(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2010330096 B2**

(54) Title
Compressor end head heating arrangement

(51) International Patent Classification(s)
F04D 29/12 (2006.01) ***F16J 15/16*** (2006.01)
F04D 29/58 (2006.01) ***F16J 15/26*** (2006.01)
F04D 29/62 (2006.01) ***F16J 15/34*** (2006.01)

(21) Application No: **2010330096** (22) Date of Filing: **2010.12.03**

(87) WIPO No: **WO11/069909**

(30) Priority Data

(31) Number	(32) Date	(33) Country
CO 2009 A 00061	**2009.12.07**	**IT**

(43) Publication Date: **2011.06.16**
(44) Accepted Journal Date: **2016.03.17**

(71) Applicant(s)
Nuovo Pignone S.p.A

(72) Inventor(s)
Sassanelli, Giusepe;Bigi, Manuele;Devanbu, Suresh

(74) Agent / Attorney
Phillips Ormonde Fitzpatrick, L 16 333 Collins St, Melbourne, VIC, 3000

(56) Related Art
WO 2005/026589

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
16 June 2011 (16.06.2011)

PCT

(10) **International Publication Number**
WO 2011/069909 A1

(51) **International Patent Classification**:
F04D 29/12 (2006.01) ***F16J 15/16*** (2006.01)
F04D 29/58 (2006.01) ***F16J 15/26*** (2006.01)
F04D 29/62 (2006.01) ***F16J 15/34*** (2006.01)

(21) **International Application Number**:
PCT/EP2010/068845

(22) **International Filing Date**:
3 December 2010 (03.12.2010)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
CO 2009 A 00061 7 December 2009 (07.12.2009) IT

(71) **Applicant** *(for all designated States except US)*: **NUOVO PIGNONE S.P.A.** [IT/IT]; Via Felice Matteucci, 2, I-50127 Florence (IT).

(72) **Inventors; and**
(75) **Inventors/Applicants** *(for US only)*: **SASSANELLI, Giusepe** [IT/IT]; Nuovo Pignone S.p.A., Via Felice Matteucci, 2, I-50127 Florence (IT). **BIGI, Manuele** [IT/IT]; Nuovo Pignone S.p.A., Via Felice Matteucci, 2, I-50127 Florence (IT). **DEVANBU, Suresh** [IN/IN]; John F. Welch Technology Center, Plot No. 122, EPIP, Phase 2, Whitefield Road, Banagalore 560066 (IN).

(74) **Agent**: **ILLINGWORTH-LAW, William**; GE International Inc., Global Patent Operation - Europe, 15 John Adam Street, London WC2N 6LU (GB).

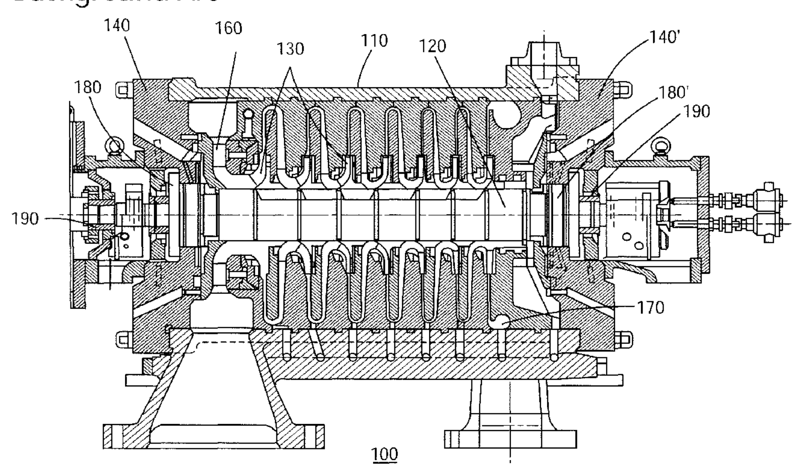
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: COMPRESSOR END HEAD HEATING ARRANGEMENT

FIG. 1
Background Art



(57) **Abstract**: A compressor end head (200) for providing a thermal barrier near a mechanical seal includes an inner end head (210) and an outer end head (220). The outer end head (220) includes an opening (221) in the center for enclosing the inner end head (210), an outlet (224) and grooves (225) alongside surfaces radially adjacent the opening (221). The inner end head (210) has an opening (211) in the center, an inlet (213), grooves (212) in the opening (211) for enclosing an end portion of a compressor shaft and a flow path along an outer surface.

WO 2011/069909 A1

COMPRESSOR END HEAD HEATING ARRANGEMENT

TECHNICAL FIELD

[0001] Exemplary embodiments relate generally to compressors and, more specifically, to the provision of thermal barriers for ensuring the smooth operation of a compressor over a wide temperature range.

BACKGROUND

[0002] A compressor is a machine which increases the pressure of a compressible fluid, e.g., a gas, through the use of mechanical energy. Compressors are used in a number of different applications and in a large number of industrial processes, including power generation, natural gas liquification and other processes. Among the various types of compressors used in such processes and process plants are the so-called centrifugal compressors, in which the mechanical energy operates on gas input to the compressor by way of centrifugal acceleration, for example, by rotating a centrifugal impeller.

[0003] Centrifugal compressors can be fitted with a single impeller, i.e., a single stage configuration, or with a plurality of impellers in series, in which case they are frequently referred to as multistage compressors. Each of the stages of a centrifugal compressor typically includes an inlet conduit for gas to be compressed, an impeller which is capable of providing kinetic energy to the input gas and a diffuser which converts the kinetic energy of the gas leaving the impeller into pressure energy.

[0004] A multistage compressor 100 is illustrated in Figure 1. Compressor 100 includes a shaft 120 and a plurality of impellers 130. The shaft 120 and impellers 130 are included in a rotor assembly that is supported through bearings 190 and 190' and sealed to the outside through sealings 180 and 180'.

[0005] The multistage centrifugal compressor operates to take an input process gas from an inlet duct 160, to increase the process gas pressure through operation of the rotor assembly, and to subsequently expel the process gas through an outlet duct 170 at an output pressure which is higher than its input pressure. The process gas may, for example, be any one of carbon dioxide, hydrogen sulfide, butane, methane, ethane, propane, liquefied natural gas, or a combination thereof. Between the impellers 130 and the bearings 190 and 190', the sealings 180 and 180' are provided to prevent the process gas from flowing through to the bearings.

[0006] Each of the impellers 130 increases the pressure of the process gas. Each of the impellers 130 may be considered to be one stage of the multistage compressor 100. Additional stages, therefore, result in an increase in the ratio of output pressure to input pressure.

