US 20080193311A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2008/0193311 A1

Helies

(43) Pub. Date: Aug. 14, 2008

(54) **MULTI-SHAFT VACUUM PUMP WITH CIRCULAR TRANSLATION CYCLE**

(75) Inventor: **Maurice Helies**, Chouzy Sur Cisse (FR)

Correspondence Address:
YOUNG & THOMPSON
209 Madison Street, Suite 500
ALEXANDRIA, VA 22314

(73) Assignee: **V.G.B.**, Pont Audemer (FR)

(21) Appl. No.: **11/795,799**

(22) PCT Filed: **Jan. 20, 2006**

(86) PCT No.: **PCT/FR06/00132**

§ 371 (c)(1), (2), (4) Date: **Oct. 17, 2007**

(30) **Foreign Application Priority Data**

Jan. 21, 2005 (FR) 0500663

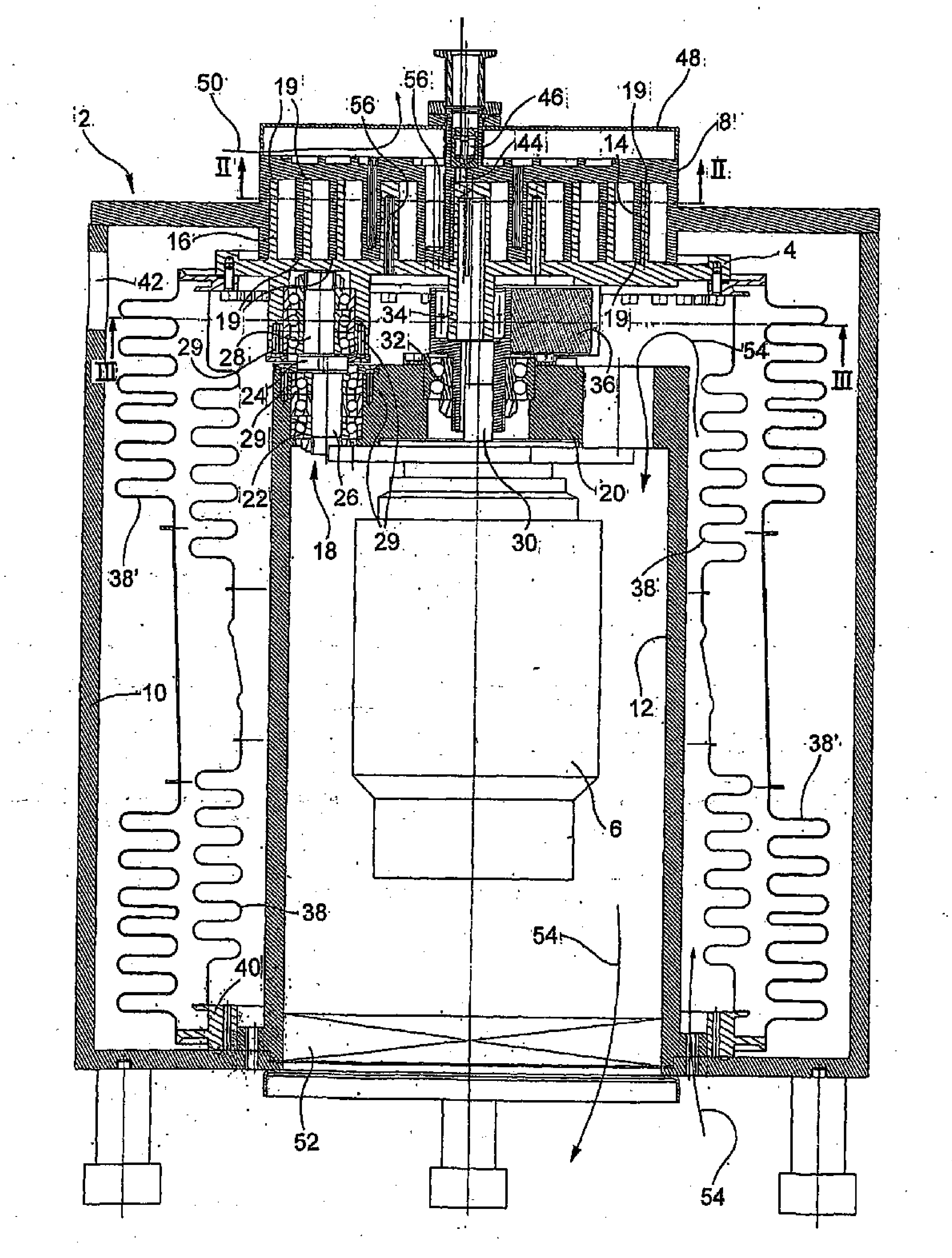
Publication Classification

(51) **Int. Cl.**
F04C 18/02 (2006.01)

