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(54) Orbiting piston type fluid displacement apparatus with internal balanceweight.

(57) An orbiting piston type fluid apparatus is disclosed. The apparatus includes a housing having a casing (11) with a cylindrical inner surface and a front end plate covering an end opening to the casing. A cylindrical core member (20) is carried in the center portion of the casing (11) and has an outer surface concentric with the inner surface of the casing (11). A blade (14) extends axially between the casing (11) and the core member (20). An orbiting cylindrical member (23) is carried for orbital motion within the annular space between the inner surface of the casing (11) and the outer surface of said core member (20) by eccentric crank portions of a drive shaft (17). The core member has a hollow space (201) at its center portion and a balanceweight (27) is assembled on the drive shaft (17) within the hollow space (201).

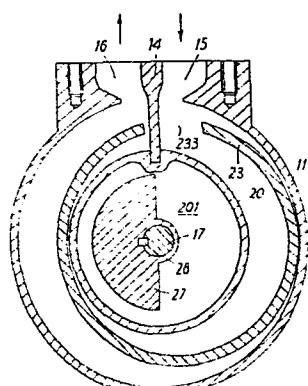


Fig 3

ORBITING PISTON TYPE FLUID DISPLACEMENT APPARATUS WITH INTERNAL BALANCEWEIGHTBackground Of The Invention

This invention relates to a fluid displacement apparatus, and more particularly, to a fluid displacement apparatus of the orbiting piston type for use as a supercharger for an engine or as an air compressor.

There are several type of fluid apparatus capable for use as air pumps or compressors. One well known machine is a velocity type compressor or blower which can handle a large air flow due to the high rotational speed of a fan blade. Another type of fluid apparatus is the fluid displacement apparatus, for example a piston-type fluid apparatus or a rotary vane type fluid apparatus, which can handle large pressure of fluid due to the enclosure of the fluid within a cylinder, and its discharge against the pressure at a discharge side.

These two types of the fluid apparatus are respectively used for specific purposes. However, these two types of fluid apparatus have the various advantages and disadvantages, i.e., a velocity type apparatus can handle a large air flow but is not particularly suitable for high discharge pressure, while a fluid displacement apparatus has the reverse advantage and disadvantage.

The supercharger for an engine, which is designed to increase the output of the engine by supercharging the suction air, must have intermediate character between the velocity type apparatus and fluid displacement apparatus, i.e. compress air at about 0.5 pressure above atmospheric pressure, and handle an air flow at  $5\sim 10\text{m}^3/\text{min}$ . Furthermore, the supercharger must be compact and lightweight, because the supercharger is preferably located within the engine compartment, which is already designed, without any influence on the other mechanisms connected with the engine. In prior superchargers, which have been driven by the engine through a rotation transmitting device,

for example, a gear or belt, the output of the engine, which is improved by the supercharging of supercharger, has generally not been sufficiently large to drive the supercharger. The supercharger is usually driven over a large range of rotational speeds, so that both 5 high volume efficiency and total pressure efficiency have not been attained. Furthermore, the supercharger requires a change over device to control the supercharging and non-supercharging operations, as occasion demands however, prior mechanisms which have controlled the change over device have not attained smooth change over operation. 10

#### Summary Of The Invention

It is a primary object of this invention to provide an improved orbiting piston type fluid apparatus having a large range of the rotational speeds and long life.

15 It is another object of this invention to provide an orbiting piston type fluid apparatus with increased volume efficiency and total pressure efficiency.

20 It is a further object of this invention to provide an orbiting piston type fluid apparatus having a changeover device to control the operation of the apparatus.

It is still another object of this invention to provide an orbiting piston type fluid apparatus with improved dynamic balance so that 25 vibration of the apparatus is reduced.

It is yet another object of this invention to provide an orbiting piston type fluid apparatus which is simple to construct and can be simply and reliably manufactured.

30 An orbiting piston type fluid apparatus according to this invention includes a housing having a cylindrical casing and a front end plate, attached to one end opening of the casing. A cylindrical core member is located in the center portion of the casing and has an outer surface concentric with the inner surface of the casing.

5 A blade axially extends within the space between the casing and core member. An orbiting cylindrical member is disposed in an annular space defined between the inner surface of the casing and the outer surface of the core member to form a working fluid chamber, and has a slot for passage of the blade in a radial direction. A drive shaft is rotatably supported by the housing at both end portion thereof. The orbiting cylindrical member is supported for orbital motion by eccentric crank portions disposed on both end portions of the drive shaft, which carry the orbiting cylindrical member through bearings.

10 The core member has a hollow space at its center portion. A balanceweight which cancels the unbalance caused by the orbital motion is assembled on the drive shaft within the hollow space of the core member.

15 Further objects, features and aspects of this invention will be understood from the following detailed description of preferred embodiments of this invention, referring to the annexed drawings.

#### Brief Description Of The Drawings

Figure 1 is schematic perspective view of an orbiting piston type fluid displacement apparatus according to this invention;

20 Figure 2 is a vertical sectional view of the orbiting piston type fluid displacement apparatus shown in Figure 1;

Figure 3 is a vertical sectional view taken along line III-III in Figure 2;

25 Figure 4 is a vertical sectional view taken along line IV-IV in Figure 2;

Figure 5 is a vertical sectional view taken along line V-V in Figure 2;

30 Figure 6 is a perspective view of the cylindrical orbiting member shown in Figure 2;

Figure 7 is a perspective view of a cylindrical orbiting member according to another embodiment of this invention;

Figure 8 is a vertical sectional view of an orbiting piston type fluid displacement apparatus according to another embodiment of this invention;

5 Figure 9a-9h are schematic views illustrating the relative movement of cylindrical orbiting member shown in Figure 2;

Figure 10 is a vertical sectional view of an orbiting piston type fluid displacement apparatus according to a further embodiment of this invention;

10 Figure 11 is a vertical sectional view of an orbiting piston type fluid displacement apparatus according to another embodiment of this invention;

Figure 12 is a vertical sectional view of an orbiting piston type fluid displacement apparatus according to another embodiment of this invention;

15 Figure 13 is a schematic perspective view of the cylindrical orbiting member shown in Figure 12;

Figure 14 is a perspective view of the crank member for a rotation preventing device shown in Figure 12; and

20 Figure 15a is a partially sectional view of the orbiting piston type fluid displacement apparatus shown in Figure 12; and

Figure 15b is an enlarged detail view of portion A in Figure 15a.

#### Detailed Description Of The Preferred Embodiments

25 Referring to Figures 1 and 2, an embodiment of a fluid apparatus in accordance with the present invention, in particular an orbiting piston type apparatus 1 is shown. Apparatus 1 includes a housing 10 having a cylindrical or cup shaped casing 11 with one end opening closed by an end plate member 111. A front end plate 12 is attached to other end opening of cylindrical casing 11 by a plurality of bolts 13. The end openings of cylindrical casing 11 are thus covered by end plate member 111 and front end plate

12 to seal off the inner chamber of casing 11. A rectangular shaped projection 112 projects from the outer peripheral surface of cylindrical casing 11 and extends from the front end portion of the casing 11 to its rear end portion to form a rectangular opening. A blade or partition 14 is located within the rectangular opening and extends axially to define a suction port 15 and discharge port 16 within the opening. Each longitudinal end of partition 14 is attached to projection 112.

5 An opening 121 is formed in the center of front end plate 12 for passage or penetration of a drive shaft 17. An annular sleeve 122 projects from the front end surface of front end plate 12 and surrounds drive shaft 17. The outer end of drive shaft 17 which extends from sleeve 122 is connected to a rotation transmitting device which may be disposed on the outer peripheral surface of sleeve 122 for transmitting rotational movement to drive shaft 17.

10 Drive shaft 17 is rotatably supported by front end plate 12 and end plate member 111 of cylindrical casing 11 through two bearings 18 and 19. Bearing 18 is located within opening 121 of front end plate 12 and the other bearing 19 is located within an annular depression 113 of end plate member 111. A cylindrical core member 20 is arranged on and around drive shaft 17, and supported by drive shaft 17 through bearings 21 and 22. The outer peripheral surface of cylindrical core member 20 is concentric with the inner surface of cylindrical casing 11. Cylindrical core member 20 has a cylindrical cavity 201 at its center portion and two supporting members 202 and 203 at both end portions of cylindrical cavity 201. Supporting members 202 and 203 extend radially inward from the inner surface of core member 20 and are supported on drive shaft 17 through bearings 21 and 22. Furthermore, the inner end portion of blade 14 is fixed on the outer peripheral surface of cylindrical core member 20, as shown in Figure 3, to fixedly locate it within the inner chamber of cylindrical casing 11. As shown in Figure 2, one supporting member, support member 202, is formed separately from the cylindrical core member 20 and is fitted in the inner surface of cylindrical core

member 20. Alternatively, cylindrical core member 20 may be fixed by blade 14 alone, as shown in Figure 11, or supported by one supporting member 204 formed in the center portion of its inner wall, as shown in Figure 10.