[0007] Compressors in oil and gas industries and power plants are operated with different gas temperatures. The temperature varies from cryogenic to very high temperature. The internal surfaces in boiled off gas application (BOG) compressors are subjected to cryogenic temperature while the outer surfaces of the compressor are exposed to atmospheric temperature. Due to the cryogenic temperature, thermal contraction occurs in the components. The contraction is not uniform due to variation in temperature on different parts. The non-uniform contraction reduces clearance and/or creates interference between the adjacent components and affects performance of the compressors. In BOG compressors, the differential thermal contraction between the sealings 180 and 180' (in general, mechanical seals or dry gas seal type or DGS), the end head 140 and 140' (which could also include heated seal carrier), the bearings 190 and 190' and the shaft 120 creates interference between them and affects normal operation of the compressor.

[0008] In order to remove or reduce thermal tension across the operating temperatures involved, dry gas seals 180 and 180' are encapsulated in heated seal carriers 140 and 140' that also act as thermal shields.

[0009] It would be desirable to minimize thermal tension and stress on the dry gas seal and the end head by introducing a thermal barrier around the DGS to ensure smooth operation of the BOG compressor.

2010330096 11 Feb 2016

[0009a] A reference herein to a patent document or other matter which is given as prior art is not to be taken as an admission that the document or matter was known or that the information it contains was part of the common general knowledge as at the priority date of any the claims.

SUMMARY

[0010] Systems and methods according to these exemplary embodiments provide radial and axial thermal barriers to minimize thermal tension and stress on a mechanical seal and an end head by introducing a thermal barrier around the mechanical seal to ensure smooth operation of the BOG compressor.

[0011] According to one aspect of the present invention, there is provided a compressor end head for providing a thermal barrier near a mechanical seal that includes an inner end head and an outer end head. The outer end head includes an opening in a center for enclosing the inner end head, an outlet and grooves alongside surfaces radially adjacent the opening. The inner end head has an opening in a center, an inlet, grooves in the opening for enclosing an end portion of a compressor shaft and a flow path along an outer surface.

[0012] Also described is a compressor end head for providing a thermal barrier near a mechanical seal that includes an inner end head and an outer end head. The inner head includes an opening in the center, an inlet, grooves in the opening for enclosing an end portion of a compressor shaft. The outer end head includes an opening in a center for enclosing the inner end head, an outlet, grooves alongside surfaces radially adjacent the opening, an inlet chamber connected to the inlet, an outlet chamber connected to the outlet and axial channels connecting the inlet chamber and the outlet chamber.

[0013] According to another aspect of the present invention, there is provided a compressor that includes a shaft, a plurality of impellers, an inner end head and an outer end head. The outer end head includes an opening in a center for enclosing the inner end head, an outlet and grooves along an inner surface and an outer surface radially adjacent the opening. The inner head has an opening in a center, an inlet, a plurality of grooves along a surface adjacent the opening for enclosing an end portion of the shaft and at least one flow path along radially outward surface.

[0013a] In some embodiments, the compressor includes a plurality of seals and the outer end head is adjacent the seals.

[0013b] Where the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components, or group thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The accompanying drawings illustrate exemplary embodiments, wherein:

[0015] FIG. 1 illustrates a multistage compressor;

[0016] FIG. 2 illustrates a dry gas seal end head according to exemplary embodiments;

[0017] FIGS. 3 and 4 illustrate a cut view of a dry gas seal end head according to exemplary embodiments;

[0018] FIGS. 5 and 6 illustrate inner and outer sides of an outer end head according to exemplary embodiments;

[0019] FIG. 7 illustrates a cut view of an outer end head according to exemplary embodiments;

[0020] FIGS. 8 and 9 illustrate internal and external cut views of an inner end head according to exemplary embodiments;

[0021] FIG. 10 illustrates an oil flow path in an inner end head according to exemplary embodiments;

[0022] FIG. 11 illustrates an oil flow path in an end head according to exemplary embodiments;

[0023] FIGS. 12 and 13 illustrate a cut view of a dry gas seal end head according to exemplary embodiments;

[0024] FIG. 14 illustrates a cut view of an outer end head according to exemplary embodiments; and

[0025] FIGS. 15 and 16 illustrate a cut view of an inner end head according to exemplary embodiments.

DETAILED DESCRIPTION

[0026] The following detailed description of the exemplary embodiments refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements. Also, the following detailed description does not limit the invention. Instead, the scope of the invention is defined by the appended claims.

[0027] In exemplary embodiments, interference between a mechanical seal and an end head is prevented by providing axial thermal barriers around the mechanical seal to ensure smooth operation of a BOG compressor.

[0028] For BOG applications, the mechanical seal (such as sealings 180 and 180' of FIG. 1) may include a dry gas seal encapsulated in a heated seal carrier as is known. The dry gas seal closes the compressor to seal the compressor from the outside.

[0029] A dry gas seal may be in contact with an end head 140 and 140' at the end of the compressor. Referring to FIG. 2, end head 200 may includes an inner end head 210 and an outer end head 220. Each or both of the end heads 210 and 220 may be circular or may be some other shape but are illustrated as being circular in exemplary embodiments. End head 200 may be formed by, for example, welding the inner end head and outer end heads 210 and 220 in some embodiments.

[0030] A circular or ring shaped outer end head 220 is illustrated in FIGS. 5 and 6. Outer end head 220 may include a circular opening 221 in the center within which inner end head 210 may be is circumferentially enclosed or fitted (as illustrated in FIG. 2).

[0031] Referring to FIG. 2, outer end head 220 includes a hot oil outlet 224 on an inner side surface 222. Outer end head 220 also includes a circular groove 225 surrounding the circular opening 221 where the inner end head 210 may be welded with the outer end head 220 to form the circumferential enclosure. Outer end head 220 may include grooves 225 along both side surfaces (i.e. inner side surface and outer side surfaces). Inner end head 210 includes a hot oil inlet 213.

[0032] Cut section views of the outer and inner surfaces of inner end head 210 are illustrated in FIGS. 8 and 9. Inner end head 210 includes a circular opening 211 in the center. As illustrated in FIG. 8, inner end head 210 includes a plurality of grooves 212 within the opening for facilitating the placement and sealing of the end portion of a compressor shaft.

[0033] The diameter of inner end head 210 may be approximately equal to the diameter of circular opening 221 of outer end head 220 in order to facilitate the enclosure of inner end head 210 within outer end head 220.

[0034] As illustrated in FIG. 9, inner end head 210 may also includes an oil flow path 214 along an outer surface. Flow path 214 may be a helical flow path. Flow path 214 along the outer surface may be formed between the grooves 212 which are on the inner surface of inner end head. That is, the helical path 214 on the outer surface may correspond to the raised portion of the inner surface of the inner end head between the grooves 212 (path 214 may be positioned on the outer surface corresponding to the raised portions between grooves 212 on the inner surface of the inner end head 210). In some embodiments, flow path 214 may correspond to the grooves 212. When the inner end head 210 is welded to outer end head 220, flow path 214 may provide a path for hot oil or gas to flow from inlet 213 to outlet 224.

