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(54) **Scroll fluid displacement machine**

(57) A scroll fluid displacement machine that produces thrust loads during operation such as an oil-less compressor, includes a housing (14), a scroll (12) fixed to the housing and having an involute (16), an orbiting scroll (20) having an involute (22) interengaging the other involute and mounted on an eccentric drive shaft (42). The drive shaft (42) moves the orbiting scroll member through a predetermined path relative to the fixed scroll and the machine includes a bearing (60a,b) for supporting the orbiting scroll and counteracting axial thrust present during operation of the machine. The bearing (60a,b) is mounted at one end of the drive shaft (42). The machine incorporates means for achieving a desired alignment and clearance between the two involutes (16,22).

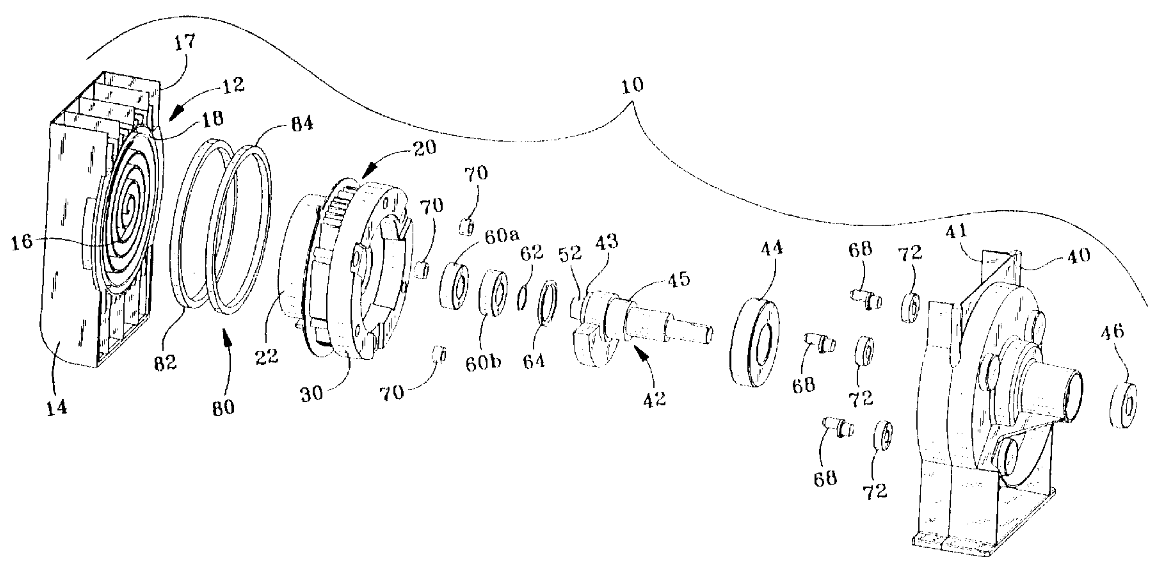

FIG. 1

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Description

This invention relates to scroll type fluid displacement machines and more particularly to means for adjusting the operating clearance and parallelism between fixed and orbiting scrolls and also to means for counteracting thrust and radial loadings present during operation of the machine.

Scroll fluid displacement machines, such as scroll compressors for example, include a fixed scroll with a fixed spiral or involute mounted on the fixed scroll and an orbiting scroll having a spiral or involute that is movable in a circular path relative to the fixed scroll by an eccentric drive shaft. The involute of the orbiting scroll is adapted to interengage with the fixed involute as it is moved along the circular path, thereby to form spiral regions of limited extent which move radially inwardly or outwardly.

As a volume of fluid, such as air, is compressed or expanded by movement through the spiral regions of limited extent, radially and axially directed pressure loadings are produced. The bearings in conventional oil-less scroll-type machines are arranged to counteract the radial and thrust loadings. In conventional lubricated scroll machines, bearings do not counteract thrust and radial loadings, rather, such loadings are counteracted by an oldham ring. Conventional bearing arrangements for oil-less scroll machines include a central needle bearing which is mounted on the eccentric drive shaft to support one end of the eccentric drive shaft and to transmit drive torque to the orbiting scroll. Additionally, conventional oil-less scroll machines commonly include six sets of grease filled angular contact bearings along the outer periphery of the orbiting scroll. These grease filled bearings are used to counteract the pressure loadings present during expansion and compression of the fluid and also to support the rotation of guide shafts to create the required orbital motion of the orbiting scroll. Incorporating such a large number of grease filled bearings in the scroll machine design significantly increases the manufacturing cost of the scroll machine.

In addition to counteracting the pressure loads present during operation of the machine, other variables that must be considered in order to maximise the efficiency of scroll-type fluid displacement machine are the clearance and parallelism between the orbiting and fixed involutes. If the clearance between the involutes is too large, the fluid will leak from between the involutes, resulting in an increase in the power consumption by the scroll machine, a reduction in the machine capacity, and potentially, an overall reduction in the life of the bearings. If the clearance between the orbiting and fixed involutes is reduced to zero, or the required parallelism between the involutes is not achieved, the orbiting involute will engage the fixed involute as it is moved during operation, and by this engagement will likely cause significant damage to the machine.

In order to prevent damage to the scroll machine and maximise machine efficiency, oil-less scroll-type displacement machines include an adjustment assembly for setting the clearance between the fixed and orbiting involutes and achieving the required parallelism therebetween. Such a required adjustment assembly is complex in design, includes a large number of discrete parts and increases the manufacturing and overall costs associated with the scroll machine. However, even using conventional adjustment assemblies, alignment between the scroll involutes is difficult to achieve, is a very time consuming step in the assembly of scroll machines, and requires that a large degree of precision be exercised by the technician assembling the machine. The high degree of precision required can result in frequent assembly errors. The fact that the step is time consuming and requires such a complex adjustment device is due in large part to the arrangement of bearings used in conventional oil-less scroll machines.