Drive shaft 17 has two eccentric crank portions 171 and 172 attached at both end portions of drive shaft 17 and located in the same angular position. Eccentric crank portion 171, which is located closest to front end plate 12, is formed separately from drive shaft 17 and fixed on drive shaft 17 by a key 211. An orbiting cylindrical member 23 is disposed within the inner chamber of cylindrical casing 11 and surrounds cylindrical core member 20. One end opening of orbiting cylindrical member 23 is closed by block end plate 231, and the other by block end plate 232. The orbiting cylindrical member 23 is supported by drive shaft 17 through crank portions 171 and 172 and two bearings 24 and 25 which are located between the outer peripheral surfaces of crank portions 171 and 172 and the inner peripheral surfaces of end plates 231 and 232. Orbiting cylindrical member 23 has an axially extending slot 233 to prevent interference between orbiting cylindrical member 23 and blade 14 during the orbital motion of orbiting cylindrical member 23. As shown in Figure 2, the front block end plate 231 is formed separately from orbiting cylindrical member 23 to permit the insertion of core member 20. Front block end plate 231 is fixed on the end portion of orbiting cylindrical member 23 by any suitable conventional technique.

A rotation preventing device 26 is located between the inner end surface of front end plate 12 and the axial end surface of block end plate 231 of orbiting cylindrical member 23. Rotation preventing device 26 includes an orbiting ring 261 which is fastened against the end surface of block end plate 231, a fixed ring 262 which is fastened against the inner end surface of front end plate 12, and bearing elements, such as a plurality of spherical balls 265. Both rings 261 and 262 have a plurality of pairs of adjacent circular indentations

or holes 263 and 264. As shown in Figure 2, both rings 261 and 262 are formed of separate plate elements 261a and 262a, each of which are respectively fixed on an end surface by pins 266 (Fig. 4), and ring elements 261b and 262b which have the plurality of pairs of holes 263 and 264. Alternatively, the plate and ring elements may be formed integral with one another. In operation, the rotation of orbiting cylindrical member 23 is prevented by balls 265, which interact with the edges of holes 264 and 263 to prevent the rotation. In the embodiment shown by Figure 2, rotation preventing device 26 is located between the inner surface of front end plate 12 and one end surface of orbiting cylindrical member 23. However, as shown in Figure 8, another rotation preventing device 26' may be located between an inner surface of end plate member 111 of casing 11 and other end surface of orbiting cylindrical member 23 to prevent twisting of orbiting cylindrical member. If rotating motion of orbiting cylindrical member 23 is prevented by only one rotation preventing device located between the first end plate and one end surface of orbiting cylindrical member 23, the other end portion of orbiting cylindrical member 23 is free to rotate, so that twisting motion may be caused.

A balanceweight 27 is fixed on drive shaft 17 by a key 28 and is disposed within a cylindrical cavity of core member 20 to hold the dynamic balance of the apparatus. The centroid of balance-weight 27 is angularly offset  $180^{\circ}$  from the angular location of eccentric crank portions 171 and 172. In order to further enhance dynamic balance, cut-out portions 267 are formed in orbiting ring 261 as shown in Figure 7, to coincide the centroid of the orbiting cylindrical member 23 with the axis of drive shaft 17 since the orbiting cylindrical member 23 is formed with slot 233, which would cause an unbalance.

In this construction of the fluid apparatus, the parts which define the working chamber of the apparatus move through a non-contacting point with respect to one another, i.e., a gap between the

outer surface of core member 20 and the inner wall surface of orbiting cylindrical member 23, and a gap between the inner surface of cylindrical casing 11 and the outer wall surface of orbiting cylindrical member 23 are created with minimum clearance to prevent interference of the parts caused by the eccentricity of the parts which results in manufacturing.

The axial positioning of the two bearings 21, 22 and one crank portion 171 is maintained by spacers 177 and 179 which are disposed on the drive shaft 17. The axial movement of orbiting cylindrical member 23 is absorbed by a spring washer 175 located between the crank portion 172 and bearing 19.

The principle of operation of a typical orbiting piston type fluid apparatus will be described with reference to Figures 9a-9h.

In Figure 9a, the longitudinal axis of the eccentric crank portion is shown at its top vertical position or at  $0^\circ$ . The point of tangency Q4 between the inner wall surface of orbiting cylindrical member 23 and the outer peripheral surface of core member 20 defines an inner fluid chamber B which has two sections, each extending from the point of tangency to opposite side of blade 14. In this stage, an outer fluid chamber A, which extends substantially from one side of blade 14 to the other, is also formed between the outer wall surface of orbiting cylindrical member 23 and the inner wall of cylindrical casing 11. Figure 9b shows the state of the orbiting cylindrical member 23 at a drive shaft crank angle which is advanced  $\alpha^\circ$  from that in Figure 9a. In this state, a point of tangency P1 between the outer wall surface of right end portion of orbiting cylindrical member 23 and the inner wall of cylindrical casing 11 is formed, therefore the outer fluid chamber A is sealed off. However, a clearance between the outer wall surface of left end portion of orbiting cylindrical member 23 and the inner wall of cylindrical casing 11 is created, so that outer fluid chamber A is connected with the discharge port 15 through the clearance. The fluid in outer fluid chamber A is discharged through the clearance

due to reduction of volume of outer fluid chamber A which is caused by the further orbital motion of orbiting cylindrical member 23, as shown in Figures 9c-9f. On the opposite side of the point of tangency P, (P1-P6), a new chamber A' is formed to take in fluid.

5 During the discharge of fluid within outer fluid chamber A, the volume of inner fluid chamber B is increased to take in fluid, as shown in Figure 9a-9d. When the inner wall surface of right end portion of orbiting cylindrical member 23 contacts the outer wall surface of core member 20, the inner fluid chamber B is sealed off, as shown in Figure 9f, and simultaneously connected with the discharge port 15 through a clearance between the left end portion of orbiting cylindrical member 23 and core member 20. The volume of the inner fluid chamber B is gradually reduced due to further orbital motion of member 23, as shown in Figures 9a-9c. The discharging of fluid within the inner fluid chamber B thus continues until the inner wall surface of left end portion of orbiting cylindrical member 23 contacts the outer wall surface of core member 20. On the opposite side of point of tangency Q, (Q1~Q7), a new inner fluid chamber B' is formed to take in fluid.

10 In such operation, suction port 15 is in fluid communication with discharge port 16 while passing the stages from Figure 9h to Figure 9b, and also while passing the stages from Figure 9d to Figure 9f. This occurs because while passing the stages from Figure 9h to Figure 9b, clearance between the outer wall surface of both end portions of orbiting cylindrical member 23 and the inner surface of cylindrical casing 11 is created; and also while passing the stages from Figure 9d to Figure 9f, clearance between the inner wall surface of both end portions of orbiting cylindrical member 23 and the outer surface of core member 20 is created. However, if the angular aperture  $24^\circ$  of slot 233 is designed to a set minimum degree 15 without interference between orbiting cylindrical member 23 and

blade 14, the apparatus can operate at a pressure ratio 1 or 2 without causing problems. Furthermore, the apparatus can be made with an orbiting cylindrical member having a comparatively small radius, so that the apparatus can be operated at high speeds without expending great energy to thereby shorten the time during which the suction and discharge ports are connected.

In comparison with rotary apparatus which include a rotatable piston member, inertia moment of the moving parts of this apparatus will be smaller; the suction side and discharge side is penetrated by two cylindrical members of close curvature, and transfer of the air due to the rotation of the drive shaft does not result in shearing of the air, therefore, this apparatus can be operated at high speed.

Referring to Figures 12-15, another embodiment is shown. This embodiment is directed to a modification of the orbiting cylindrical member to improve the volumetric efficiency by filling in the gap between the axial end surface of the blade and the opposite surface as far as possible. In this embodiment, an annular axial projection 233 extends from the center portion of axial end surface of front block end plate 231, and a radial flange portion 234 extends radially outward from the outer end portion of annular projection 233. Radial flange portion 234 thus is located at an axially spaced distance from the front end surface of front block end plate 231. The outer diameter of radial flange portion 234 is formed the same as outer diameter of orbiting cylindrical member 23. An annular plate 29 is fixed on one end surface of casing 11, and extends radially inward into the space between flange portion 234 and block end plate 231.

A rotation preventing device 30, for example, a crank type coupling mechanism is located between the inner surface of front end plate 12 and an end surface of radial flange portion 234. In this embodiment, rotation preventing device 30 includes a plurality of cranks 301, as shown in Figure 14, and pairs of adjacent circular indentations 302 and 303 formed on the front end plate 12 and radial flange portion 234. Crank shaft portions 301a and 301b of crank 301 are inserted into indentations 302 and 303 to permit smooth orbital movement without rotation. Bearings 305 are

preferably interposed between crank shaft portions 301a, 301b and indentations 302 and 303.

In this construction, the gap between the axial end surface of the blade and the fixed element 20 which defines the working chamber, is formed smaller, thus improving the volumetric efficiency.

Furthermore, as shown in Figure 15, an annular groove 32 is formed on the axial end surface of block end plate 231 and a seal element 33 is placed within groove 32. The area containing the working space can be partitioned from the space containing the rotation preventing device 30 which may be lubricated. The grease therefore can be enclosed in the space containing the rotation preventing device.

This invention has been described in detail in connection with preferred embodiments, but these are examples only and this invention is not restricted thereto. It will be easily understood by those skilled in the art that the other variations and modifications can be easily made within the scope of this invention.