[0035] End head 200 of FIGS. 3 and 4 illustrates a helical flow path 214 and hot oil or gas outlet 224. When viewed in conjunction with FIG. 2, hot oil or gas entering inlet 213 of inner end head 210 flows through helical flow path 214 to outlet 224 of outer end head 220.

[0036] The outer surface of inner end head 210 may includes the helical flow path 214 as described above and illustrated in FIG. 10. The flow path may be similar to a spiral path providing an axial thermal barrier as illustrated in FIG. 11. The flow path as described herein provides a thermal barrier between the end head and DGS.

[0037] In some embodiments, an additional thermal barrier may also be provided. Referring to FIG. 7, a hot oil/gas chamber 223 proximate the outer side surface of outer end head 220 (nearer to DGS) reduces the thermal differential further.

In this embodiment, oil in helical flow path 214 flows into chamber 223 and to outlet 224.

[0038] In order to prevent leakage from the helical flow path, a light interference fit may be made between the inner end head 210 and the outer end head 220 in some embodiments. The inner and outer end heads can also be bolted to the compressor housing in some embodiments.

[0039] In some embodiments, the helical flow path may be substituted with straight holes in the outer end head to provide heating to the inner end head so that inner end head and the dry gas seal can be maintained at required temperature to avoid interference between the dry gas seal and end head when the compressor handles or processes gas at cryogenic temperatures.

[0040] Referring to FIGS. 12 and 13, an end head 300 includes inner end head 310 and outer end head 320 (corresponding to inner end head 210 and outer end head 220 of end head 200 as described above). Inner end head 310 includes a hot oil inlet 313. Outer end head 320 includes hot oil outlet 324 and groove 325 for facilitating welding of inner end head 310 to outer end head 320. Outer end head also includes an inlet gas or oil chamber 326 and an outlet gas or oil chamber 327.

[0041] Chamber 326 is provided near the inner head hot oil inlet 313 for receiving the oil from inlet 313. A plurality of passages 328 in the outer end head 320 (illustrated in FIG. 14) facilitates oil flow from inlet chamber 326 to outlet chamber 327. Outlet chamber 327 is connected to oil outlet 324. In exemplary embodiments, there may be four passages (or channels or holes) 328.

[0042] Chambers 326 and 327 may be connected with each other via straight holes 328 in outer end head 320 in order to facilitate uniform hot oil flow along the axis of the inner end head 310.

[0043] Inner end head 310 may be in the form as illustrated in FIGS. 15 and 16. Inner end head 310 may also facilitate oil flow along its outer surface 315 from inlet 313 to outlet 324 of outer end head 320. Inner end head 310 may provide a labyrinth seal.

[0044] The term "inner side surface" of an outer end head (or the inner end head) as used herein may refer to the side of the end head that is facing an impeller (i.e. between an impeller and end of the shaft). The term "outer side surface" as used herein may refer to the side of the end head that is on a side not facing an impeller (i.e. side of the end head that faces toward the outside of the casing).

[0045] The outer surface of the outer end head is adjacent the mechanical seal.

The mechanical seal may be a dry gas seal (DGS). The inlet, the outlet, the chamber (of FIG. 7) and the flow path may be for hot oil or gas.

[0046] The inlet chamber 326 and the outlet chamber 327 provide a radial thermal barrier. Channels or passages 328 (of FIG. 12) may be axial channels and provide an axial thermal barrier.

[0047] Exemplary embodiments as described herein provide multiple advantages. A heating system according to exemplary embodiments provides a radial and axial thermal barrier. The thermal barrier reduces heat transfer between inlet and the zone surrounding the DGS leading to a smooth operation of the BOG compressor. The optimized flow path provides gradual change in temperature in radial and axial directions around the DGS and also reduces internal thermal stress. In addition, the heating system according to exemplary embodiments prevents interference between DGS and the end head. The system is simple and compact. The system also prevents interference and provides smooth operation of the BOG compressor at cryogenic temperatures.

[0048] Exemplary embodiments as described provide an axial thermal barrier or an axial and a radial thermal barrier for handling temperature gradients in boiled off gas applications. The end head may be bolted to the compressor. The inner and outer heads may also be interference fitted to form the end head.

[0049] The above-described exemplary embodiments are intended to be illustrative in all respects, rather than restrictive, of the present invention. Thus the present invention is capable of many variations in detailed implementation that can be derived from the description contained herein by a person skilled in the art. All such variations and modifications are considered to be within the scope and spirit of the present invention as defined by the following claims. No element, act, or instruction used in the description of the present application should be construed as critical or essential to the invention unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items.

2010330096 11 Feb 2016

The claims defining the invention are as follows:

1. A compressor end head for providing a thermal barrier to a mechanical seal, the end head comprising:

an inner end head having an opening in a center, an inlet, grooves in the opening for enclosing an end portion of a compressor shaft and a flow path along an outer surface; and

an outer end head having an opening in a center for enclosing the inner end head, an outlet and grooves alongside surfaces radially adjacent the opening.

2. The end head of claim 1, wherein the outer end head further comprises a chamber adjacent to the groove along an outer surface.

3. The end head of claim 1 or claim 2, wherein the outer surface of the outer end head is adjacent the mechanical seal.

4. The end head of any one of the preceding claims, wherein the mechanical seal is a dry gas seal (DGS).

5. The end head of any one of the preceding claims, wherein a diameter of the inner end head is approximately equal to a diameter of the opening in the center of the outer end head.

6. The end head of any one of the preceding claims, wherein the flow path on an outer surface of the inner end head corresponds to the grooves on an inner surface of the inner end head.

7. The end head of any one of the preceding claims, wherein the inlet, the outlet, the flow path and the chamber are for hot oil or gas.

8. The end head of any one of the preceding claims, wherein the flow path is connected to the inlet and the outlet.

9. The end head of any one of the preceding claims, wherein the flow path is a

2010330096 11 Feb 2016

helical flow path and provides at least an axial thermal barrier to the mechanical seal.

10. The end head of any one of the preceding claims, wherein the flow path provides a radial thermal barrier to the mechanical seal.

11. The end head of any one of the preceding claims, wherein the inner end head is welded to the outer end head along the grooves of the outer end head.

12. The end head of any one of the preceding claims further comprising:

an inlet chamber connected to the inlet, an outlet chamber connected to the outlet and axial channels connecting the inlet chamber and the outlet chamber.

13. The end head of claim 12, wherein the inlet chamber is connected to the inlet of the inner end head and the outlet chamber is connected to the outlet.

14. The end head of claim 12 or claim 13, wherein a heating substance flows from the inlet to the inlet chamber and from the inlet chamber to the outlet chamber via one of the channels.

15. A compressor comprising:

a shaft;

a plurality of impellers;

an inner end head having an opening in a center, an inlet, a plurality of grooves along a surface adjacent the opening for enclosing an end portion of the shaft and at least one flow path along a radially outward surface; and

an outer end head having an opening in a center for enclosing the inner end head, an outlet and grooves along an inner surface and an outer surface radially adjacent the opening.