In summary, conventional adjustment assemblies and bearing arrangements in scroll machines increase manufacturing costs of the scroll machines and do not enable a technician to simply establish the required clearance and the required parallelism between involutes.

Preferably, the means for achieving the desired clearance between the involutes is comprised of a shim sandwiched between the eccentric drive shaft and the bearing, and the means for achieving the alignment between the scroll involutes comprises a back up ring and thrust seal located in a groove formed on the fixed scroll, along the outer periphery of the first involute.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is an exploded isometric view of a first embodiment scroll compressor;

Figure 2 is a sectional view of the assembled scroll compressor of Figure 1 that includes at least one angular contact bearing adapted to counteract thrust loading during operation;

Figure 3 is an enlarged view of a portion of the scroll compressor illustrated in Figure 2;

Figure 4 is a sectional view like the sectional view of Figure 2 showing a second embodiment;

Figure 5 is a sectional view like the sectional view of Figure 2, showing a third embodiment scroll compressor; and

Figure 6 is a sectional view taken along line 6--6 of Figure 5 showing the alignment means of the third embodiment.

Referring to the drawings, wherein similar reference characters designate corresponding parts throughout the several views, Figures 1, 2, and 3 generally illustrate a first embodiment scroll machine 10. For purposes of describing the preferred embodiments, the scroll machine described will be an oil-less scroll compressor. However, the scroll machine 10 may be any scroll-type machine including, but not limited to, a scroll motor for a tool, a scroll pump, a scroll compressor or any other apparatus that conveys a volume of fluid in the general manner described hereinafter.

The scroll compressor 10 compresses a fluid in a known manner and includes a number of features and components which are also known. The known features of compressor 10 and the operation thereof are shown and described in US-A-5,391,065.

The scroll compressor 10 includes a first fixed scroll 12 formed in a compressor housing 14. As shown in Figures 1 and 2, the first scroll includes a first wrap or involute 16. A groove 18 is formed in the fixed scroll 12 adjacent the outer periphery of the first involute 16 and extends completely around the involute 16. The groove forms an opening along face 19 of the fixed scroll 12.

The compressor 10 also includes an orbiting scroll 20 that has a second wrap or involute 22 made integral with the scroll along scroll face 23. The second involute is adapted to interengage with the first involute in a known manner. The entirety of the orbiting scroll moves along a predetermined circular path but does not rotate as it moves. During operation of the scroll compressor 10, as the orbiting scroll is moved along the predetermined circular path relative to the fixed scroll, the orbiting scroll 20 and fixed scroll 12 interengage to form spiral regions of limited extent which move radially inwardly, thereby compressing a volume of fluid such as air.

As shown in Figure 3, the orbiting scroll 20 includes a recess 24 provided along the orbiting scroll opposite the second involute 22 and forms an opening along the face 25. When the compressor 10 is assembled and includes the present construction, the faces 19 and 23 are separated by a predetermined acceptable distance thereby achieving the desired clearance between the involutes of the scroll members.

A carrier 30 is joined to the orbiting scroll along the face 25 by conventional connection means such as a threaded fastener, such as a bolt or the like. The connection means is generally identified as 32 in Figures 2 and 3. The carrier includes an integral hub 34 that is closed at one end. The hub defines a cavity 35 and includes an annular bearing shoulder 36 located in the cavity adjacent the closed end of the hub. A seat 38 for a seal member 64 is provided at the open end of the hub.

A housing section 40 supports an eccentric drive shaft 42 which in turn is supported by bearings 44 and 46 which are conventional radial ball bearings. Other bearings and bearing arrangements may be used. For example, the bearings also both may be tapered, angular contact or needle bearings or may be any combination of radial, tapered, needle or angular contact bearings. The eccentric shaft has at least one step 43, a shaft stem 52, and a drive end 48. A pulley or gear (neither shown) or other member which is adapted to be connected to a prime mover such as an electric motor may be mounted along the drive shaft 42 at the shaft drive end. The prime mover, which is not shown, produces the required rotation of the shaft 42 about axis 50. The eccentric drive shaft stem 52 is operably connected to the orbiting scroll 20 to drive the orbiting scroll along a predetermined circular path. As shown most clearly in Figure 2, the carrier 30 is adapted to receive stem 52, step 43 and a portion of drive shaft 42.

In order to achieve the desired displacement of the orbiting scroll 20 along the predetermined circular path with respect to fixed scroll 16 without rotating, at least one passive eccentric guide shaft assembly 66 is employed. The rotation of the orbiting scroll is inhibited by the or each guide shaft assembly 66 and as a result, the controlled movement of the orbiting scroll along the predetermined circular path is achieved.

The or each guide shaft assembly executes eccentric rotations corresponding to the eccentricity of the eccentric drive shaft 42 through use of an eccentric guide shaft 68. The eccentric guide shaft 68 is supported at the ends by bearings 70 and 72 which in turn are supported in the carrier 30 and housing 40 respectively. In the first embodiment, bearing 70 is a needle bearing and bearing 72 is a radial ball bearing. The bearings counteract radial loadings during operation of the scroll compressor 10. In the first embodiment, three like eccentric guide shaft assemblies 66 are provided and are arranged symmetrically around the eccentric guide shaft 42 each being separated from the next adjacent assembly by approximately 120° as illustrated in Figure 1.

The scroll compressor 10 allows for angular compliant alignment between the fixed involute walls and orbiting scroll involute walls thus the potential for damage to the machine is reduced.