(52) **U.S. Cl.** **418/55.3**

(57) **ABSTRACT**

The invention relates to a vacuum pump comprising: a fixed disc (**8**) which is solidly connected to a fixed body (**2**) and which is equipped with a spiral-shaped element (**14**); a movable disc (**4**) facing the fixed disc (**8**) and having a spiral-shaped element (**16**) which is interleaved with the spiral (**14**) of the fixed disc (**8**); a connection between the fixed body (**2**) and the movable disc (**4**), which is provided with at least two cranks (**18**) each comprising two shafts (**26**, **28**) that are displaced with the same eccentricity; and motor means (**6**) which are used to drive the movable disc (**4**) in a circulation translational motion and which comprise a motor (**6**) having an output shaft (**30**) which is parallel to the axes of the discs, said output shaft (**30**) of the motor (**6**) being centred on the axis of the movable disc (**4**) and driving same with the aid of a coupling piece (**32**) having the same eccentricity as the cranks (**18**).



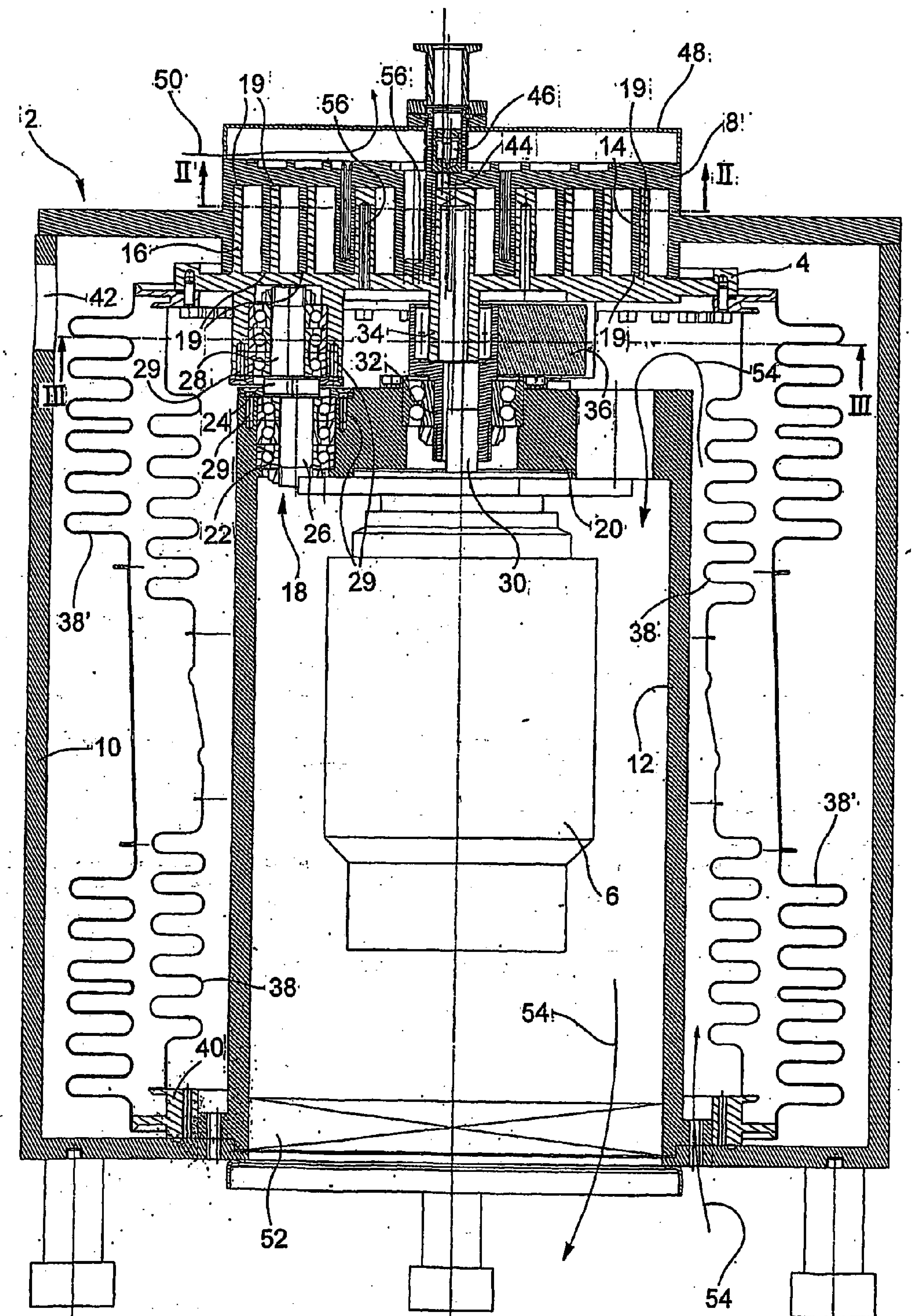

2
50
19
56
56
46
44
48
19
14
8
II
II
16
4
42
19
34
32
19
54
29
28
III
III
24
36
29
22
26
20
18
29
30
38'
38
10
12
38'
6
38
54
40
52
54
54