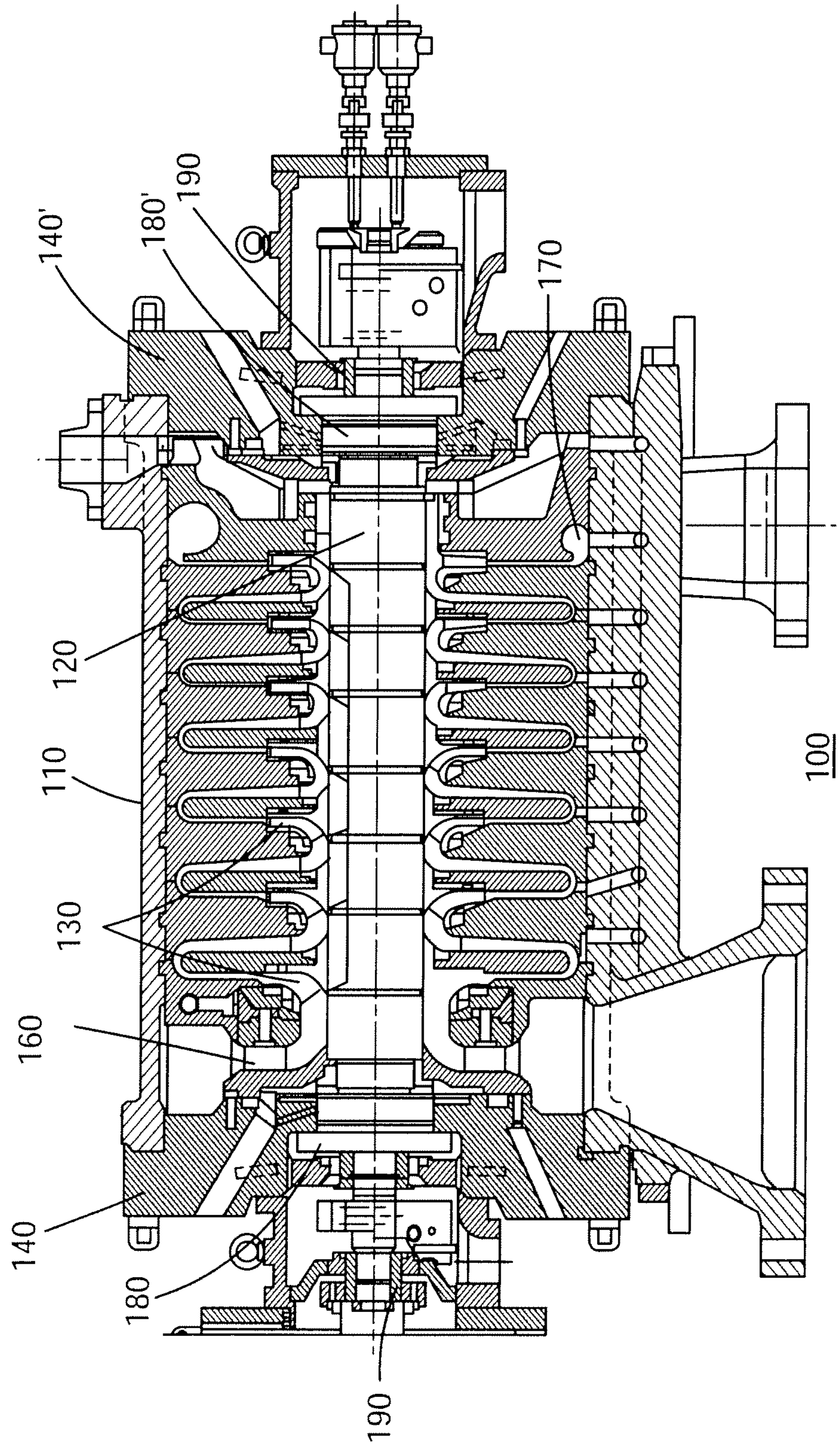


FIG. 1
Background Art

FIG. 2

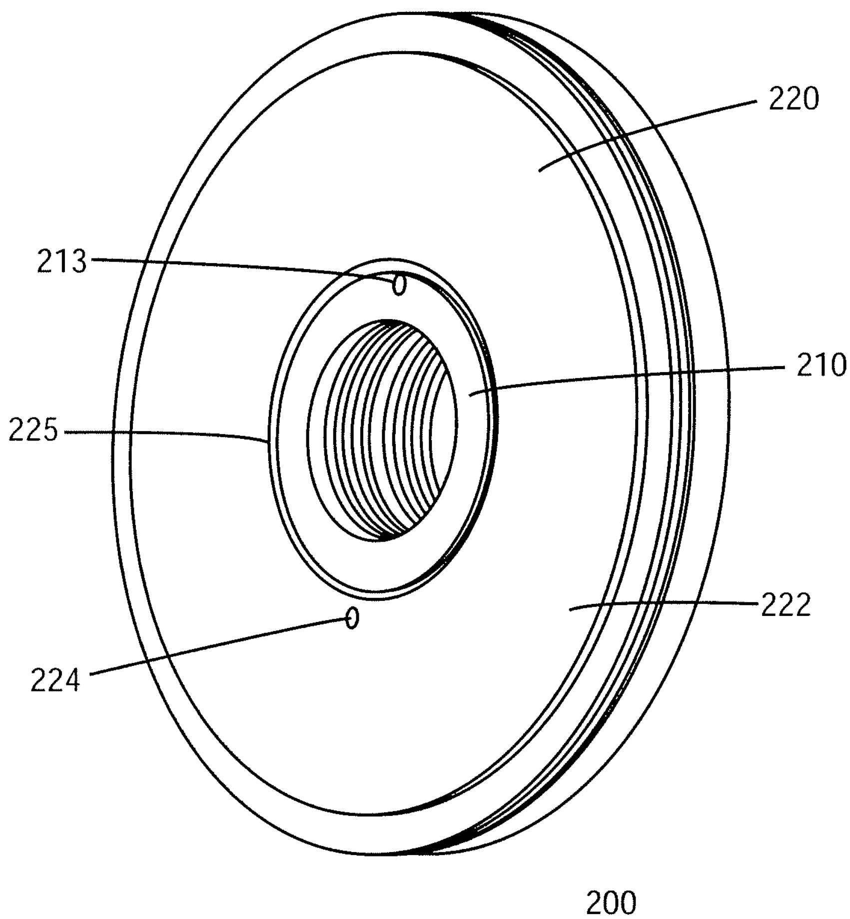