Turning now to Figure 3, the shaft stem 52 is supported by first and second bearings 60a and 60b which in turn are mounted side-by-side along the stem. The bearings and stem are located in the hub cavity 35, with one side of the bearing 60a located against the shoulder 36. A shaft seal 64 is mounted on the eccentric drive shaft 42 at a location along the shaft step 43. The seal 64 sealingly abuts seat 38 when the bearings 60a and 60b and stem 52 are located in cavity 35. In this way, the seal 64 prevents bearing lubricant from leaking out of cavity 35 and also prevents dirt and other undesirable matter from entering the cavity and damaging the bearings 60a and 60b.

Centrally located bearings 60a and 60b are both angular contact bearings and the bearings counteract thrust and radial loadings present during operation of the compressor 10. For purposes of disclosing the first embodiment, two bearings are disclosed in a side-by-side arrangement; however, any suitable number of bearings may be used. Since the angular contact bearings 60a and 60b counteract thrust and radial loadings, the radial ball and needle bearings 70 and 72 previously described above, may be used in the guide shaft assemblies 66. Additionally, since the thrust loadings are counteracted by the bearings 60a and 60b rather than by the guide shaft assembly bearings, it is contemplated that only one guide shaft assembly may be used. By this bearing arrangement manufacturing costs are reduced. Counteracting thrust pressure loadings at centrally located angle bearings is different than conventional oil-less scroll bearing arrangements which counteract thrust loadings along the outer periphery of the orbiting scroll.

A shim 62 is sandwiched between the bearing 60b and shaft step 43 as shown in Figure 3. The shim serves to locate the orbiting scroll 20 along the axis 50 relative to the housing 14 so that the faces 19 and 23 are separated by a predetermined acceptable distance. The shim is preferably made from a steel or alloy steel material. As a result of separating faces 19 and 23 by the acceptable distance, proper clearance between the fixed and orbiting involute faces is achieved. In order to accommodate variations in the dimensions of orbiting and fixed scrolls and still achieve the required predetermined acceptable separation distance the thickness of the shim may be increased or decreased to increase or decrease the separation distance between the faces 19 and 23. Using the proper thickness shim, the distance between the face 23 and face 19 will be within tolerance and the required clearance between the involutes will be achieved. Thus the shim represents a means for adjusting the location of the orbit along axis 50 and, in part it replaces more complicated adjustment assemblies of conventional scroll machines.

Generally, the shim may be located between two components of the compressor 10 to produce the required separation distance between the faces 23 and 19. In addition to the location between the bearing 60b and shaft step 43, the shim member 62 may be located between the face 17 of the housing 14 and the face 41 of the housing section 40; between the back of the housing 40 and bearing 44; between the bearings 60a and 60b; and between the bearing 60a and the closed side of the hub 34.

The compressor 10 includes alignment means 80 which is comprised of a back up ring 82 and thrust seal 84. Together the thrust seal and back up ring achieve the required parallelism and angular alignment between the fixed and orbiting scroll members.

The back up ring 82 is located in the groove 18 and is positioned between the closed side of the groove and the thrust seal 84 and counteracts the pressure moment created by gas loading - see Figure 2. The back up ring 82 and thrust seal 84 create the alignment force to maintain the scrolls in proper parallelism.

The back up ring member 82 is preferably made from either Neoprene, Viton ® (Viton is a registered trademark of E.I. Dupont), or rubber and the preferred material has a low spring rate. (A spring rate of about 0.09 lb/mm/mm - 0.040824 kg/mm/mm - is preferred.) The preferred thrust seal member should have a relatively low coefficient of wear. The preferred thrust seal has a coefficient of wear of about 6 x 10^{-10} in^3 min/lb•ft hr (0.12 x 10^{-3} mm^3/N.Km) and is made from material known as Torlon (a registered trademark of the Amoco Corporation).

The alignment means comprising the combination thrust seal and backup ring serves dynamically to align the orbit and housing and therefore eliminates the need for complex adjustment assemblies typically included in conventional oil-less scroll machines. Using the angular contact bearings allows the orbit to align axially with the fixed involute using the loading of the thrust seal and back up ring. The assembly of the compressor is simplified; therefore, assembly costs are minimised by using the angular contact bearings, shims and alignment means.

Figure 4 discloses a second embodiment in which the scroll compressor generally referred to as 100 in Figure 4 operates in the same manner as first embodiment machine 10 and includes the housing 14 and 40, scroll members 12 and 20, alignment means 80 comprised of back up ring 82 and thrust seal 84, carrier 30 with hub 34, hub cavity 35, shoulder 36, eccentric drive 42, seal 64, shim 62 and at least one guide assembly 66.

In addition to these components, the scroll compressor 100 includes a spherical bearing 102 that is located in the cavity 35 of the hub 34 with one side of the bearing 102 located against bearing shoulder 36. The shim 62 is sandwiched between the opposite side of the bearing 102 and step 43 in the same way as the shim is sandwiched between the bearing 60b and the step as described for the first embodiment.

The spherical bearing counteracts thrust and radial loadings during operation of the compressor 100. The bearing 102 compensates misalignment between the scrolls 12 and 20. As a result of the use of the centrally located spherical bearing 102, bearings 70 and 72 are used to support the guide shaft assembly 66. Therefore, in the same way that first embodiment compressor 10 reduced manufacturing costs by simplifying assembly of the machine and eliminating angular contact bearings along the outer periphery of the carrier, assembly of the compressor 100 is simplified and as a result manufacturing costs are reduced.

Both the first and second embodiment compressors are less sensitive to misalignment over time due to the effects of temperature.

Figures 5 and 6 disclose a third embodiment of the scroll machine 200, which operates in the same manner as machines 10 and 100. The third embodiment scroll machine or compressor 200 includes a fixed scroll 210 with first involute 211 and an orbiting scroll 212 with second involute 213 where the involutes 211 and 213 are adapted to interengage in the manner previously described.