CLAIMS:

1. In an orbiting piston type fluid apparatus including a housing having a casing with front and back end portions and a cylindrical inner surface extending between the end portions, a front end plate attached to an opening in the front end portion of said casing, a cylindrical core member disposed in a center portion of said casing and having an outer surface concentric with the inner surface of said casing, a blade extending axially between said casing and core member, an orbiting cylindrical member disposed in an annular space defined between the inner surface of said casing and the outer surface of said core member to form a working fluid chamber and having a slot for passage said blade in a radial direction, a drive shaft having front and back end portions rotatably supported by said housing at both end portions thereof, and eccentric crank portions disposed on both end portions of said drive shaft for carrying said orbiting cylindrical member in an orbital motion through bearings located on the outer surface of said crank portions, the improvement comprising said core member having a hollow space at the center portion thereof and a balanceweight assembled on said drive shaft within said hollow space for cancelling unbalance caused by the orbital motion of said orbiting cylindrical member.

2. The orbiting piston type fluid apparatus of claim 1 wherein said casing has a projection which extends axially from the front end portion to a back end portion of said casing and forms a rectangular opening in said casing, said blade being disposed within the opening of said projection to partition the opening into a suction port and a discharge port, and said blade having one end portion fixed on said core member.

3. The orbiting piston type fluid apparatus of claim 2 wherein said core member has a supporting portion projecting radially from its inner wall and supported by said drive shaft through a bearing

located between said drive shaft and said supporting portion.

4. The orbiting piston type fluid apparatus of claim 1 further comprising a rotation preventing device disposed between the inner surface of said front end plate and an end surface of said orbiting cylindrical member to prevent the rotation of said orbiting cylindrical member during its orbital motion.

5. The orbiting piston type fluid apparatus of claim 4 wherein a further rotation preventing device is disposed between the end surface of said casing at its back portion and the end surface of said orbiting cylindrical member adjacent thereto.

10. 6. The orbiting piston type fluid apparatus of claim 4 or 5 wherein said rotation preventing device comprises a plurality of pairs of circular indentations formed on the end surfaces of said housing and said orbiting cylindrical member and a plurality of spherical balls carried in facing pairs of indentations.

15. 7. The orbiting piston type fluid apparatus of claims 4 or 5 wherein said rotation preventing device comprises a plurality of crank members each of which has an eccentric pin on each side thereof, and pairs circular indentations formed on the end surfaces of said housing and orbiting cylindrical member into which the pins of said crank are inserted.

20. 8. The orbiting piston type fluid apparatus of claim 8 further comprising a bearing disposed between each of the pins of said crank members and the circular indentation within which it is inserted.

25. 9. The orbiting piston type fluid apparatus of claim 1 or 4 wherein said orbiting cylindrical member has block end plate at both of its end portions to cover the opening thereof, and said block end plates being carried on said bearings which are located on the outer surface of said crank portion.

30. 10. The orbiting piston type fluid apparatus of claim 9 wherein one of said block end plates which faces said front end plate has an axial projection from which a radial flange extends and faces the

end surface of said last-mentioned block end plate at an axially spaced distance, a rotation preventing device is located between the inner surface of said front end plate and said radial flange, and an annular plate is located between said radial flange and said last mentioned block end plate.

5 11. The orbiting piston type fluid apparatus of claim 10 wherein said block end plate which is adjacent to said annular plate has an annular groove, and seal element is disposed within said groove to seal off the gap between said last-mentioned block end plate and said annular plate.

10 12. The orbiting piston type fluid apparatus of claim 10 wherein said rotation preventing device comprises a plurality of pairs of circular indentations formed on the end surfaces of said housing and said orbiting cylindrical member and a plurality of spherical balls carried in facing pairs of indentations.

15 13. The orbiting piston type fluid apparatus of claim 10 wherein said rotation preventing device comprises a plurality of crank members each of which has an eccentric pin at each side thereof, and pairs circular indentations formed on the end surfaces of said housing and said orbiting cylindrical member into which the pins of said crank are inserted.

20 14. The orbiting piston type fluid apparatus of claim 13 further comprising a bearing disposed between each of the pins of said crank members and the circular indentation within which it is inserted.

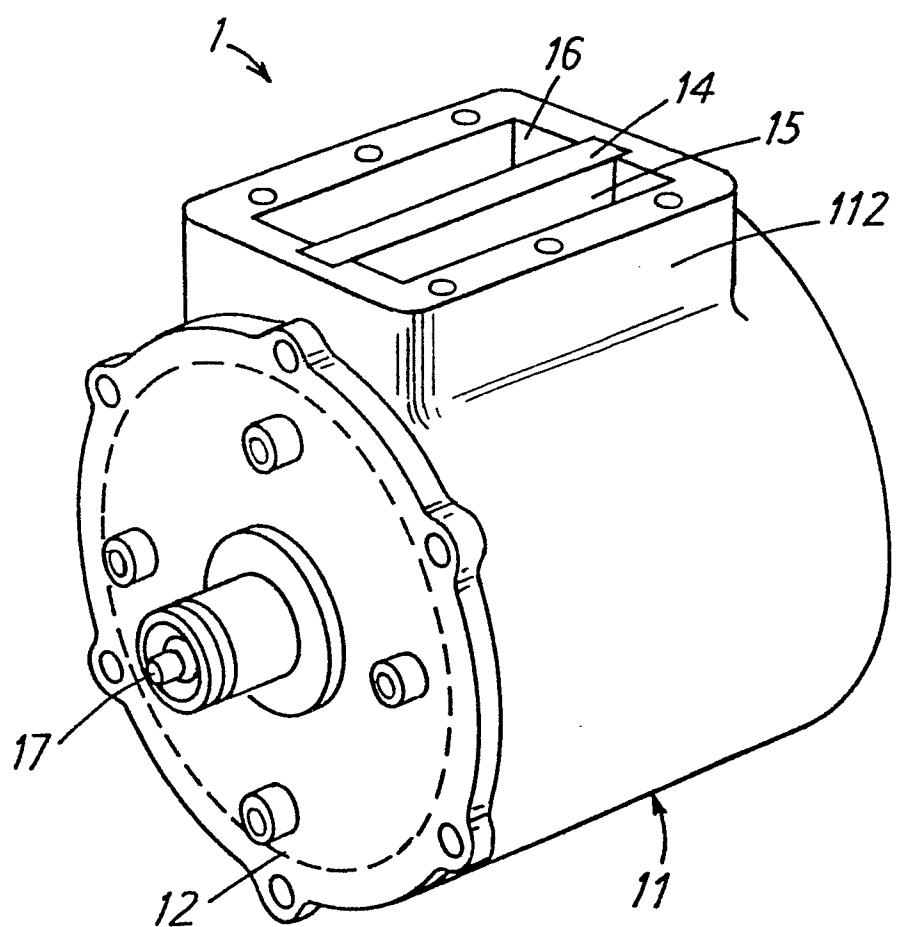
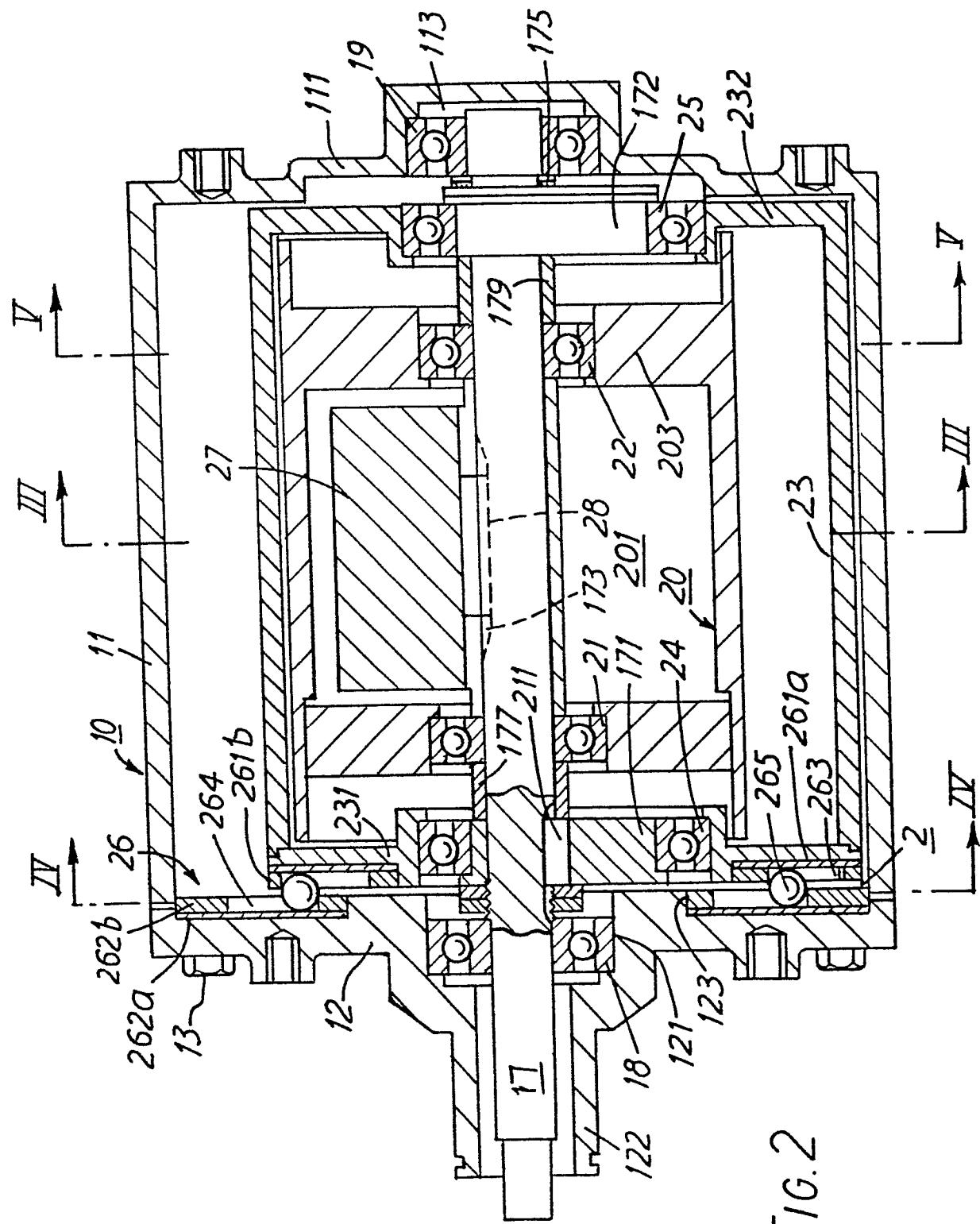