FIG. 4

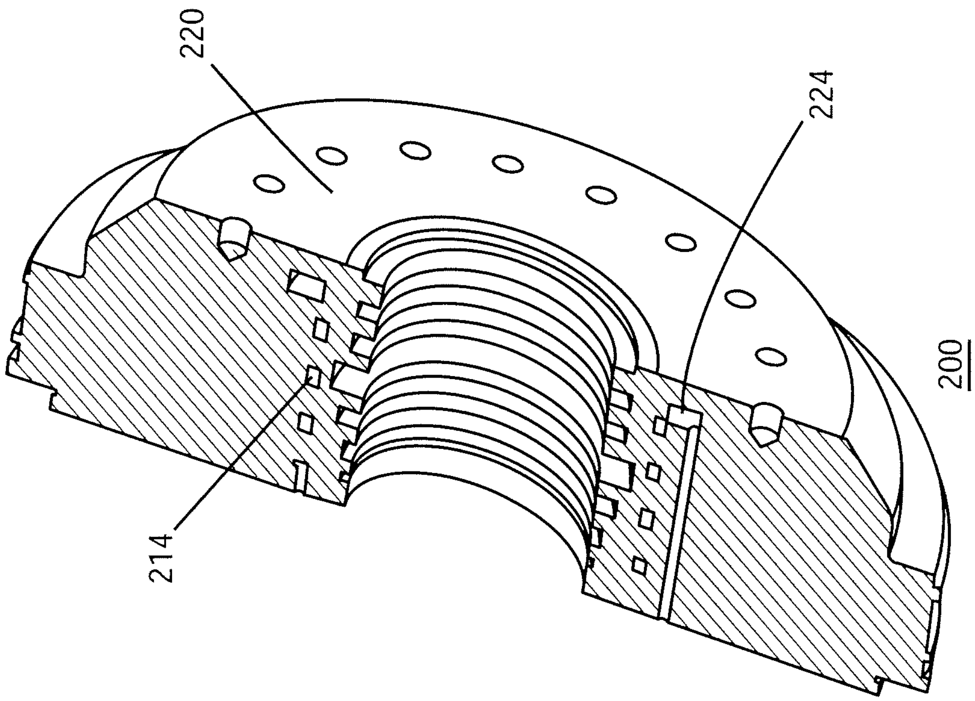
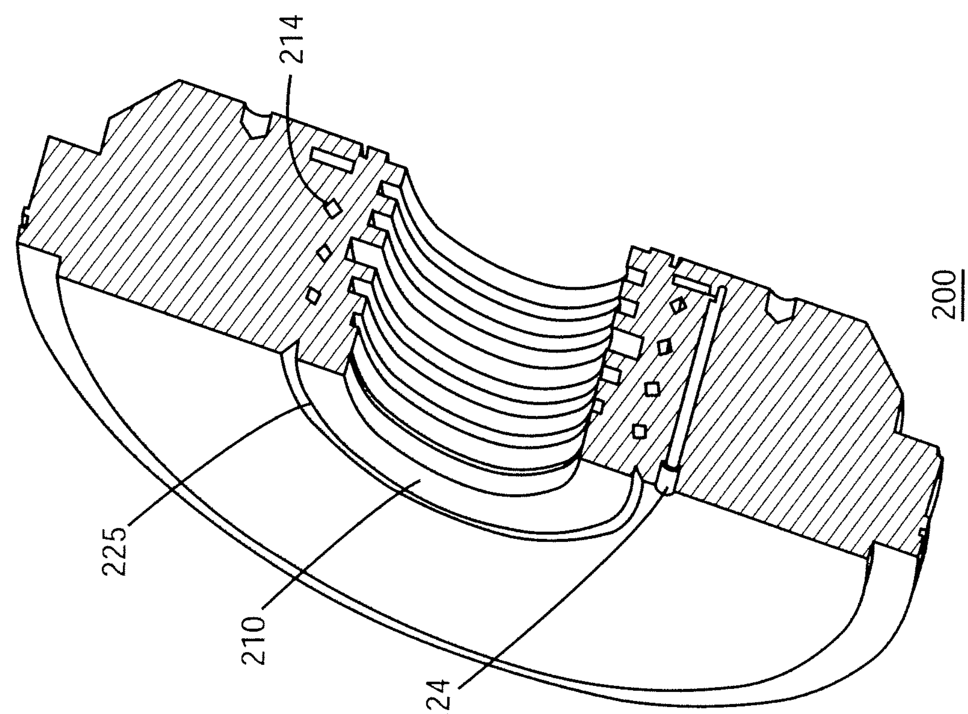