The third embodiment also includes a carrier 214, like the carrier 30 that is joined to the orbiting scroll 212 by conventional connection means 215. A centrally located carrier hub 216 having a closed side and an open side defines a cavity 217. Annular grooves are provided along the interior of the hub and the grooves are adapted to receive conventional seal members.

The compressor 200 includes an eccentric drive shaft 222 having a shaft stem 224. Eccentric guide shaft assemblies 220 are also provided to produce the required motion of the orbiting scroll along a predetermined circular path. At least one guide shaft assembly is required. Bearings 226 and 227 support the eccentric drive and are located in a compressor housing 228.

Bearings 230a and 230b are located along the length of the shaft stem 224 and are angular contact bearings like the bearings 60a and 60b described above. The bearings are mounted on the shaft stem in a side-by-side arrangement and the assembled stem and bearings are located in cavity 217 of the hub 216 with the outer periphery of the bearings in sealing engagement with seals and one side of the bearing 230a located against a thrust spring 240 as shown in Figure 5. The thrust spring may be a bellville washer for example and is set between the orbiting scroll and bearing 230a. Although two angular contact bearings are used, it should be understood that one or any suitable number of bearings may be used. The combination of bearings 230a and 230b and thrust spring counteract thrust loadings that are present during operation of the scroll compressor.

Alignment means 250 for achieving the required alignment between the first and second involutes is comprised of alignment plate 252 and three adjustment screws 254 - see Figure 6. The alignment plate is located against one side of the bearing 230b and is mounted on the shaft and is supported on the shaft by a bearing sleeve member 255. An alignment means access opening for each screw is provided in housing 228 and accommodates access to the alignment means. Each access opening is closed by plug member 256 when access to the alignment bolt is not required.

After the machine 200 is assembled, conventional gauges or other means are used to measure the alignment between the scrolls. If the scrolls are determined to be misaligned, the plugs 256 are removed and the screws 256 are tightened against the plate 254 or loosened to move the orbiting scroll and thereby achieve the required alignment between the first and second involutes.

Claims

1. A scroll fluid displacement machine which produces axial thrust during operation, the machine comprising:

   a) a housing (14);

   b) a fixed scroll (12) fixed to the housing, the fixed scroll having a first involute (16);

   c) an orbiting scroll (20) having a second involute (22) adapted to interengage the first involute (16),

   d) an eccentric drive shaft (42), the orbiting scroll (20) being mounted along the length of the drive shaft, said drive shaft (42) being for moving the orbiting scroll (20) member through a predetermined path relative to the fixed scroll (12); and

   e) a first bearing means (60a, 60b) for supporting the orbiting scroll and counteracting the axial thrust during operation of the fluid displacement machine, said first bearing being mounted at one end of the drive shaft (42); characterised by:-

   f) means for achieving a desired alignment and clearance between the first and second involutes (16, 22).

2. A machine according to claim 1, wherein the first bearing means is at least one angular contact bearing (60a, 60b).

3. A machine according to claim 2, wherein there are two angular contact bearings (60a, 60b) located side-by-side.

4. A machine according to claim 1, wherein the first bearing means comprises a spherical bearing.

5. A machine according to any one of the preceding claims, and further including a carrier (30) having a hub (34), which defines a cavity (35) and also having a bearing seat (36) located in the cavity, said bearing means being located in said cavity.

6. A machine according to claim 5, wherein the alignment means comprises an alignment plate (252) mounted on the eccentric drive shaft (255) and mounting means (254).

7. A machine according to claim 6, wherein the machine includes a thrust spring (240) located in said cavity (35) between one side of said hub (34) and said first bearing means (60a, b), said mounting means (254) for said alignment plate being adapted to be connected to the carrier (30).

8. A machine according to claim 7, wherein the thrust spring is a bellville washer and said mounting means comprises three screws (254).

9. A machine according to any one of the preceding claims, wherein said first involute (16) has an outer periphery and wherein said fixed scroll (12) includes

a groove (18) adjacent the outer periphery, said alignment means comprising a backup ring (82) and thrust seal member (84) located in said groove.

10. A machine according to any one of the preceding claims, wherein the means for achieving the desired clearance comprises a shim member (62) sandwiched between the bearing means (60a, b) and the eccentric drive shaft (42).

11. A scroll fluid displacement machine according to any one of the preceding claims, wherein the machine is a compressor.