Fig. 1

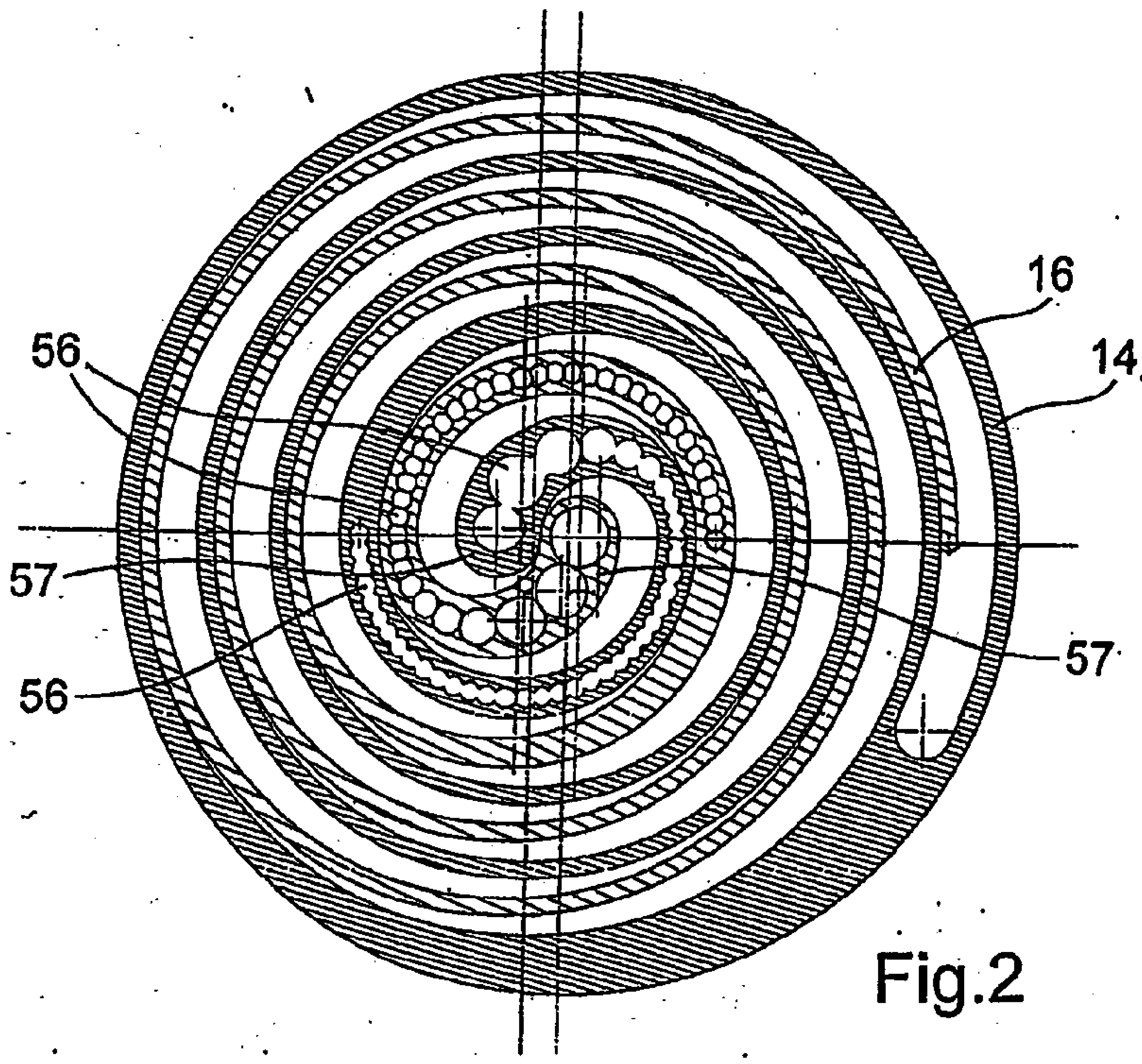


Fig.2

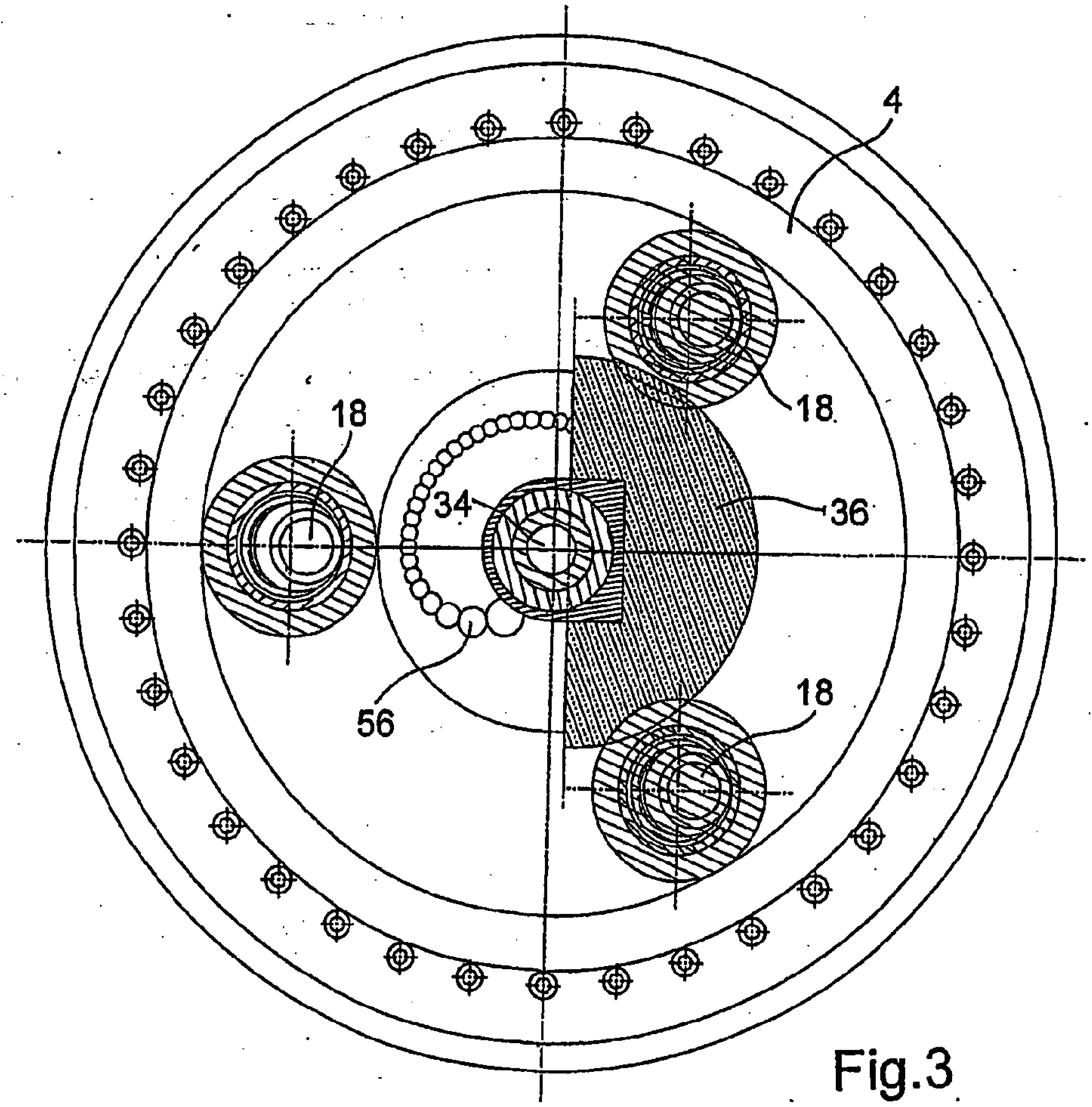


Fig.3

MULTI-SHAFT VACUUM PUMP WITH CIRCULAR TRANSLATION CYCLE

[0001] The present invention concerns a multi-shaft vacuum pump with a circular translation cycle.

[0002] A pump of this type generally includes a fixed body with a fixed disk having a spiral-shaped projection on one of its faces and a mobile disk facing the fixed disk and having on the same side as the fixed disk a corresponding spiral-shaped projection. The two spirals, one fixed and one mobile, have the same angular amplitude and are interleaved with each other. A mechanism drives movement of the mobile disk in circular translation relative to the fixed disk. The connection between the mobile disk and the fixed body of the pump is provided by a plurality of shafts, usually three shafts.

[0003] Such a pump is described in the document FR-A-2 141 402, for example. As indicated in that document, such a pump can be a totally dry and sealed pump. It gives excellent results but has the drawback of comprising many parts and of being bulky. Note also that the pump described in the above document uses a cooling liquid to cool the parts.

[0004] An object of the present invention is therefore to provide a new, dry, sealed and clean vacuum pump (i.e. a vacuum pump with no risk of pollution of the pumped fluid) that is of simple structure and also compact. This pump should preferably discharge at atmospheric pressure the gaseous fluid aspirated to create the vacuum at atmospheric pressure. Furthermore, maintenance of this new pump should be facilitated compared to known prior art pumps.