FIG.1



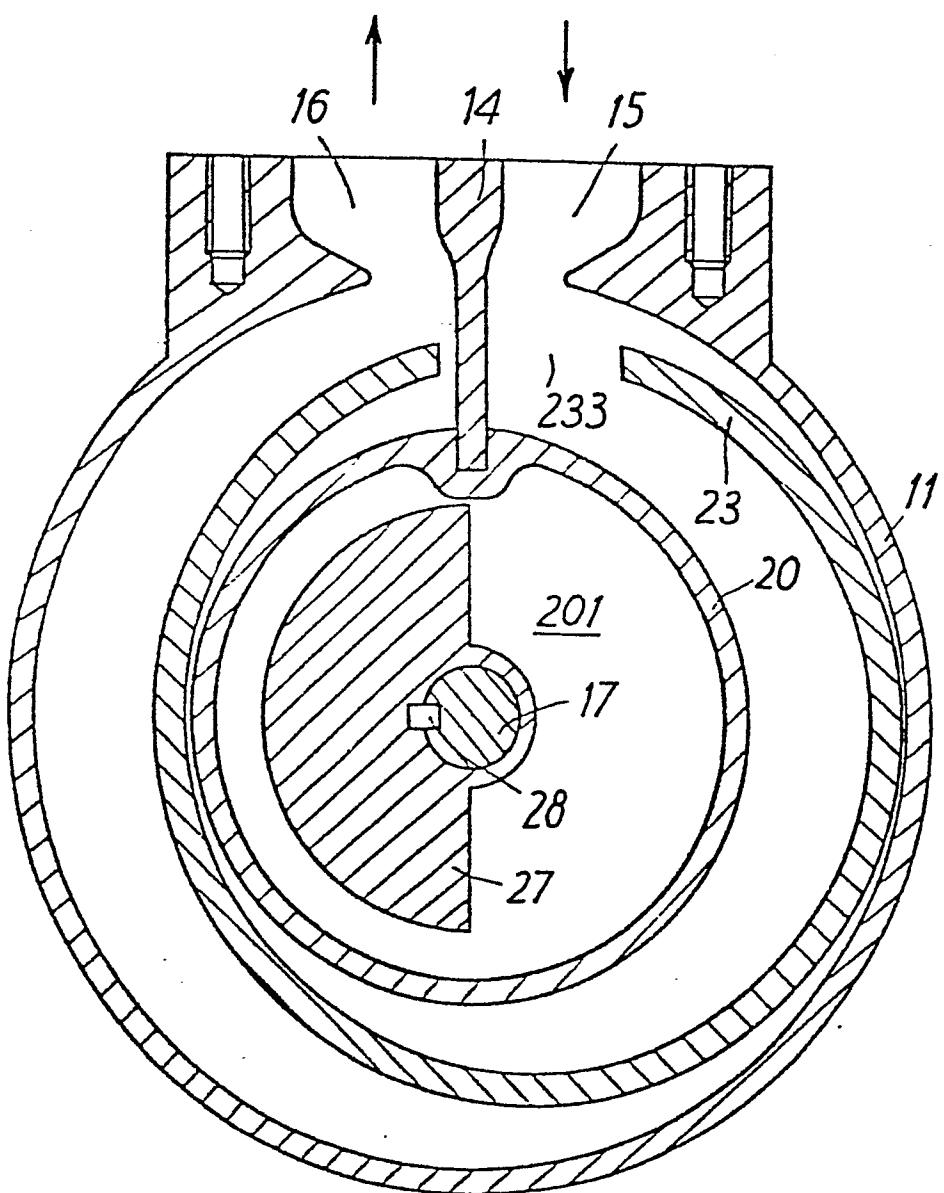


FIG. 3

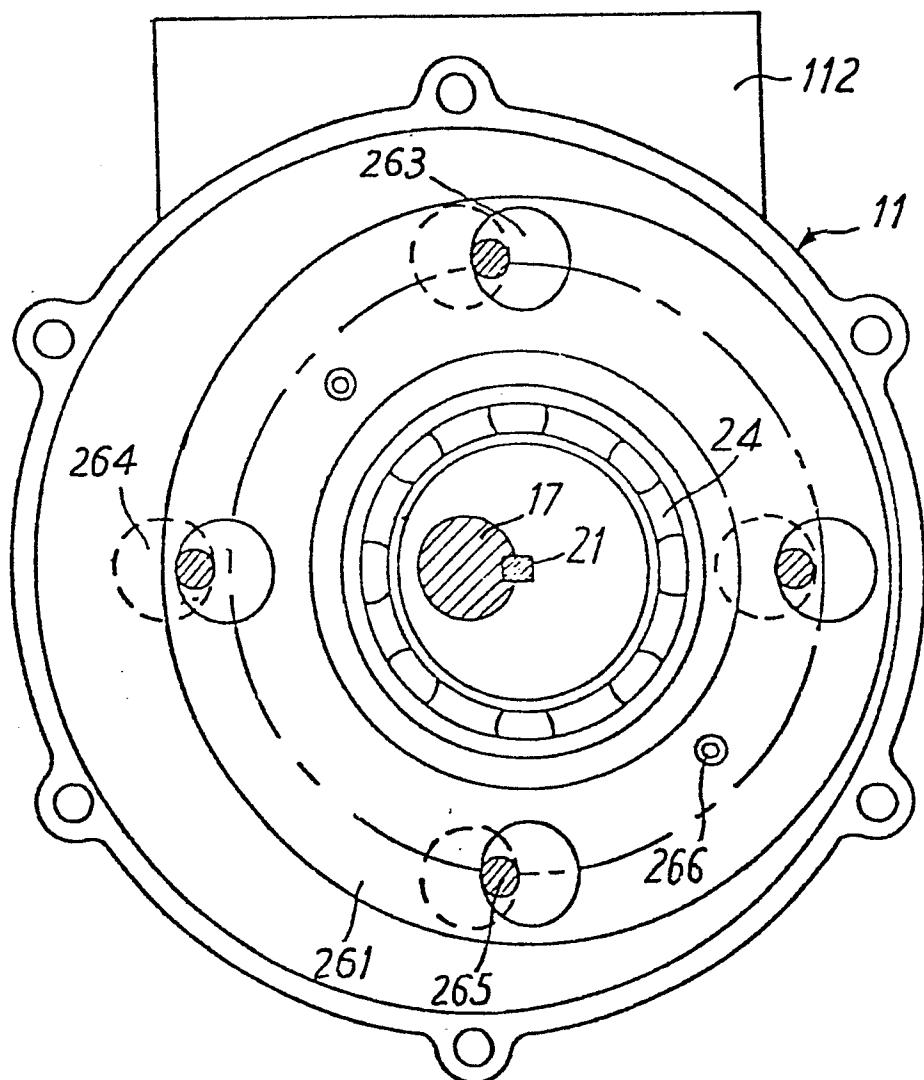


FIG.4

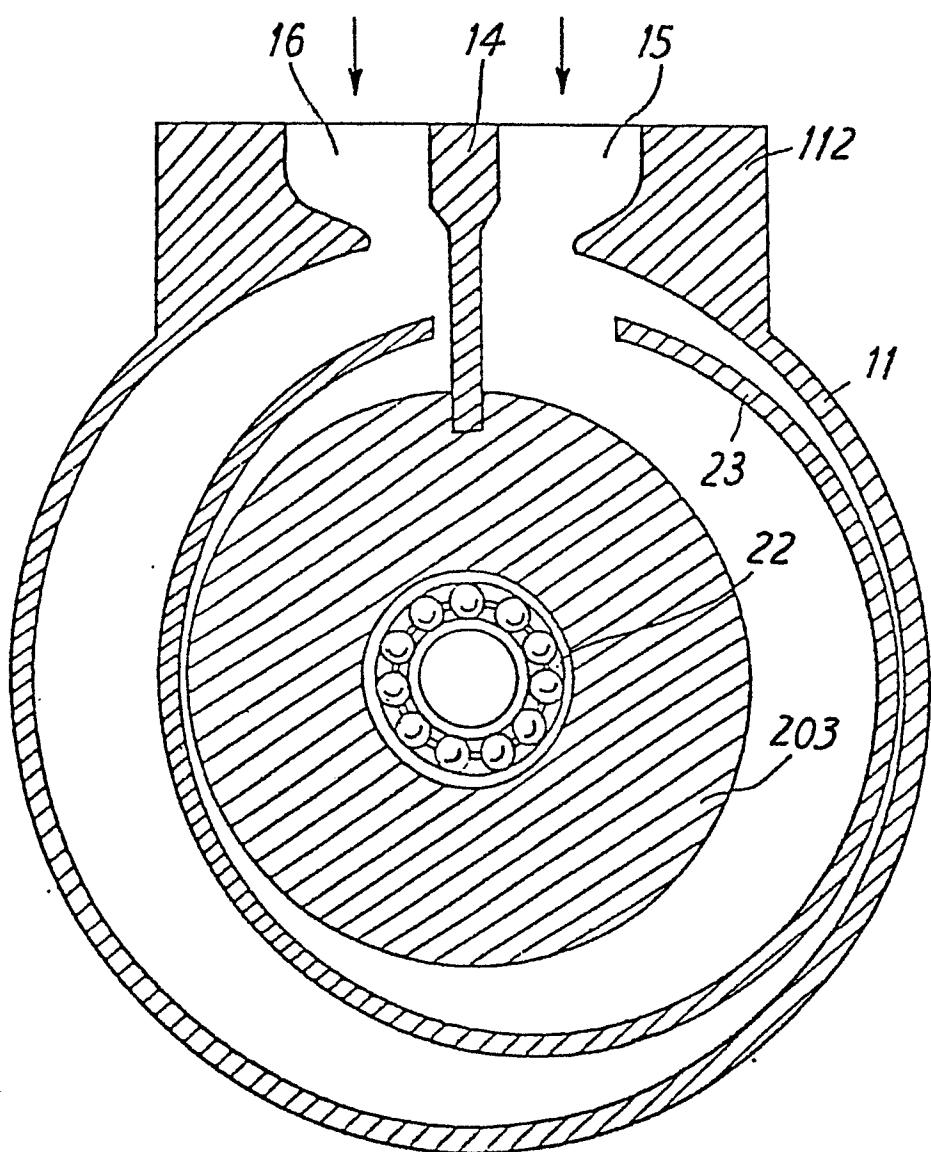