12. A machine according to claim 11, wherein said compressor is an oil-less scroll compressor.

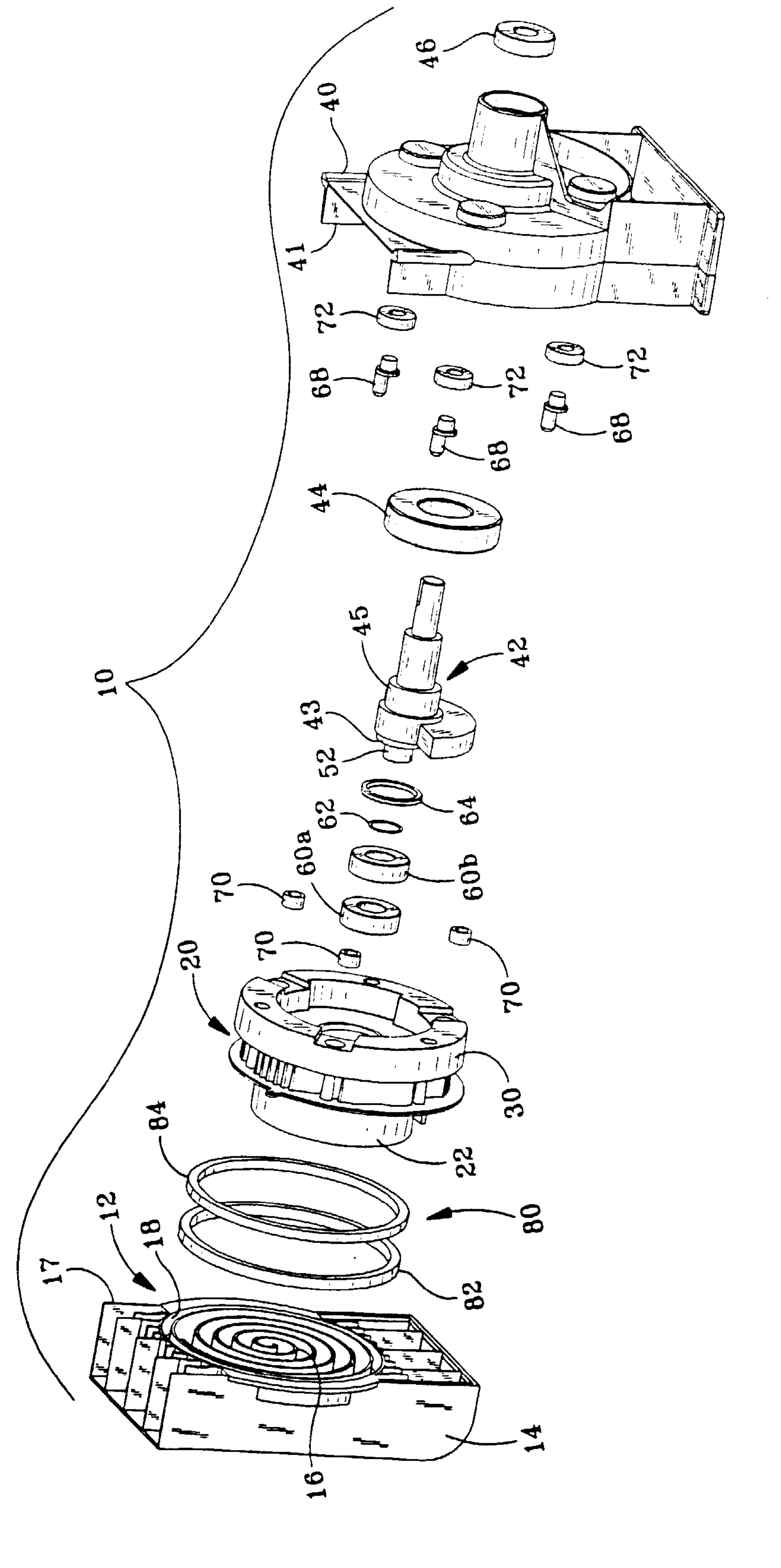
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FIG. 1

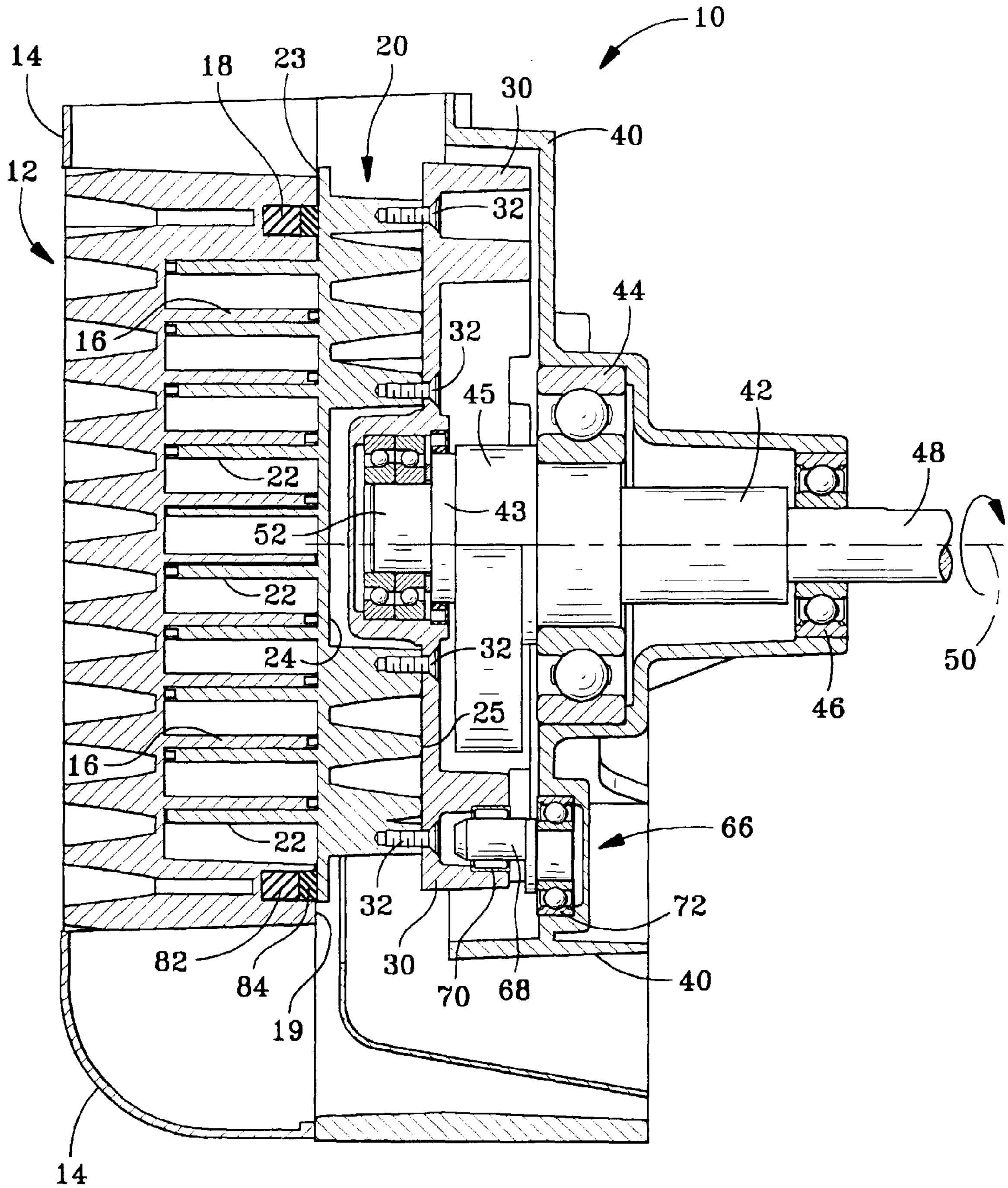
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FIG. 2