FIG. 3



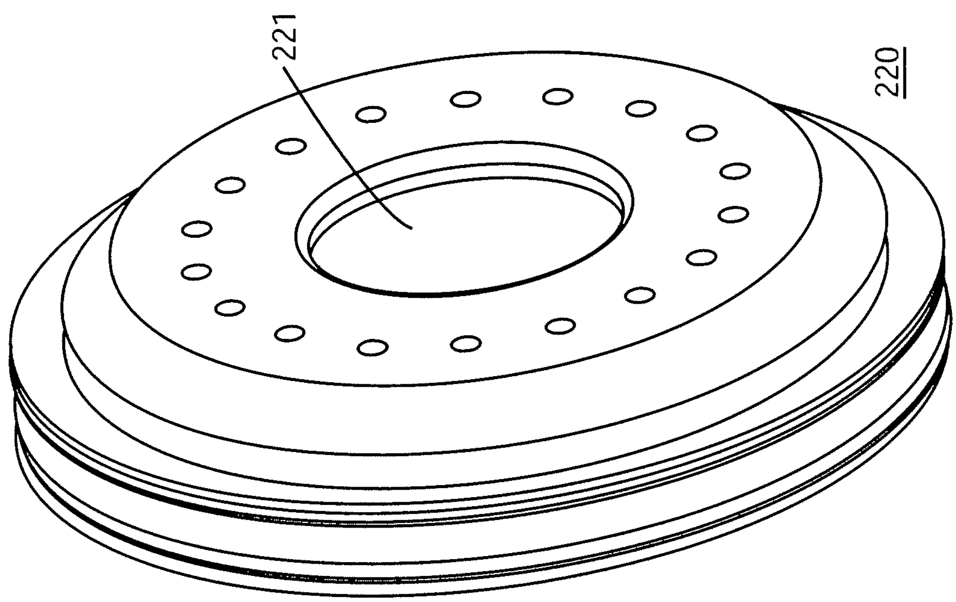


FIG. 6

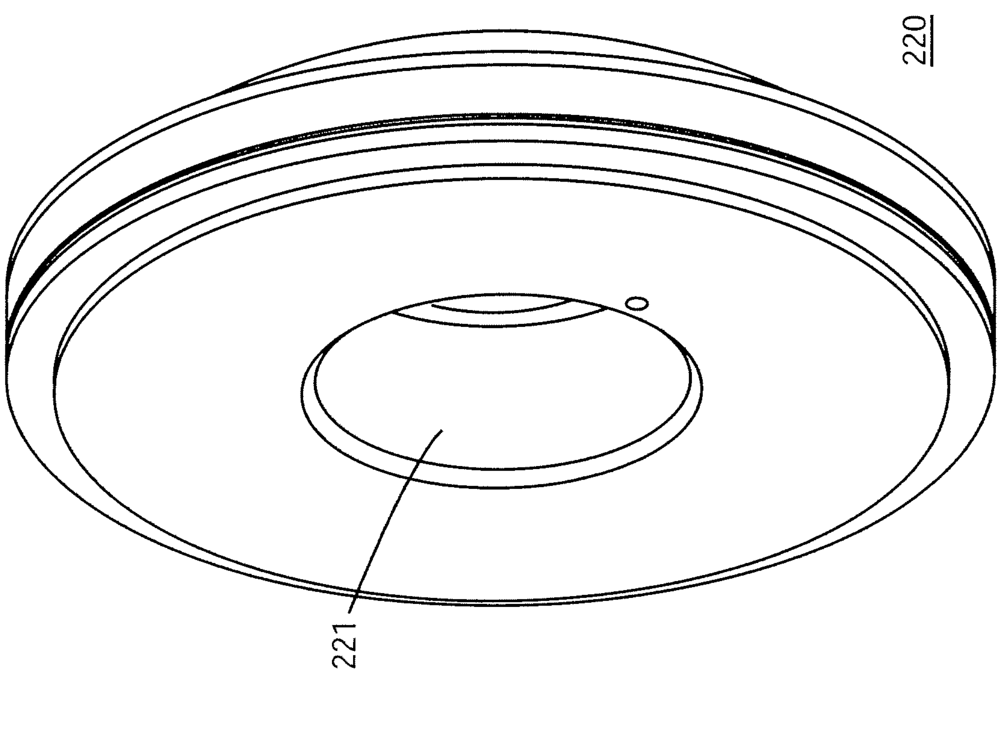
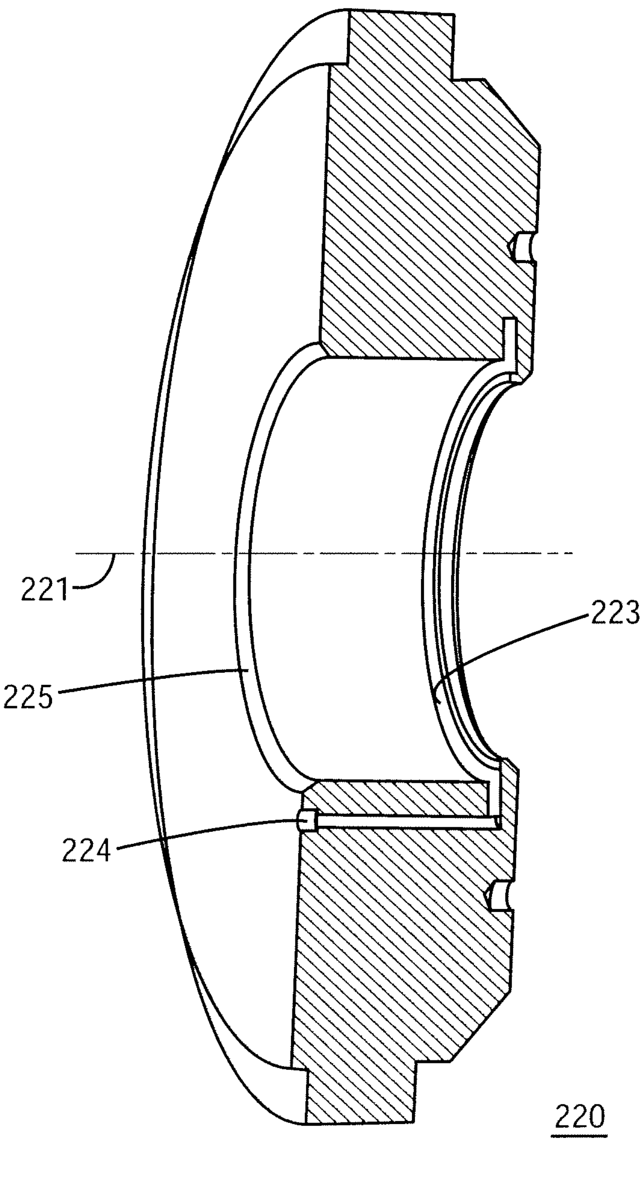