FIG.5

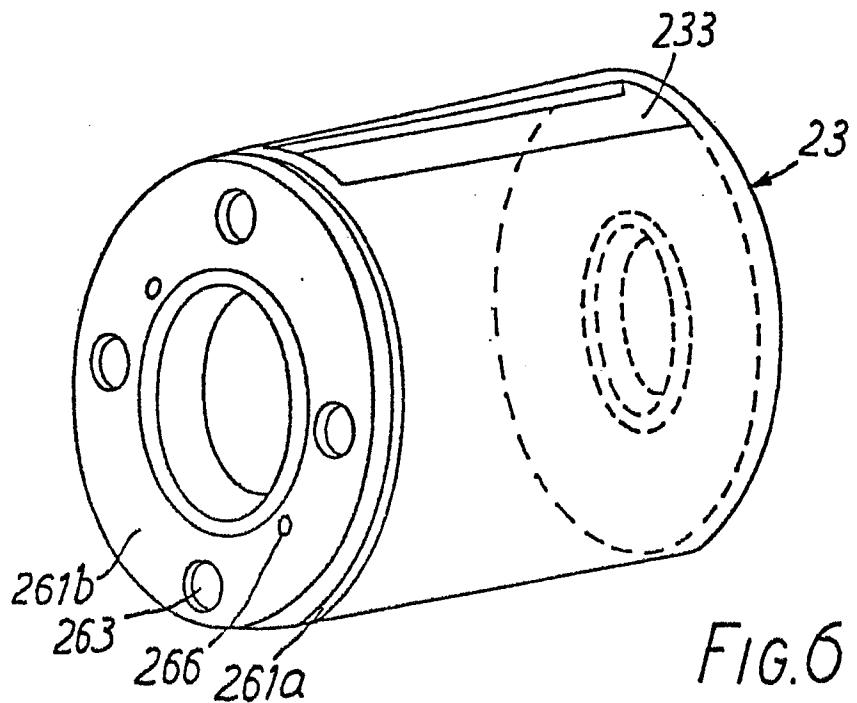


FIG. 6

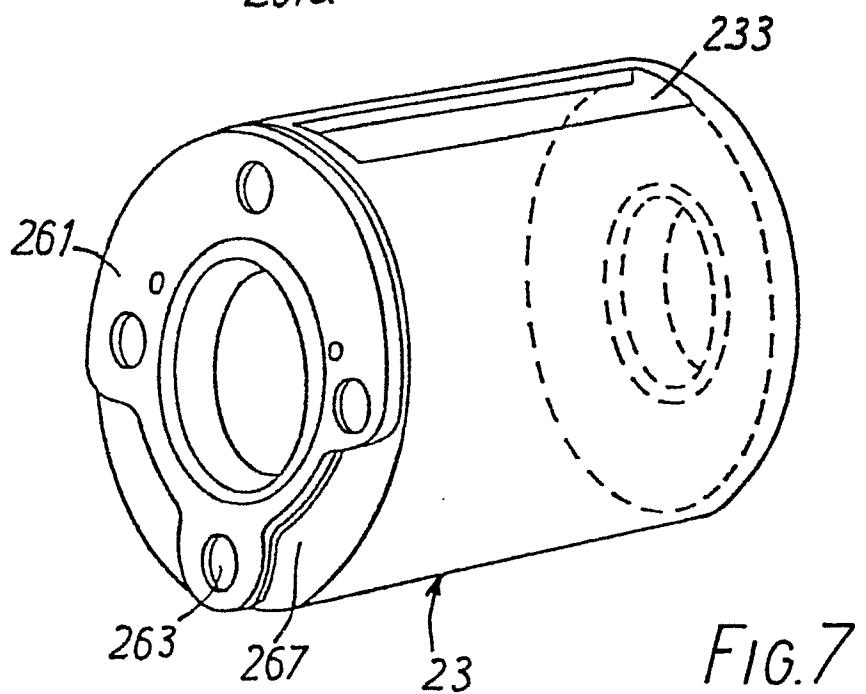
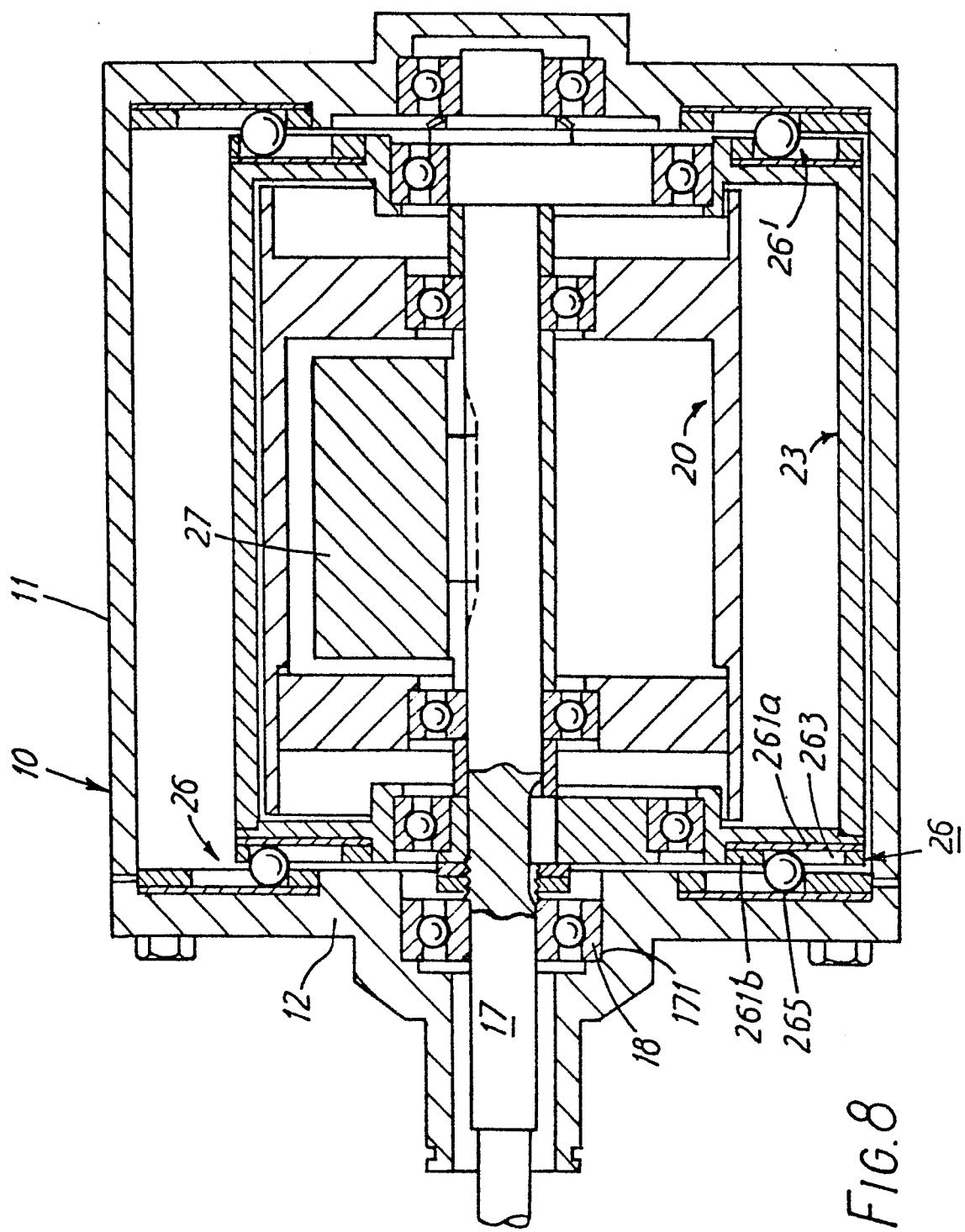