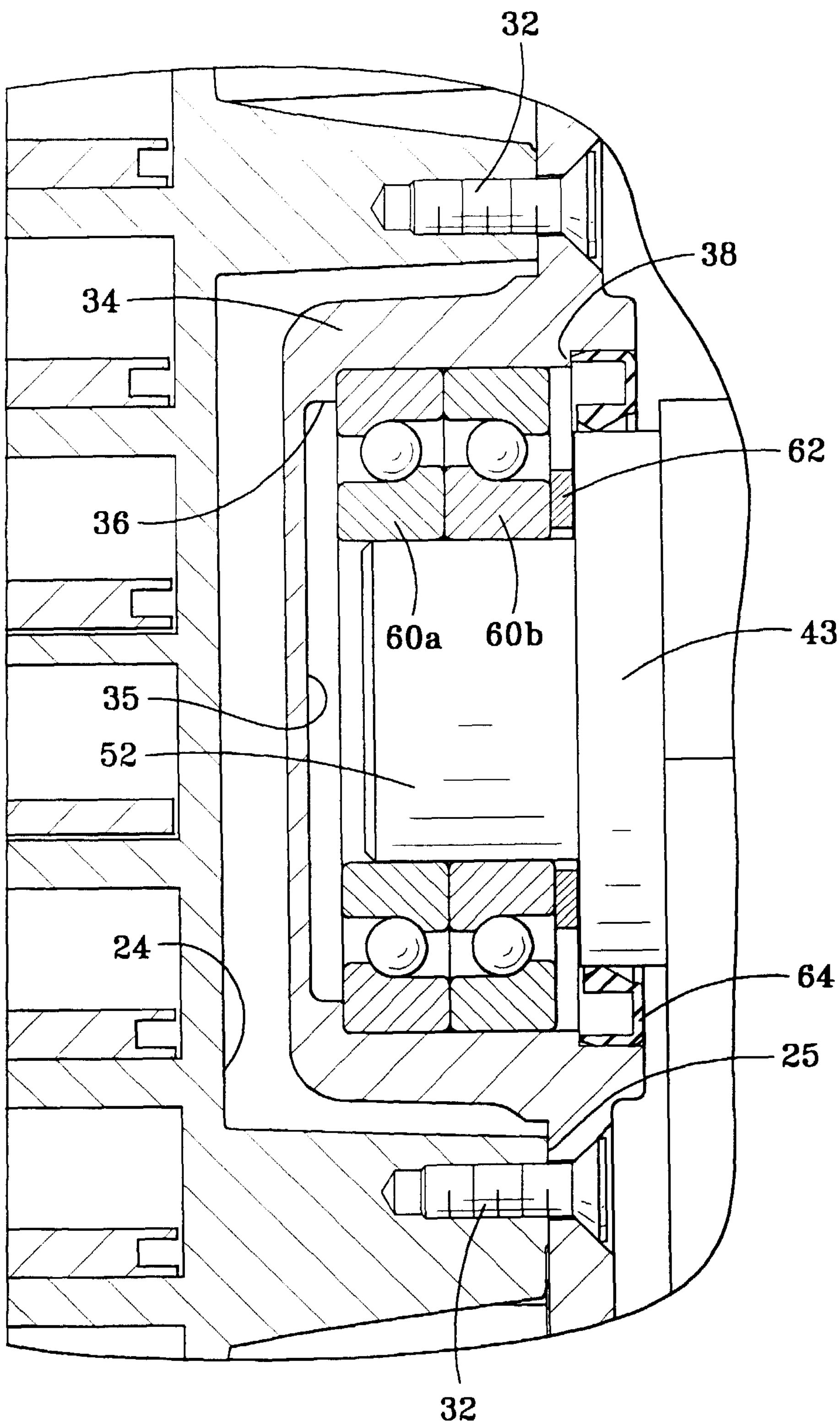

FIG. 3

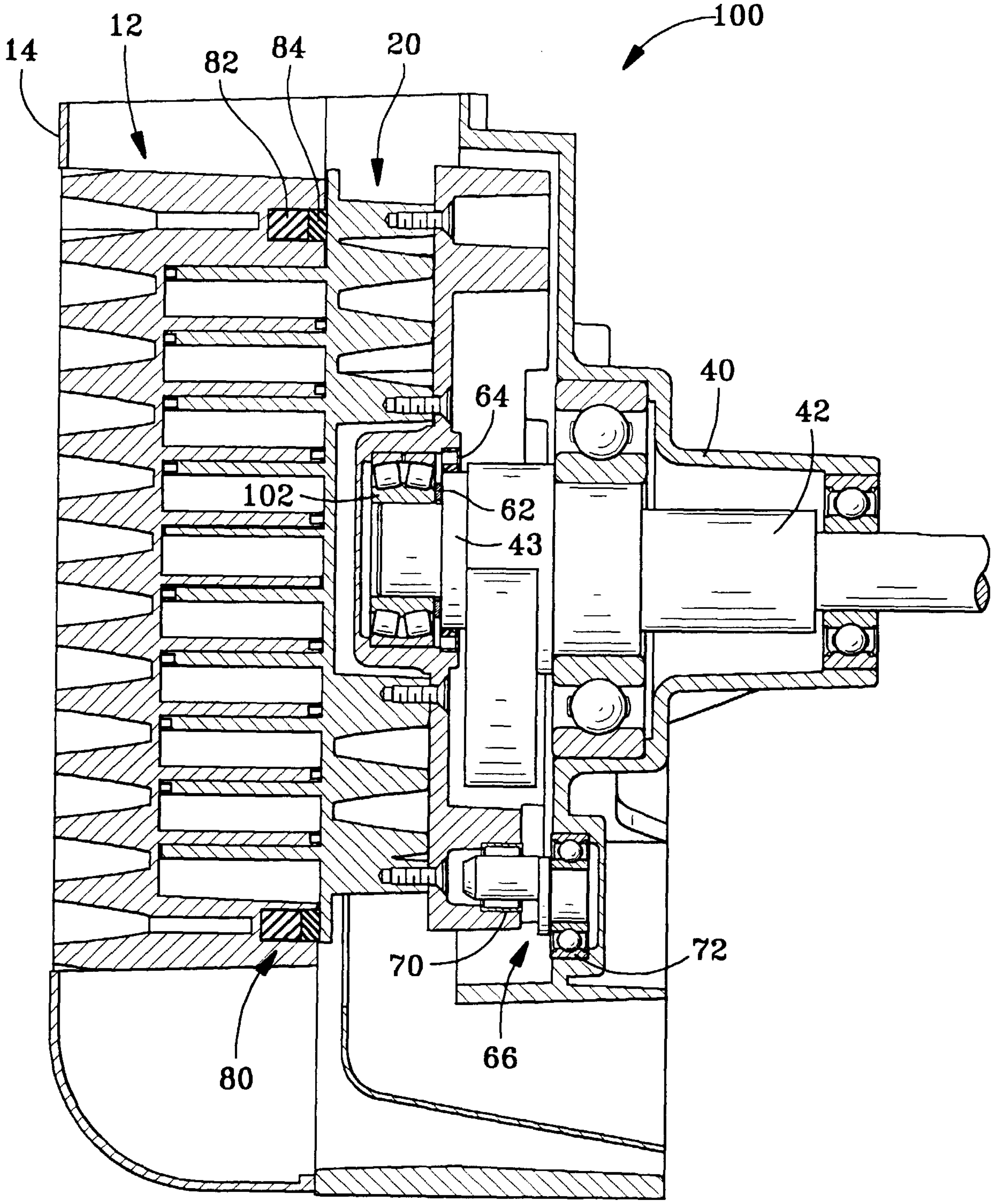

FIG. 4