[0005] To this end, the invention proposes a circular translation cycle vacuum pump including:

- **[0006]** a fixed disk fastened to a fixed body and having a spiral-shaped projection on one of its faces,
- **[0007]** a mobile disk facing the fixed disk and having on the same side as the fixed disk a spiral-shaped projection interleaved with the spiral-shaped projection of the fixed disk,
- **[0008]** a connection between the fixed body and the mobile disk including at least two cranks, each crank including two parallel shafts that are offset with the same eccentricity,
- **[0009]** drive means for driving movement of the mobile disk in circular translation relative to the fixed disk.

[0010] According to the invention, the drive means include a motor having an output shaft parallel to the axes of the fixed disk and the mobile disk, the output shaft of the motor is substantially centered on the axis of the mobile disk and drives the latter with the aid of a coupling part having an eccentricity corresponding to the eccentricity of the cranks, the two spiral-shaped projections have no contact with each other and have an axial clearance controlled by the mounting of the cranks, and the axial forces exerted on the pump are absorbed essentially by the cranks.

[0011] This new multi-shaft vacuum pump structure is highly beneficial because it improves the distribution of forces within the pump, especially in the various rolling bearings. Such a pump is clean because a pumped gaseous fluid passing through the pump does not come into contact with any part subject to wear, such as a seal or the like.

[0012] In a preferred embodiment of a vacuum pump according to the invention, the motor is fixed to a plate parallel to the mobile disk and this plate has housings for one shaft of each crank. In this way, the plate is disposed at the heart of the pump and carries both the motor and the mobile disk. On the one hand, this simplifies the structure of the pump and, on the other hand, makes it more compact. In this embodiment, the plate forms the end wall of a cylindrical tube in which the motor is housed, for example. The fixed body then includes an external casing connecting the cylindrical tube to the fixed disk, for example.

[0013] In a vacuum pump of the invention, a metal bellows can be used to connect the periphery of the mobile disk to the fixed body of the vacuum pump in a sealed manner. Such a bellows provides a seal between a part mobile in (circular) translation and a fixed body. If the vacuum pump includes a cylindrical tube, the metal bellows preferably surrounds the cylindrical tube. In this way, the bellows can be of relatively large size and the stresses exerted on it are therefore lower than for a small bellows.

[0014] The invention advantageously provides for a second metal bellows, also mounted in sealed manner between the periphery of the mobile disk and the fixed body, to surround the first metal bellows. This produces a space between the two metal bellows. By monitoring the pressure in this space, it is possible to detect failure of either bellows immediately. As a result, it is possible to ensure perfect control over the sealing of the pump.

[0015] In the embodiment in which the vacuum pump includes a cylindrical tube, there may be provision for the cylindrical tube to receive on the side opposite the plate a fan and for orifices to be provided in the plate to enable ventilation of the housing of the motor.

[0016] The vacuum pump can also include ventilation means for cooling the face of the fixed disk opposite the mobile disk.

[0017] When the pump is equipped with such ventilation means, it is not necessary to provide a cooling liquid circuit to prevent overheating of the pump in operation. This avoids one possible source of pollution of the gaseous fluid pumped by the pump of the invention.

[0018] For even better cooling of the disks of the pump, there may be provision for at least one projection forming a spiral on one disk to be perforated in the vicinity of the heart of the spiral.

[0019] For discharging the pumped gaseous fluid at atmospheric pressure the fixed disk has, for example, substantially at the center of the spiral, a discharge orifice discharging onto the face opposite the spiral and this discharge orifice can be provided with a discharge valve.

[0020] To encourage discharging of the pumped fluid at atmospheric pressure, the thickness of the projections forming a spiral has at the heart of the spiral a thickness increasing to form a bulb-shaped end of the spiral.

[0021] Details and advantages of the present invention will emerge more clearly from the following description, given with reference to the appended diagrammatic drawings, in which:

[0022] FIG. **1** is a view in longitudinal section of a vacuum pump of the invention,

[0023] FIG. **2** is a view in section taken along the section line II-II in FIG. **1**, and

[0024] FIG. **3** is a view in section taken along the section line III-III in FIG. **1**.

[0025] There is seen in FIG. **1** a circular translation cycle vacuum pump. That pump includes in particular a fixed body **2**, a mobile disk **4** and a motor **6**.

[0026] In the preferred embodiment represented in FIG. **1**, the fixed body **2** consists essentially of three elements: a fixed disk **8**, a casing **10** and a cylindrical tube **12**.