FIG. 7



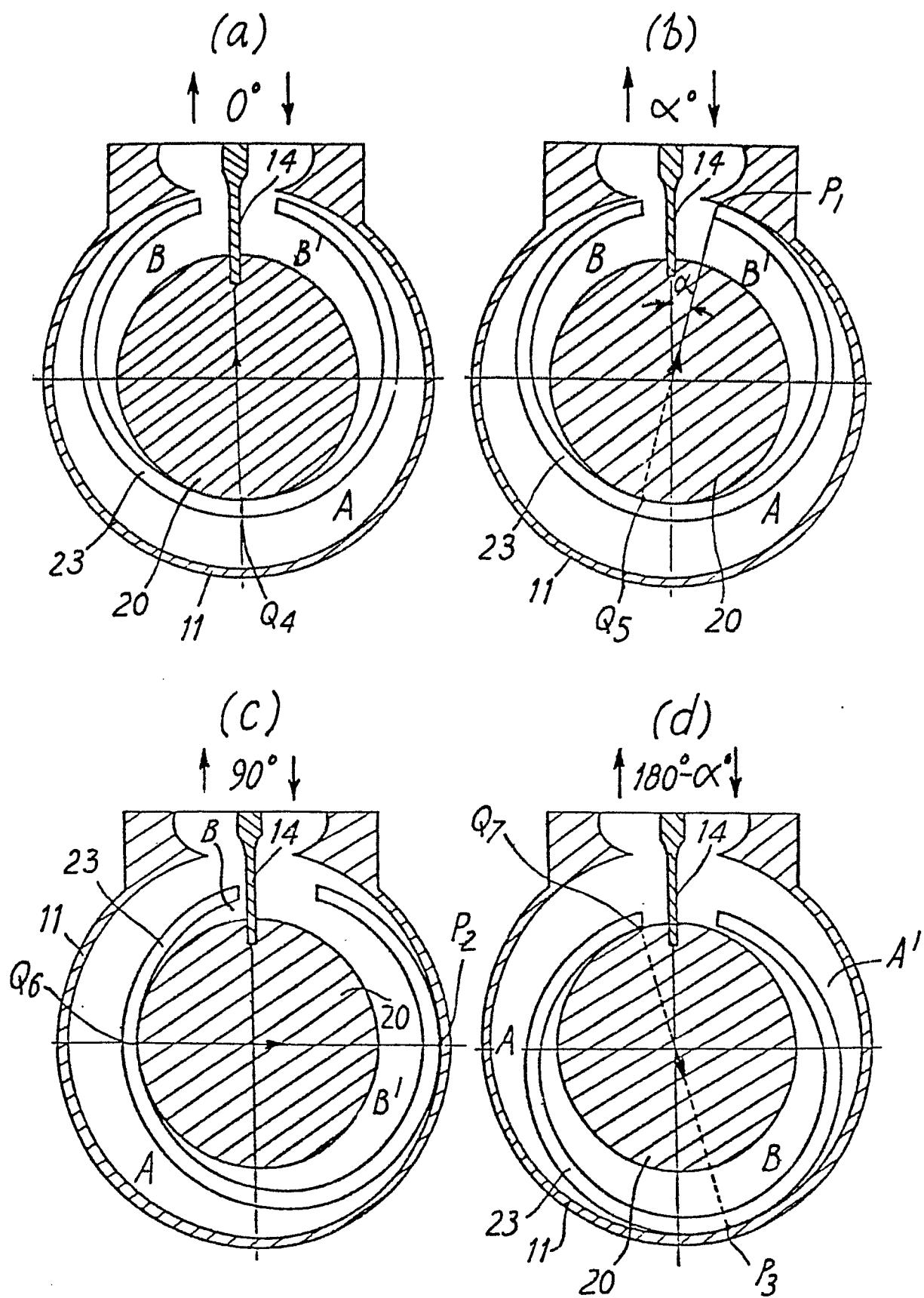


FIG.9

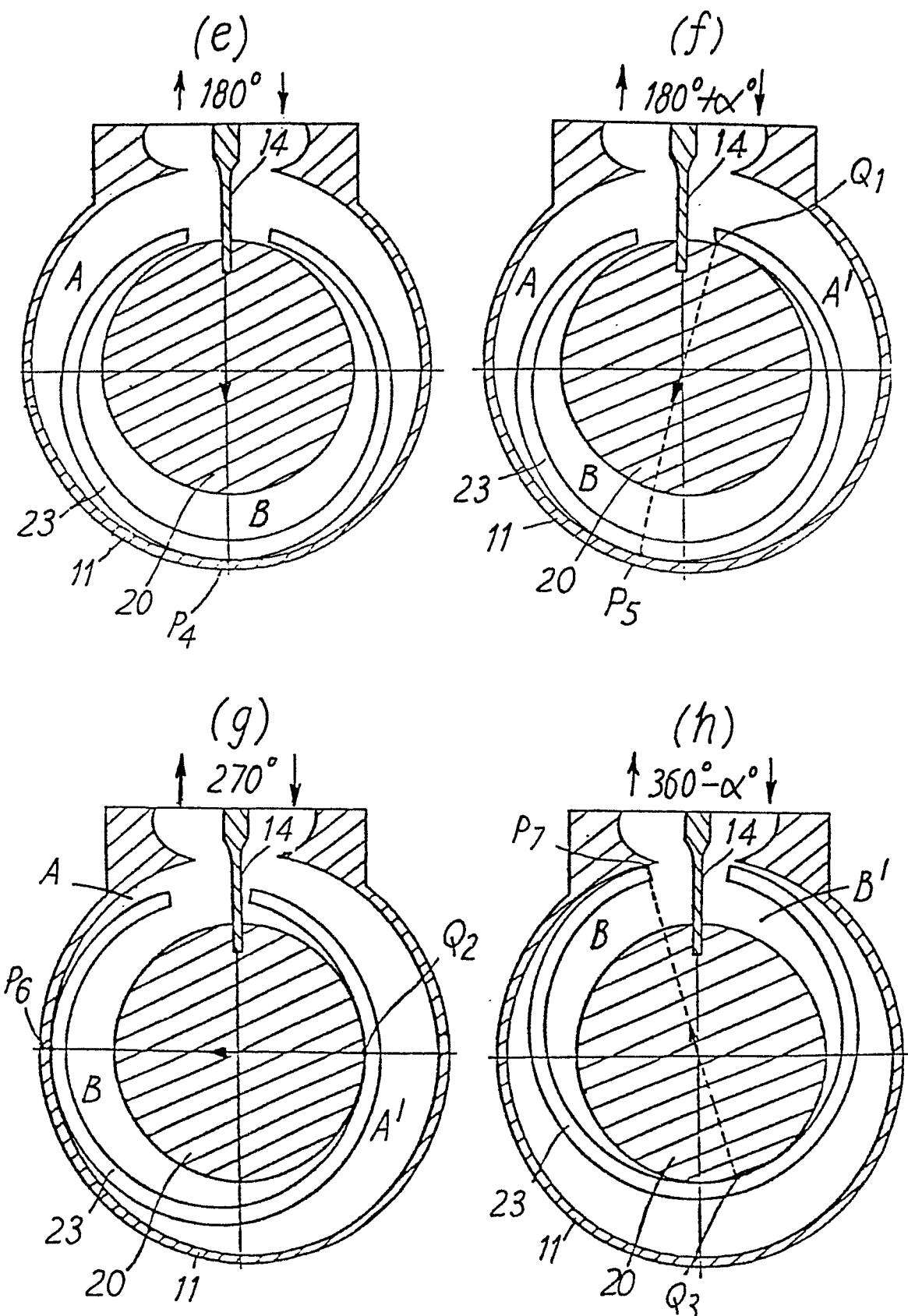
