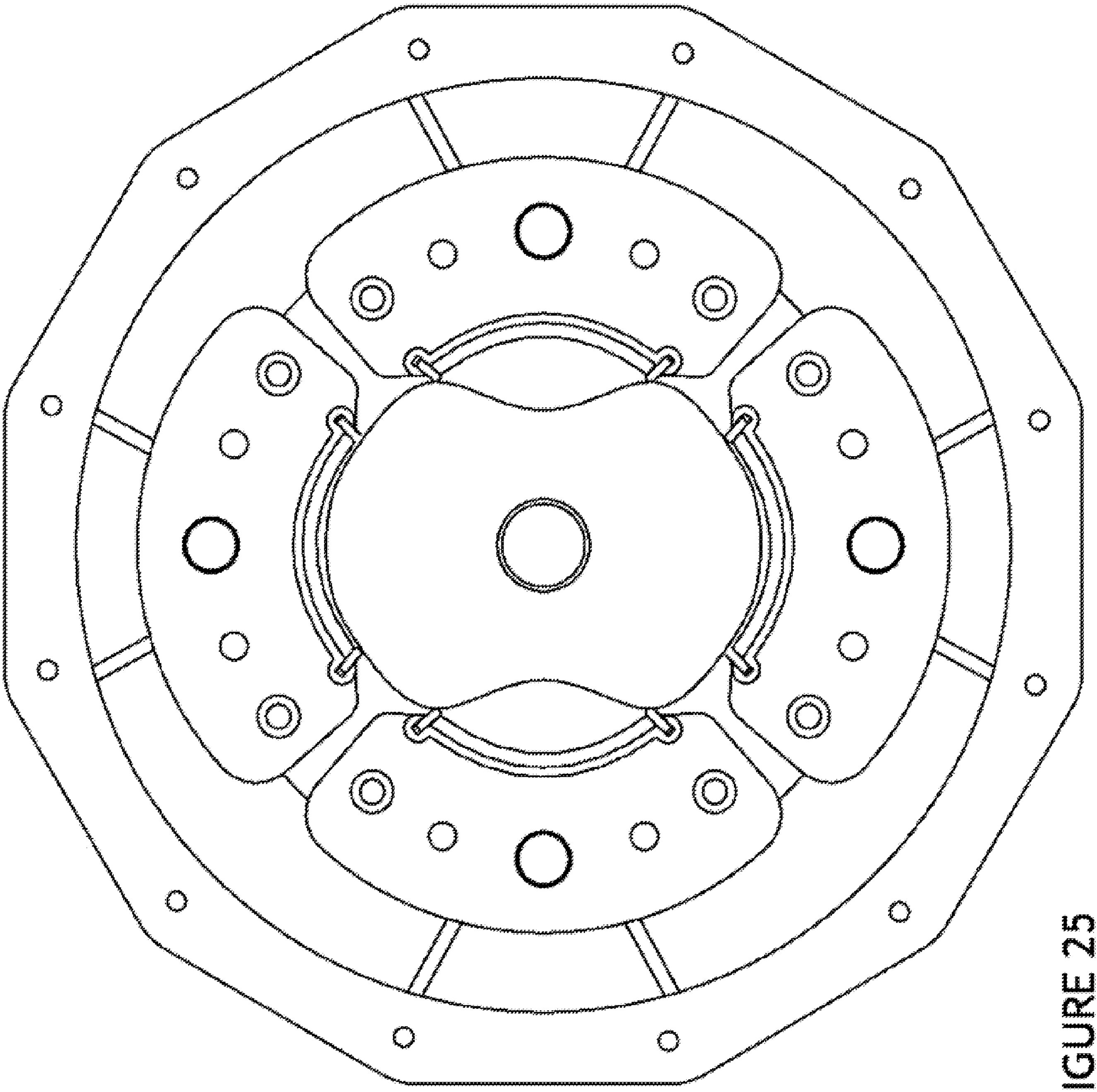
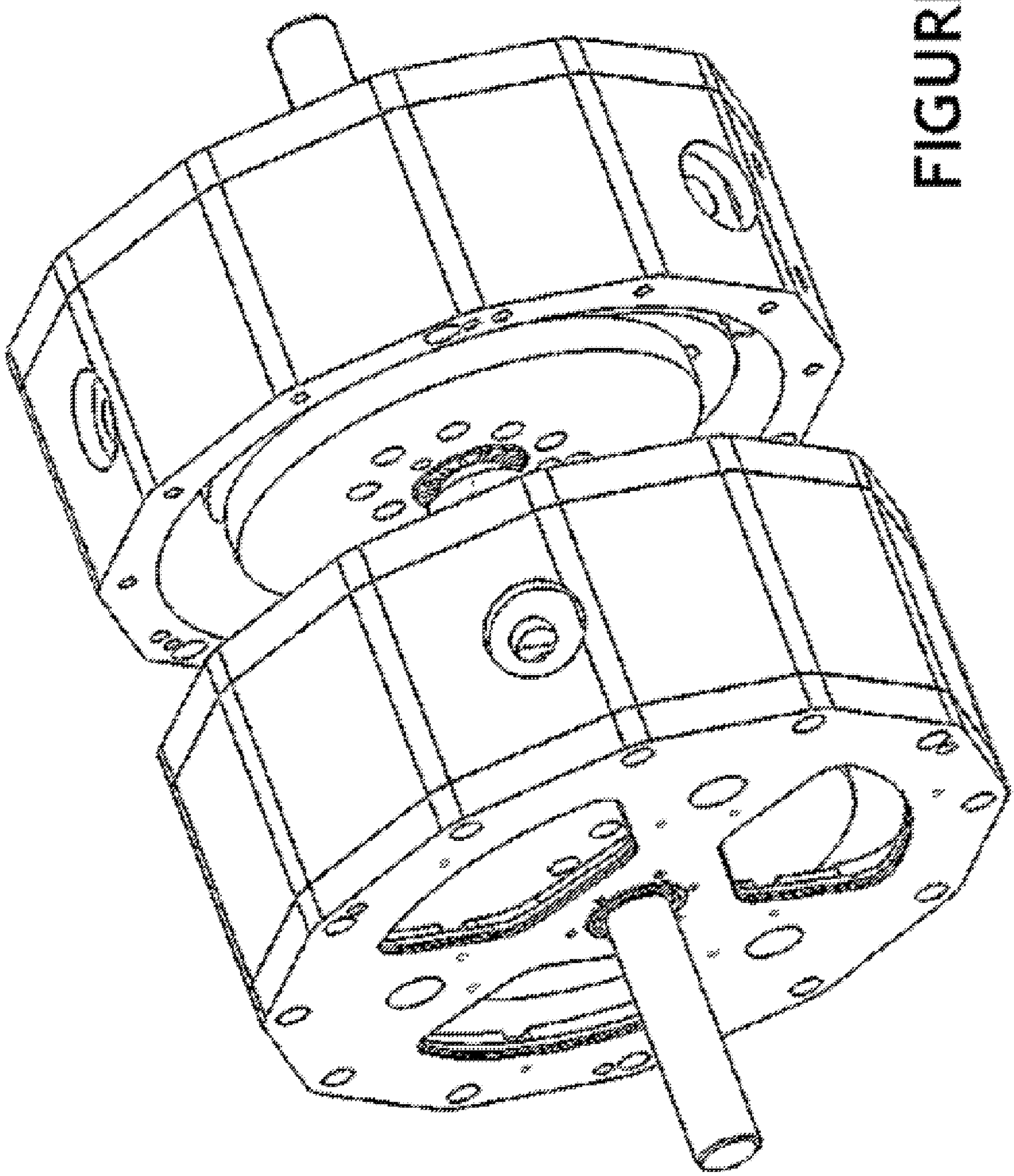