[0027] The fixed disk **8** has on its interior face a spiral-shaped projection **14**. The shape of the latter can be seen in FIG. **2**. The mobile disk **4** faces the fixed disk **8**. On its face oriented toward the fixed disk **8**, the mobile disk also has a spiral-shaped projection **16**. The spiral **16** of the mobile disk **4** is interleaved with the spiral **14** of the fixed disk **8**, as can also be seen in FIG. **2** (to simplify the view, FIG. **3** represents neither the fixed spiral **14** nor the casing **10**). The spirals **14** and **16** are separated from each other by a constant axial clearance, regardless of the position of the mobile disk **4** relative to the fixed disk **8**. This clearance is of the order of 5/100 mm, for example. There is also a radial clearance between the spirals. That radial clearance is of the same order of magnitude as the axial clearance (approximately 0.05 mm).

[0028] The fixed body **2** supports the mobile disk **4** through the intermediary of three cranks **18** of equal eccentricity E that are coupled and synchronized to obtain a movement of the mobile disk **4** in circular translation relative to the fixed body **2**, and more particularly its fixed disk **8**, when the pump is operating.

[0029] The cranks **18** connect the mobile disk **4** to the fixed disk **8** so that, on the one hand, the mobile disk **4** is perfectly guided to obtain virtually perfect control over the axial clearance at the spiral-shaped projections **14**, **16** and, on the other hand, the axial forces between these two disks are absorbed by these cranks. The axial clearance referred to here in respect of the spiral-shape projections **14**, **16** indicates that between the summit of one spiral **14**, **16** and the facing disk **4**, **8** there is a substantially constant clearance **19** (of the order of 0.05 mm).

[0030] The cylindrical tube **12** has a body having longitudinal axis is parallel to the axis of the fixed disk **8** and the mobile disk **4** and a transverse end wall **20** which is therefore situated in a plane parallel to those of the disks. This end wall **20** includes three bores **22** each receiving a crank **18**. Each crank **18** includes a journal **24**, a lower shaft **26** and an upper shaft **28**. Each journal **24** is situated at the interface between the end wall **20** and the mobile disk **4**. The lower shaft **26** of each crank **18** is housed with corresponding bearings in a bore **22** in the end wall **20** while each of the upper shafts **28** is housed with corresponding bearings in housings provided for this purpose in the mobile disk **4**. The axes of the lower shafts **26** and the upper shafts **28** are parallel and offset by a distance corresponding to the eccentricity E.

[0031] Each bore **22** has a shoulder against which rest ball-bearings guiding the lower shaft **26** of a crank **18**. The journal **24** rests on these ball-bearings on the side opposite the aforementioned shoulder. A similar arrangement is used for the housings provided in the mobile disk **4**. Each of those housings has a shoulder against which abut ball-bearings receiving the upper shaft **28** of the crank **18** and, on the side opposite that shoulder, the journal **24** rests on the ball-bearing. These bearings are retained in their housings in the mobile disk **4** and the end wall **20**, with the aid of a ring retained by screws **29**.

[0032] This type of assembly corresponds to a vacuum pump in which the mobile disk **4** tends to move axially toward the fixed disk **8**.

[0033] The movement of the mobile disk **4** in circular translation relative to the fixed disk **8** is driven by the motor **6**. The latter is disposed inside the cylindrical tube **12** and fixed to its end wall **20**. In the preferred embodiment of the invention shown in the drawings, the output shaft **30** of the motor **6** is connected to the mobile disk **4** by a coupling part **32**. Here the latter takes the form of a sleeve including two aligned cylindrical circular housings offset by a distance corresponding to the eccentricity E. The cylindrical housing on the same side as the motor receives the output shaft **30** of the motor and the cylindrical housing on the same side as the mobile disk **4** receives a crank-pin **34** projecting from the face of the mobile disk **4** opposite the spiral **16** and a needle roller bearing. In this embodiment represented in the figures, the crank-pin **34** is centered relative to the mobile disk **4**. The needle roller bearing essentially absorbs radial forces on the motor shaft. Note in the figure a ball-bearing in the vicinity of the output shaft **30**. The only function of this bearing is to retain the motor shaft if the motor is demounted for maintenance or repair or changed.

[0034] Note in FIGS. **1** and **3** the presence of a balancing mass **36** around the coupling part **32** at the level of the crank-pin **34**. This mass is calculated and positioned to provide dynamic balancing of the pump when the latter is operating.

[0035] In the embodiment that can be seen in FIG. **1**, the casing **10** of the fixed body connects the periphery of the fixed disk **8** with the free edge of the cylindrical tube **12** at the end opposite the end wall **20**.

[0036] Note also the presence of two metal bellows **38**, **38'** in FIG. **1**. Each of these bellows **38**, **38'** is mounted on and sealed, on the one hand, to a peripheral rim of the mobile disk **4** and, on the other hand, to the casing **10**. The bellows **38**, **38'** are fixed by welding them, for example.