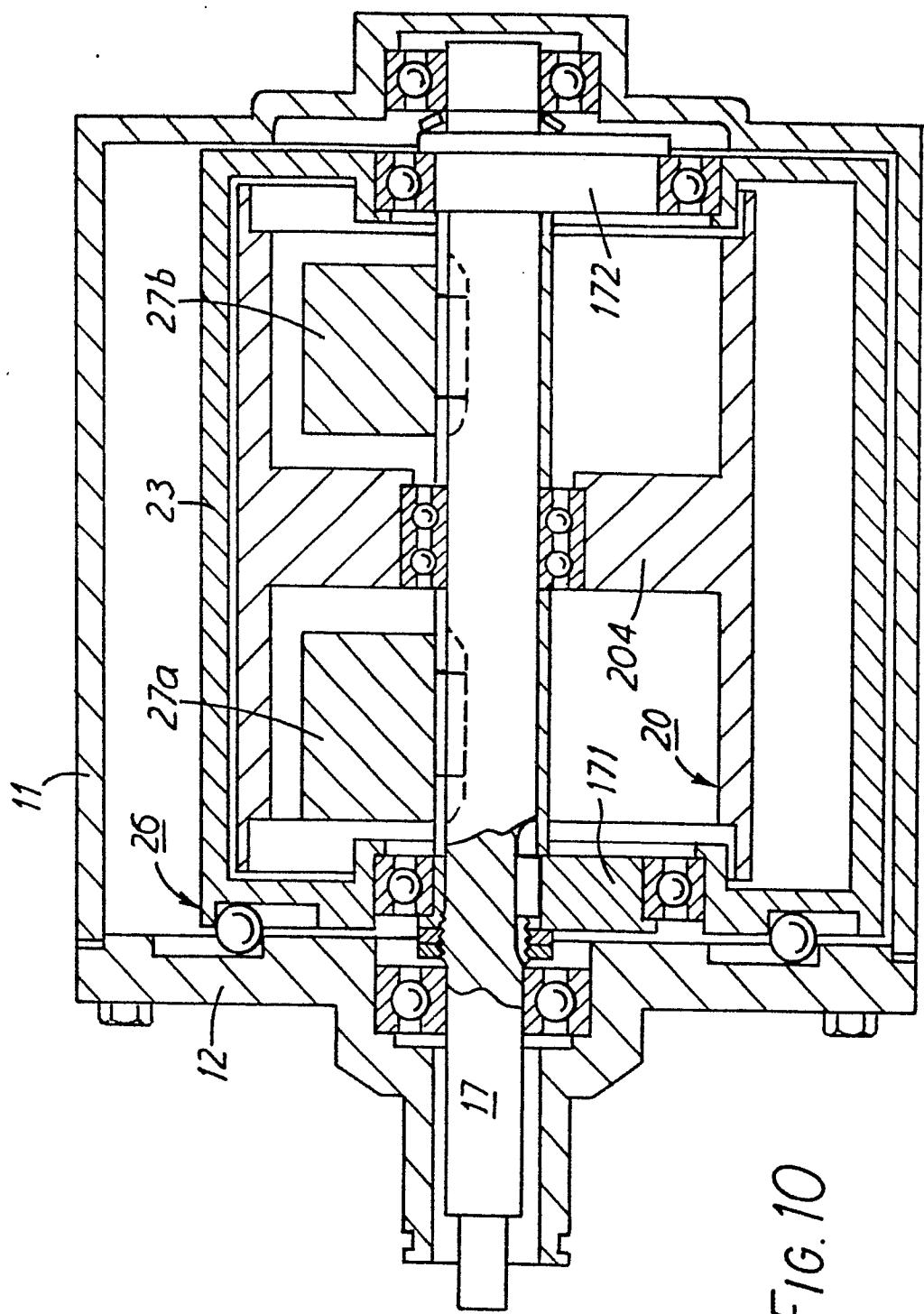
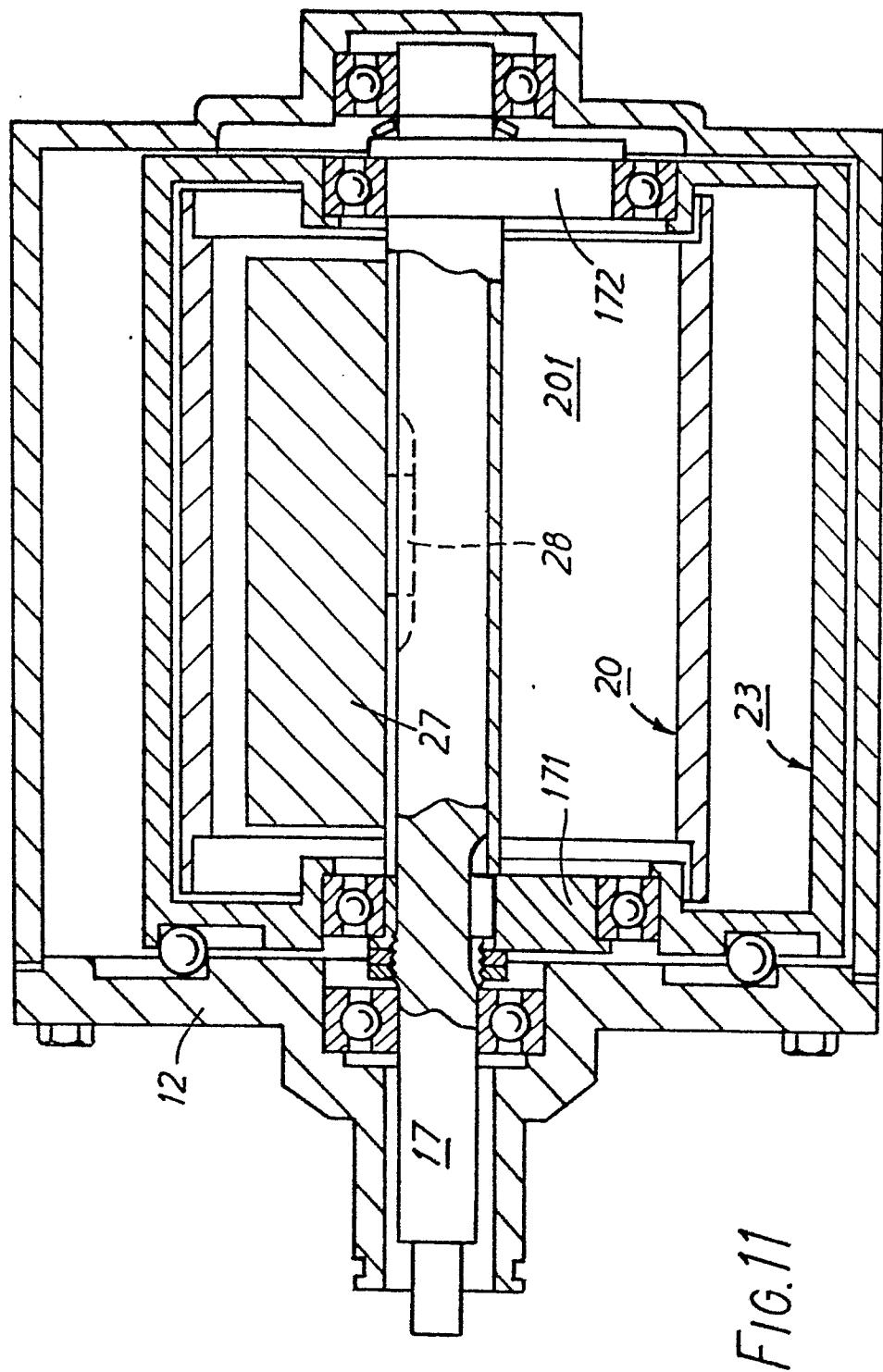