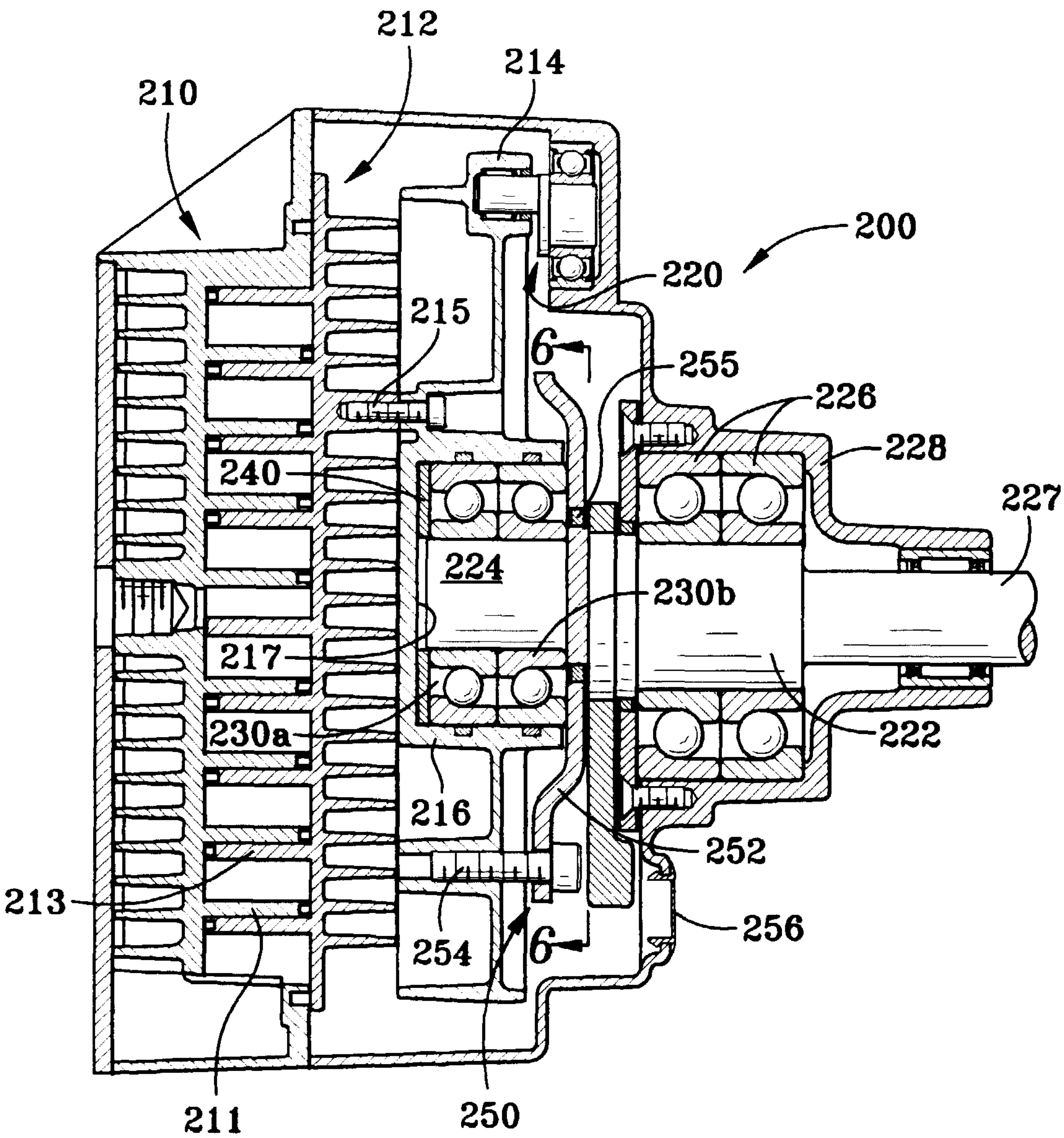
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FIG. 5