FIGURE 25

FIGURE 26



INTERNATIONAL SEARCH REPORT	International application No. PCT/US 2013/030649

A. CLASSIFICATION OF SUBJECT MATTER ***F01C 1/46*** *(2006.01)*
F01C 19/04 *(2006.01)*
F01C 19/08 *(2006.01)*
F01C 21/18 *(2006.01)*
F01C 17/04 *(2006.01)*
F02B 55/02 *(2006.01)*

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01C 1/00, 1/30, 1/40, 1/46, 17/00, 17/04, 19/00, 19/02, 19/04, 19/08, 21/00, 21/18, F02B 55/00, 55/02

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

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

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, Information Retrieval System of FIPS (http://www.fips.ru)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 3186385 A (HAMILTON WALKER ROTARY ENGINES LIMITED) 01.06.1965, fig. 1-3, 5-8, col. 1, line 68-col. 2, line 32, col. 3, lines 10-22, 56-60, 73-col. 4, line 3, col. 4, lines 11-13, claims	1-3, 5-8, 12, 13, 20, 22-27, 31-39 4, 9-11, 14-17, 19, 21, 28, 29, 40-46
X Y	US 613345 A (HENRY P. WHITE et al.) 01.11.1898, fig. 1-3, p. 1, lines 11-22, claims	47, 48 18, 30
Y	US 3302870 A (GENERAL MOTORS CORPORATION) 07.02.1967, fig. 1, col. 1, lines 8-11, col. 2, lines 3-15, 61-64, col. 3, lines 54-61	4, 45, 46

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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 July 2013 (05.07.2013)	15 August 2013 (15.08.2013)
Name and mailing address of the ISA/ FIPS Russia, 123995, Moscow, G-59, GSP-5, Berezhkovskaya nab., 30-1 Facsimile No. +7 (499) 243-33-37	Authorized officer V. Petrov Telephone No. (499) 240-25-91

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3936250 A (GENERAL MOTORS CORPORATION) 03.02.1976, fig. 1-4, col. 3, lines 9-14, claims	9-11, 14, 15
Y	US 5681157 A (LIU WEN-MING) 28.10.1997, fig. 5, 7, 8, col. 4, lines 32-63, claims	16-19, 21, 28-30, 40
Y	JP H05118283 A (HITACHI LTD) 1993.05.14, abstract, par. [0009], [0012], fig. 1. 2	19, 21, 28-30
Y	US 777692 A (WASHINGTON I. PHIFER et al.) 20.12.1904, fig. 4, 5, p. 2, lines 1-14, claims	41, 42
Y	US 6129068 A (JOHN L. WINGATE JR.) 10.10.2000, fig. 1, col. 2, lines 22-26, 54-60	43, 44