FIG. 9





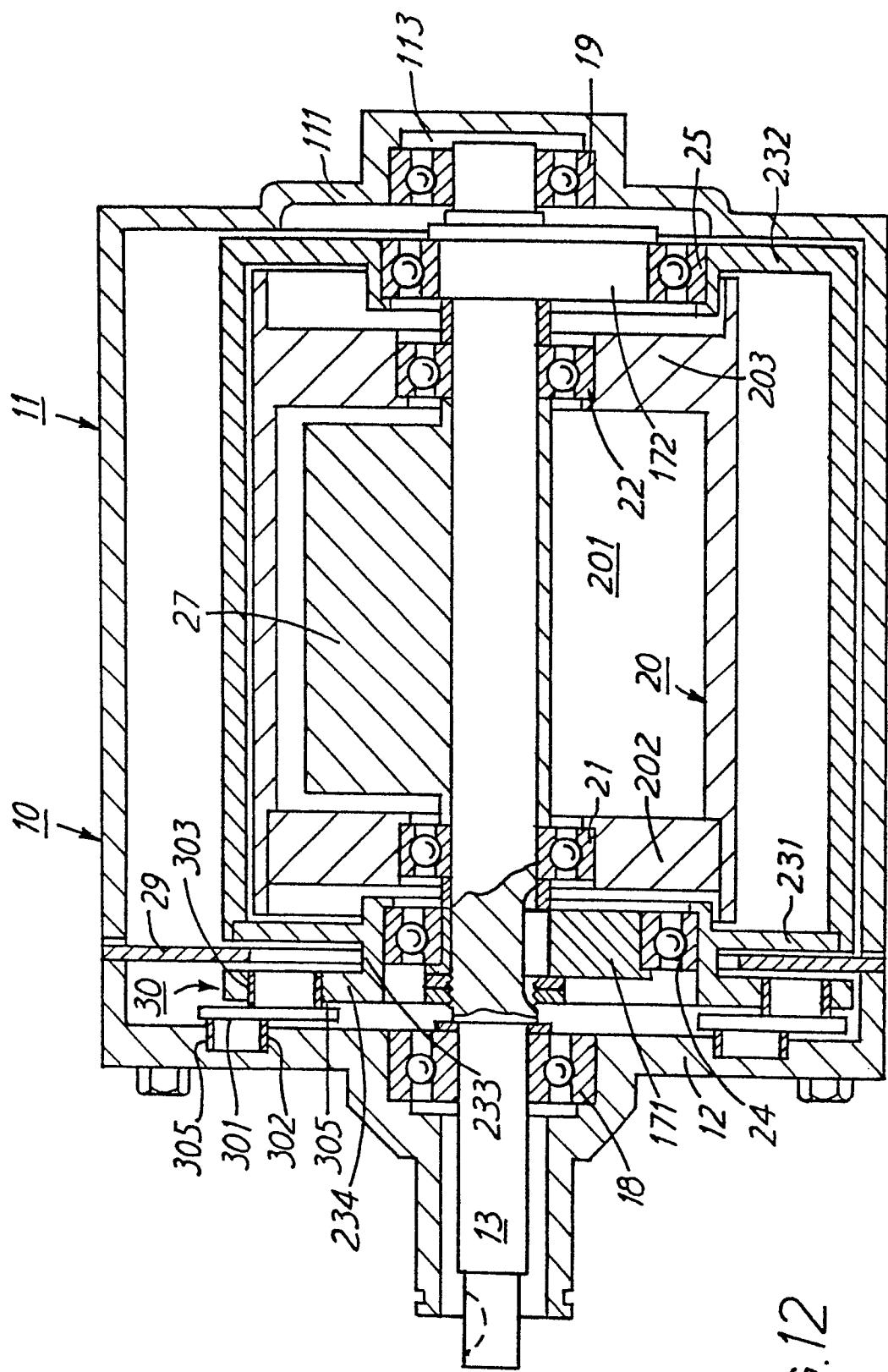


FIG. 12

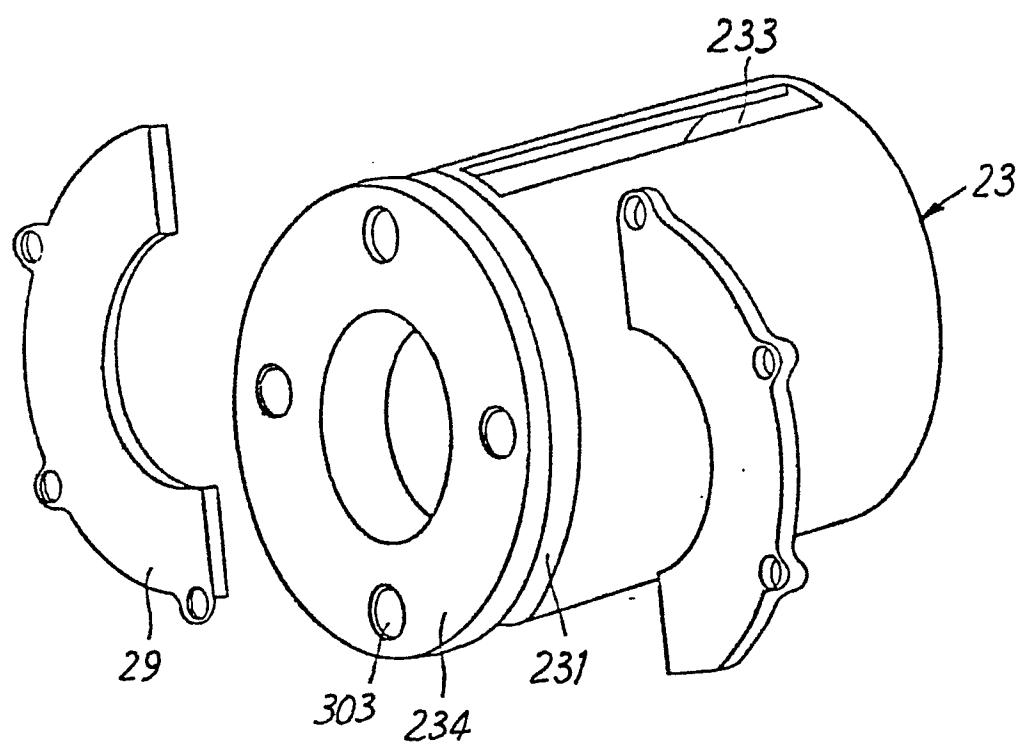


FIG.13

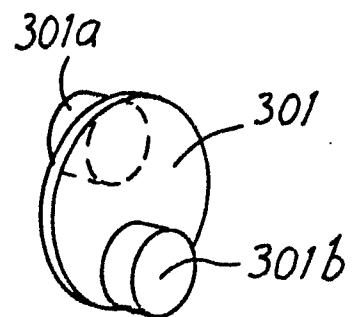


FIG. 14

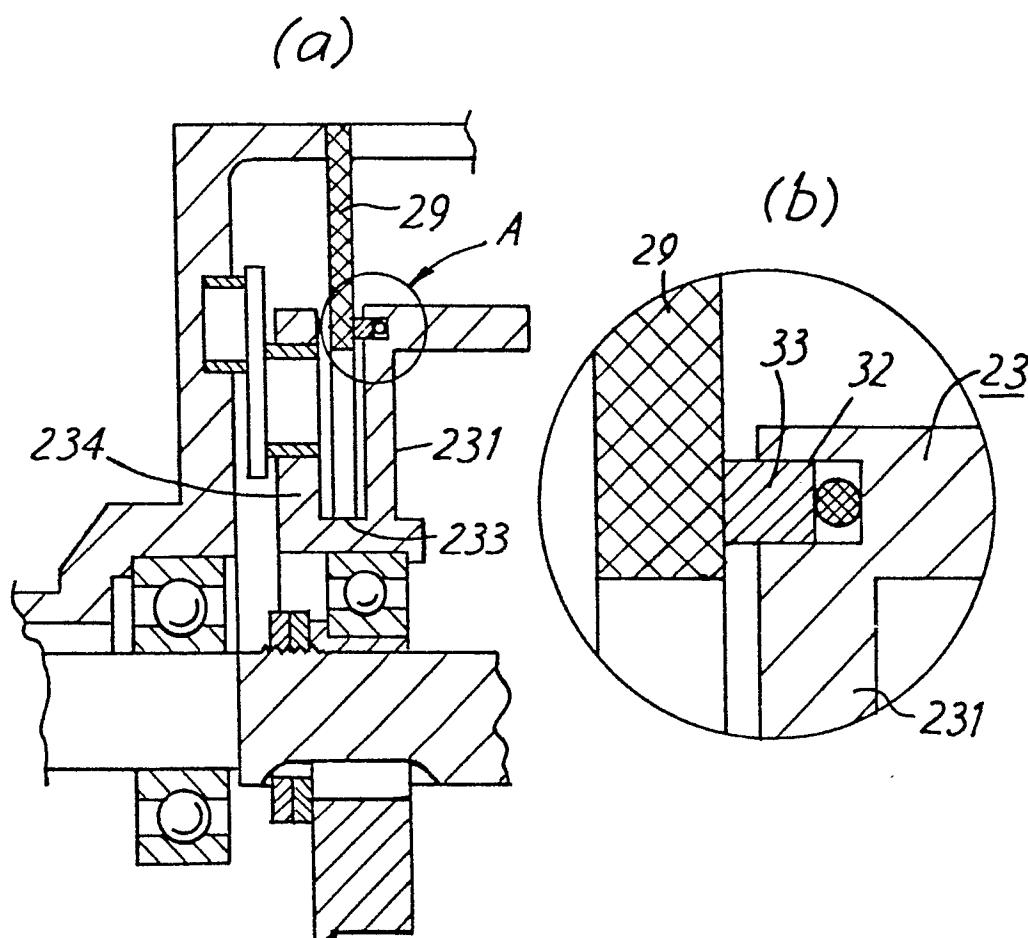


FIG. 15



DOCUMENTS CONSIDERED TO BE RELEVANT			EP 82306811.9
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	US - A - 2 649 053 (STRATVEIT) * Fig. 1,2, numeral 50 * --	1	F 04 C 15/00 F 04 C 2/04
X	US - A - 2 684 036 (STRATVEIT) * Fig. 5,6, numerals 16,17 * --	1	
A	US - A - 3 125 032 (SMITH) * Totality, especially fig. 13-15, 18, 19 * --	1,3,4	
A	US - A - 3 307 526 (BETZEN) * Fig. 15-18 * --	1	
A	DE - A - 1 815 711 (FRIEDRICH) * Fig. 2; page 2, line 3 * --	1	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	US - A - 3 125 031 (RYDBERG et al.) * Fig. 27-34 * -----	4,7-9, 13,14	F 01 C 1/00 F 02 B 53/00 F 04 C 2/00 F 04 C 13/00 F 04 C 15/00 F 04 C 18/00 F 04 C 25/00 F 04 C 29/00
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
VIENNA	26-12-1983	WITTMANN	

CATEGORY OF CITED DOCUMENTS		
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F	Interim patent document	I member of the same patent family, corresponding document