FIG. 5

FIG. 7



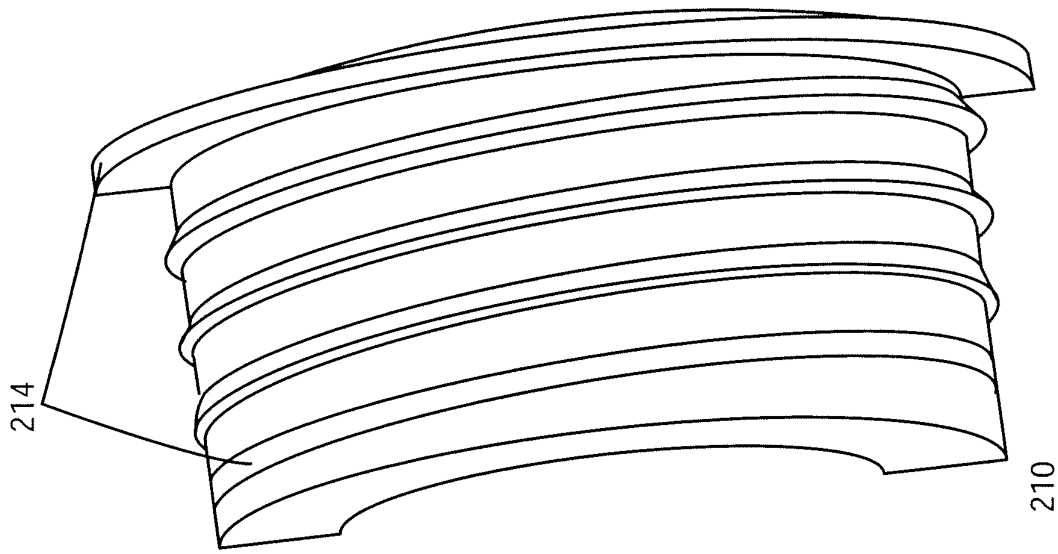


FIG. 9

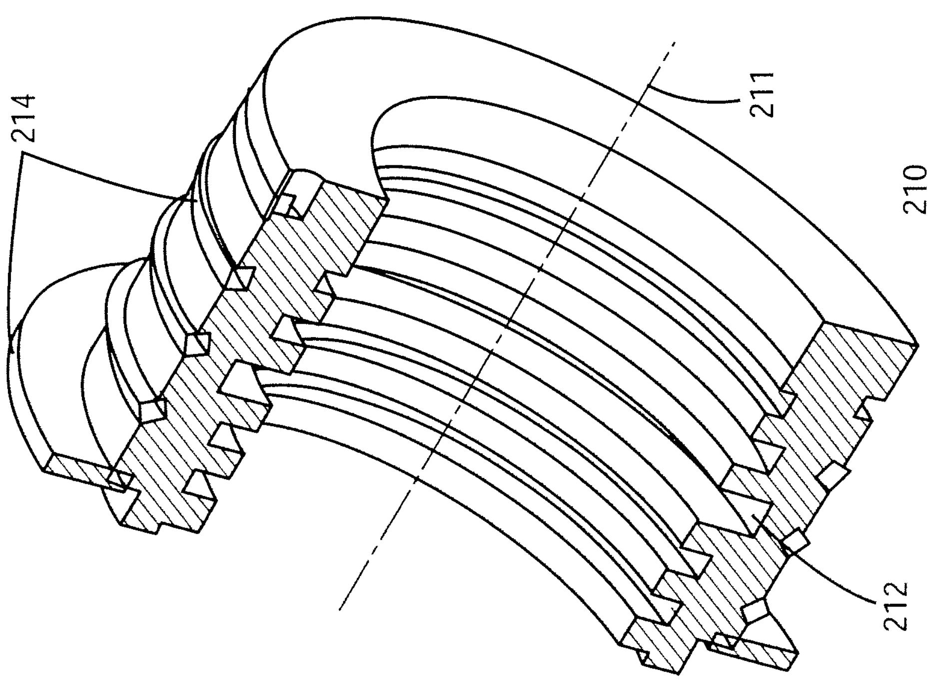


FIG. 8

FIG. 11

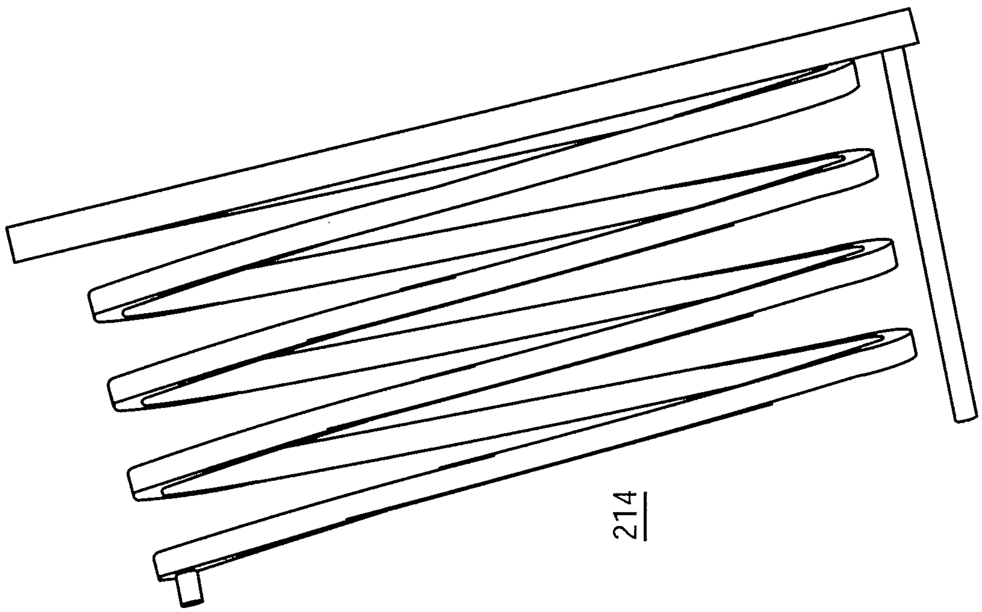


FIG. 10

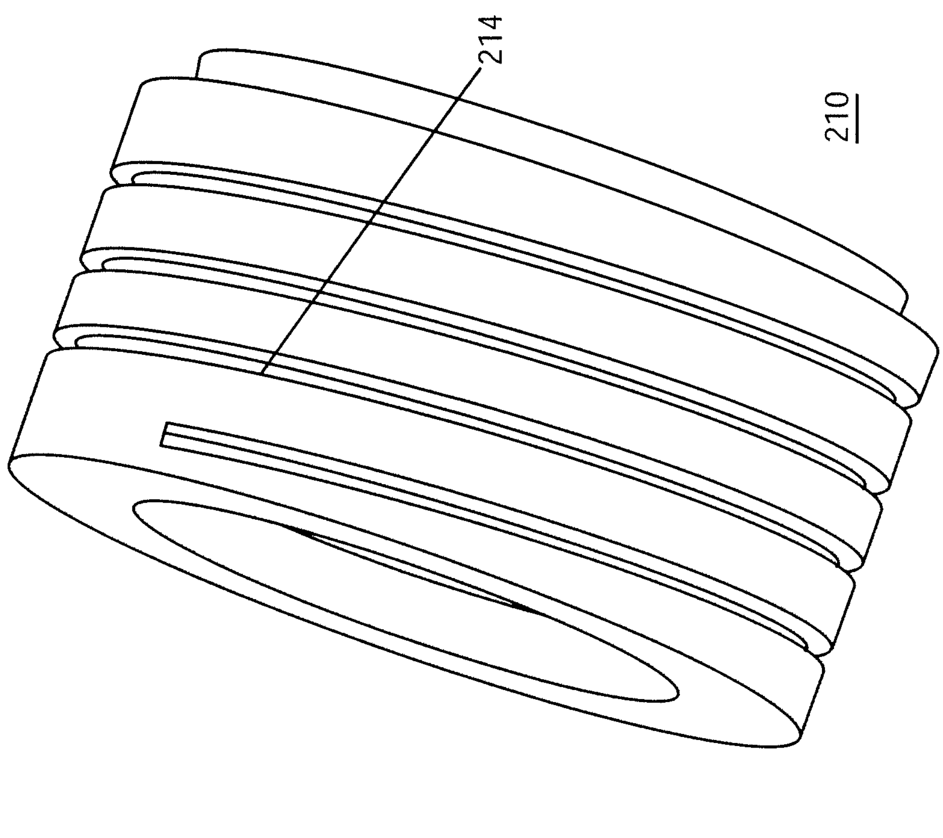