[0037] The two bellows **38**, **38'** therefore surround the (fixed) cylindrical tube **12** inside which the motor **6** is located, the bellows **38'** surrounding the bellows **38**. The presence of a single bellows is sufficient to achieve good operation of the vacuum pump of the invention. The second bellows is provided here for safety reasons. A pressure sensor connected to the empty space between the two bellows immediately detects the slightest leak in either of the bellows, the other bellows then still ensuring sealing of the pump.

[0038] The metal bellows **38**, **38'** are used to render the pump fully sealed. They are protected against twisting caused by the kinematics of the drive system. To limit the stresses exerted on these bellows, they extend substantially the full height of the pump, as can be seen in FIG. **1**. Shorter bellows (or a single bellows) might be equally suitable.

[0039] The casing **10** includes an inlet opening **42** which, in the embodiment shown, provides a radial inlet for the gaseous fluid in the vicinity of the fixed disk **8** and the mobile disk **4**. An enclosure to be evacuated (not represented in the drawings) is connected to the inlet opening **42** of the pump (by means that are not shown). As soon as the pump is started, the gaseous fluid to be pumped is subjected to the continuous and progressive effect of compression obtained by the relative movement between the two spirals **14** and **16**. In a manner that is known in the art (cf. for example FR-2 141 402), the gaseous fluid in the space between the exterior bellows **38'** and the casing **10** is driven towards a discharge orifice **44** at the center of the spiral **14** of the fixed disk **8**. This discharge orifice **44** is fitted with a valve **46** for discharging the gaseous fluid at atmospheric pressure.

[0040] The spirals tend to become heated during operation. A first ventilation unit **48**, represented very diagrammatically in FIG. **1**, is disposed on the face of the fixed disk **8** opposite the face carrying the spiral **14**. An arrow **50** represents one example of the movement of air for ventilating the fixed disk **8**.

[0041] A second ventilation set **52** is disposed in the cylindrical tube **12** to cool the motor **6** and the mobile disk **4**. This second ventilation unit **52**, shown very diagrammatically, aspirates air from outside the pump to feed it into the latter along a path illustrated by way of example by arrows **54**. To allow such flow of air, orifices are provided in the end wall **20** of the cylindrical tube and in the fixed body **2**, to enable external air to penetrate between the exterior surface of the cylindrical tube **12** and the interior of the inner bellows **38**.

[0042] To promote further the cooling of the fixed disk **8** and the mobile disk **4**, a void **56** is provided in each of the spirals **14** and **16**, as can be seen in the drawings. The spirals **14** and **16** each have at their end that is substantially at the center of the corresponding disk a bulbous portion **57** produced by enlarging the projection forming the corresponding spiral toward the center of the disk. Thus air set in motion by the ventilation units can enter the voids **56** and thereby improve the cooling of the spirals **14** and **16** and therefore of the corresponding disks **8** and **4**.

[0043] The vacuum pump described hereinabove is a totally dry pump, which operates with no oil and no cooling liquid. This pump is also entirely sealed with perfect control of the seal, thanks in particular to the two bellows.

[0044] The pump described here is a so-called clean pump. The pumped fluid does not encounter any parts subject to wear (seals, etc.) from the inlet orifice **42** to the outlet orifice **44**. The control of the axial clearance between the spiral-shaped projections **14**, **16** means that the seals usually found between each spiral and the disk facing said spiral can be dispensed with. The absence of parts subject to wear along the whole of the path of the pumped fluid protects the latter from pollution.

[0045] A pump such as that described hereinabove can be used for relatively low flow rates. By way of purely illustrative and nonlimiting example, such a pump can generate a volume of the order of 30 m^3/h, for example.

[0046] A vacuum pump according to the invention can find applications in the nuclear field, for example, in the fabrication of electronic components, in the pharmaceutical industry, in the foodstuffs industry, etc. This list of applications is not exhaustive, of course. This type of pump can be used anywhere great care is necessary to avoid any pollution of a transported fluid.

[0047] Although for prior art pumps of equivalent size it is usually necessary to provide coupling to a primary pump, the pump described can discharge directly at atmospheric pressure. This direct discharge at atmospheric pressure can be obtained here thanks in particular to the presence of a valve **46** at the outlet but also because of the bulbous portion **57** at the ends of the spirals. The good ventilation of the pump also encouraged by the voids **56** in the region of said bulbous portions is also important in enabling such rejection. In fact, given the variation of pressure, the heating effect in the pump is relatively strong and appropriate cooling must be provided.

[0048] The structure of the pump described is simple, even if it includes four shafts. Moreover, it produces a compact pump. Furthermore, maintenance of this pump is simplified. The number of seals and parts subject to wear is very small.