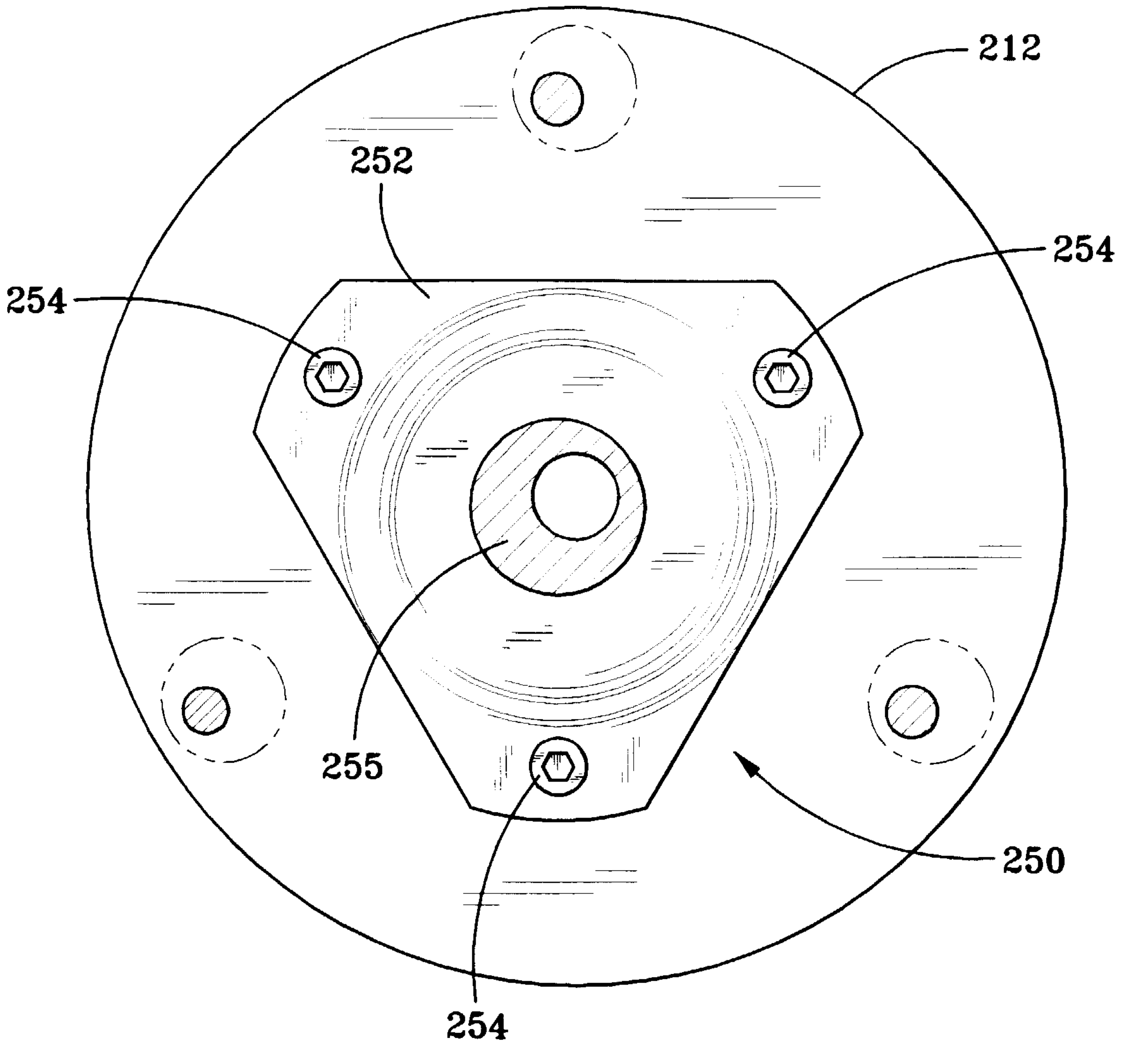

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 6186

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US 5 391 065 A (WOLVERTON) * column 1, line 7 - line 59 * * column 2, line 9 - column 4, line 35; figures *	1,5	F01C1/02
Y A	WO 95 27143 A (PURITAN-BENNETT CORP.) * page 13, line 5 - page 15, line 23; figures 12,13 *	1,5 10	
A	DE 41 00 328 A (TOYODA JIDOSHOKKI SEISAKUSHO) * column 4, line 28 - column 5, line 14; figure 1 *	2,3	
A	WO 95 21329 A (GRENCI) * page 10, last paragraph - page 16, line 26; figures 8-15 *	9	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
F01C
F04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 November 1997	Kapoulas, T

CATEGORY OF CITED DOCUMENTS

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