FIG. 13

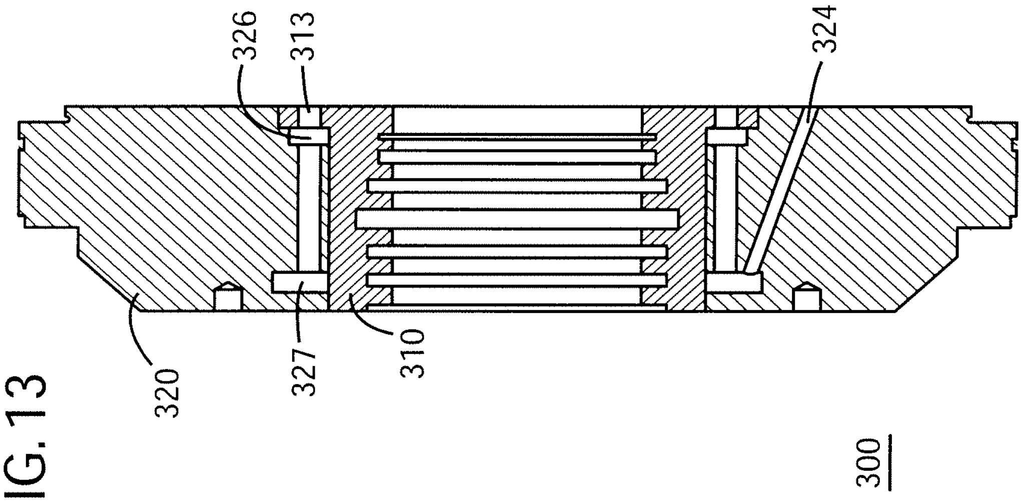


FIG. 12

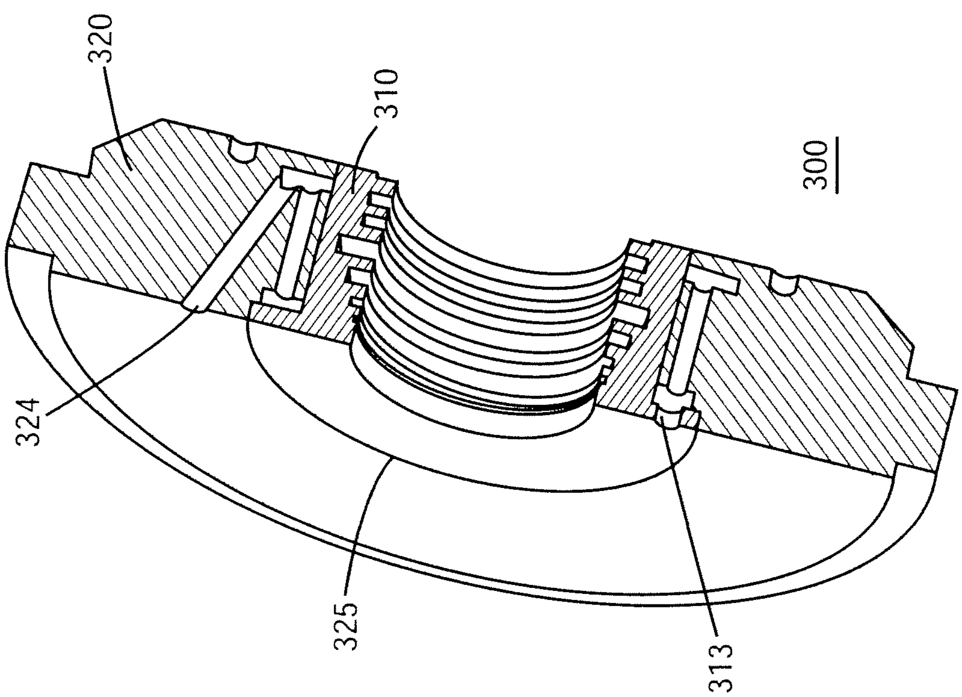


FIG. 14

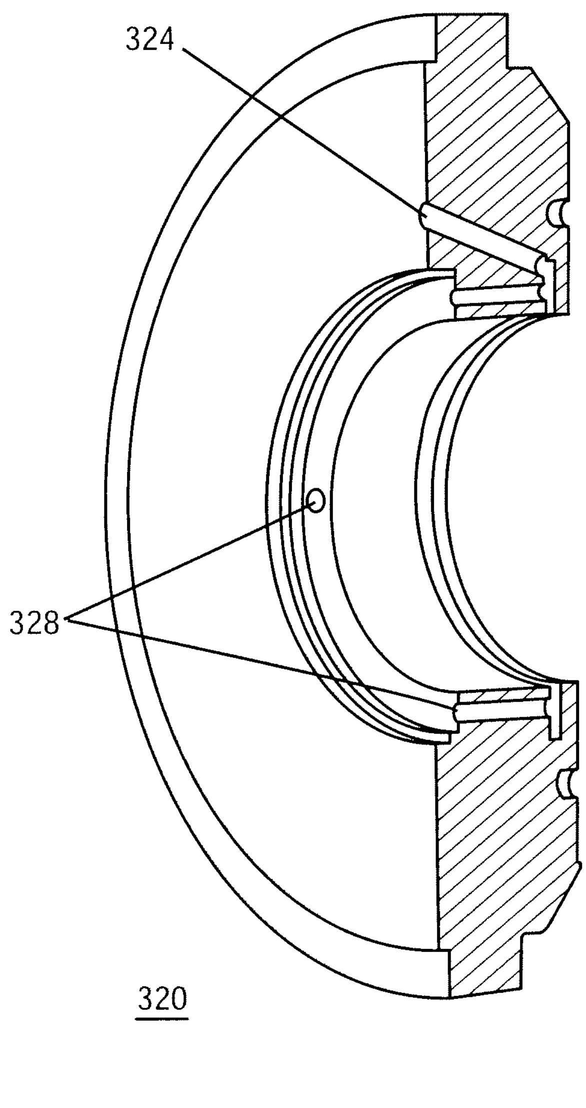


FIG. 16

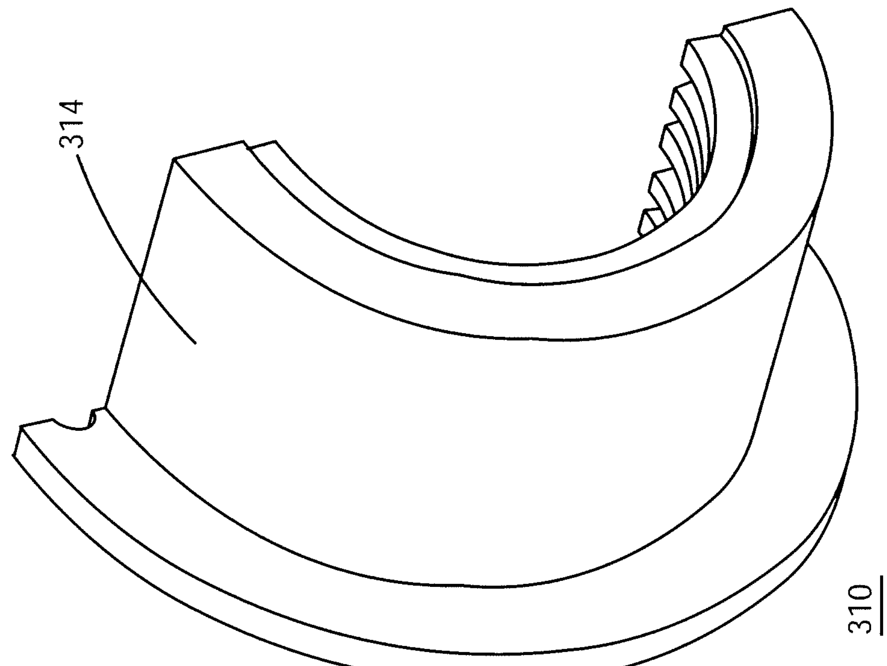


FIG. 15