[0049] An important advantage of the structure described hereinabove with a central drive shaft and peripheral shafts is how it absorbs radial forces. These are absorbed essentially by the needle roller bearing described. The load on the bearings of the peripheral shafts is limited and this allows the use of bearings with a higher axial stiffness than the bearings used in comparable prior art pumps.

[0050] The present invention is not limited to the preferred embodiment described hereinabove by way of nonlimiting example. It relates equally to all variants that might occur to the person skilled in the art within the scope of the following claims.

[0051] For example, the number of shafts (cranks) can be modified without departing from the scope of the invention. Other modifications, concerning for example the shape of the fixed body, the cooling of the parts (possibly even using a cooling liquid), the mounting of the motor, the bellows, etc. can equally be made without departing from the scope of the invention.

1-12. (canceled)

13. Circular translation cycle vacuum pump including:

a fixed disk (**8**) fastened to a fixed body (**2**) and having a spiral-shaped projection (**14**) on one of its faces,

a mobile disk (**4**) facing the fixed disk (**8**) and having on the same side as the fixed disk (**8**) a spiral-shaped projection (**16**) interleaved with the spiral-shaped projection (**14**) of the fixed disk (**8**),

a connection between the fixed body (**2**) and the mobile disk (**4**) including at least two cranks (**18**), each crank (**18**) including two parallel shafts (**26**, **28**) that are offset with the same eccentricity,

drive means (**6**) for driving movement of the mobile disk (**4**) in circular translation relative to the fixed disk (**8**), these drive means including a motor (**6**) having an output shaft (**30**) parallel to the axes of the fixed disk (**8**) and the mobile disk (**4**), and the output shaft (**30**) of the motor (**6**) being substantially centered on the axis of the mobile disk (**4**) and driving the latter with the aid of a coupling part (**32**) having an eccentricity corresponding to the eccentricity of the cranks (**18**),

the two spiral-shaped projections (**14**, **16**) having no contact with each other,

characterized in that the two spiral-shaped projections (**14**, **16**) have an axial clearance controlled by the mounting of the cranks (**18**),

in that the axial forces exerted on the pump are absorbed essentially by the cranks (**18**),

in that the motor (**6**) is fixed to a plate (**20**) parallel to the mobile disk (**4**), and

in that this plate (**20**) has housings (**22**) for one shaft (**26**) of each crank (**18**).

14. Vacuum pump according to claim **13**, characterized in that the plate forms the end wall (**20**) of a cylindrical tube (**12**) in which the motor (**6**) is housed.

15. Vacuum pump according to claim **14**, characterized in that the fixed body (**2**) includes an external casing (**10**) connecting the cylindrical tube (**12**) to the fixed disk (**8**).

16. Vacuum pump according to claim **14**, characterized in that a metal bellows (**38**) connects the periphery of the mobile disk (**4**) to the fixed body (**2**) of the vacuum pump in a sealed manner.

17. Vacuum pump according to claim **16**, characterized in that the metal bellows (**38**) surrounds the cylindrical tube (**12**).

18. Vacuum pump according to claim **16**, characterized in that a second metal bellows (**38'**), also mounted in sealed manner between the periphery of the mobile disk (**4**) and the fixed body (**2**), surrounds the first metal bellows (**38**).

19. Vacuum pump according to claim **14**, characterized in that on the side opposite the plate (**20**) the cylindrical tube

(**12**) receives a ventilation unit (**52**) and in that orifices are provided in the plate (**20**) to enable ventilation of the housing of the motor (**6**).

20. Vacuum pump according to claim **13**, characterized in that ventilation means (**48**) are provided for cooling the face of the fixed disk (**8**) opposite the mobile disk (**4**).

21. Vacuum pump according to claim **13**, characterized in that the fixed disk (**8**) has, substantially at the center of the spiral (**14**), a discharge orifice (**44**) discharging onto the face opposite the spiral (**14**) and in that this discharge orifice (**44**) is provided with a discharge valve (**46**).

22. Vacuum pump according to claim **13**, characterized in that at least one projection forming a spiral (**14**, **16**) on a disk (**8**, **4**) is perforated in the vicinity of the heart of the spiral (**14**, **16**).

23. Vacuum pump according to claim **13**, characterized in that the thickness of the projections forming a spiral (**14**, **16**) has at the heart of the spiral (**14**, **16**) a thickness increasing to form a bulb-shaped end (**57**) of the spiral.

24. Vacuum pump according to claim **13**, characterized in that a metal bellows (**38**) connects the periphery of the mobile disk (**4**) to the fixed body (**2**) of the vacuum pump in a sealed manner.

25. Vacuum pump according to claim **17**, characterized in that a second metal bellows (**38'**), also mounted in sealed manner between the periphery of the mobile disk (**4**) and the fixed body (**2**), surrounds the first metal bellows (**38**).

* * * * *