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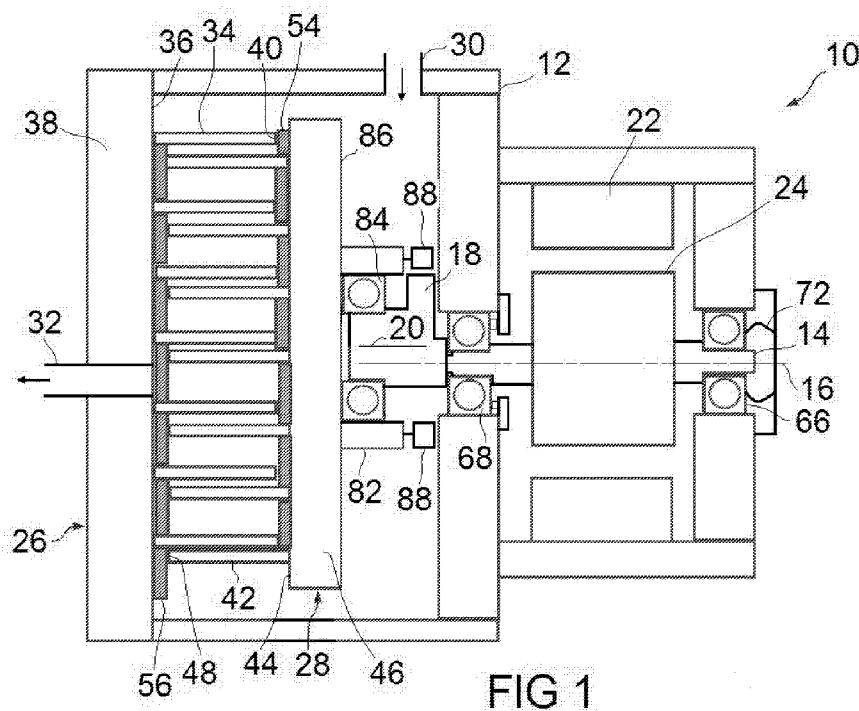
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(54) Title: SCROLL PUMP TIP SEALING



(57) Abstract: A scroll pump (10) has a fixed scroll (26) and an orbiting scroll (28). The base members (38, 46) of the scrolls are provided with respective base seals (54, 56) to seal between the major surfaces (36, 44) of the base members (38, 46) and the opposed scroll wall tip faces (40, 48). One of more orbiting scroll biasers are provided to resiliently push the fixed and orbiting scrolls (26, 28) together.

SCROLL PUMP TIP SEALING

Field of the Invention

The invention relates to scroll pump tip sealing.

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Background to the Invention

Known scroll compressors, or pumps, comprise a fixed scroll, an orbiting scroll and a drive mechanism for the orbiting scroll. The drive mechanism is configured to cause the orbiting scroll to orbit relative to the fixed scroll to cause pumping of a fluid
10 between a pump inlet and a pump outlet. The fixed and orbiting scrolls each comprise an upstanding scroll wall extending from a generally circular base plate. Each scroll wall has an end, or tip, face disposed remote from and extending generally perpendicular to the respective base plate. The orbiting scroll wall is configured to mesh with the fixed scroll wall during orbiting of the orbiting scroll so that the
15 relative orbital motion of the scrolls causes successive volumes of gas to be enclosed in pockets defined between the scroll walls and pumped from the inlet to the outlet.

A scroll pump may be a dry pump and not lubricated. In this case, to prevent back leakage, the tip of each scroll wall is provided with a tip seal to seal against the base
20 plate of the other scroll. The tip seals are located in channels defined in the tips of the scroll walls and are typically made of PTFE. There may be a small gap between the base of each channel and the opposing face of the tip seal so that, in use, fluid occupying the gap produces an actuation force that forces the tip seal towards and against the base plate of the other scroll. The tip seals close the gap between the
25 scrolls caused by manufacturing and operating tolerances and reduce the leakage to an acceptable level.

Typically, a tip seal is narrower than its channel so that there is a radial clearance between the tip seal and the opposed sidewalls of the channel. During relative
30 orbiting motion of the scrolls, the tip seal is urged against one sidewall for part of its motion and against the other sidewall for another part of its motion. As the tip seal moves back and forth between these positions, leakage is increased because there is a

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leakage path formed from one side of the seal to the other side of the seal. Known tip seals typically have an aspect ratio of height to radial width which is 1:1. That is, the radial width of the tip seal is equal to the height of the tip seal so that the tip seal has a square cross-section. Accordingly, the tip seal is relatively stiff in the radial, or
5 widthways, direction. When the tip seal moves radially between the sidewalls of the tip seal channel, this relative stiffness slows the movement of the tip seal, thereby increasing leakage.

There are applications, such as portable mass spectrometry, for which small dry
10 pumps with a capacity of about 0.1 to 3.0 m³/hr are needed. Currently this need is met by diaphragm pumps. However, diaphragm pumps are still relatively large for their pumping capacity and have a poor ultimate pressure due to their internal valving. A typical ultimate pressure for such pumps is 2 mbar. Scroll pumps may offer better performance. However, reducing the size of a scroll pump presents problems
15 actuating the tip seals. If the scroll walls are made thin with a view to reducing the radial dimension of the pump, the tip seals must be made correspondingly thin. For example, if the scroll walls are thinned to a 1.0 mm thickness, the tip seals will have a thickness in the order of 0.5 mm. At this thickness, there will be very little actuation force under the tip seal to push it against the opposing scroll.

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Summary of the Invention

The invention provides a scroll pump as specified in claim 1.

Brief Description of the Drawings

25 In the following disclosure, which is given by way of example only, reference will be made to the drawings, in which:

Figure 1 is a schematic representation of a scroll pump;

30 Figure 2 is an enlargement of a portion of Figure 1 illustrating features of a scroll pump sealing system;

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Figure 3 is another portion of Figure 1 illustrating features of a scroll driver and a scroll pump bearing system;

Figure 4 is a schematic plan view of a fixed scroll of the scroll pump; and

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Figure 5 is a schematic representation corresponding generally to Figure 3 showing an alternative scroll pump configuration.

Detailed Description

10 Referring to Figure 1, a scroll pump 10 comprises a pump housing 12 and a scroll driver, which in this example comprises a drive shaft 14 having a longitudinal axis 16 and an eccentric member 18 that has an axis 20 disposed parallel to and offset with respect to the longitudinal axis 16. The eccentric member 18 may be a separate body secured to the drive shaft 14. The scroll driver 14, 18 is driven by a motor comprising
15 a stator 22 and a rotor 24 that is connected with the drive shaft 14.

The scroll pump 10 has a scroll set comprising a fixed scroll 26 and an orbiting scroll 28. The scroll set 26, 28 is operable to pump fluid along a fluid flow path between a pump inlet 30 and pump outlet 32.

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The fixed scroll 26 comprises a spiralling, or involute, scroll wall 34. The scroll wall 34 extends perpendicularly from a major surface 36 of a generally circular base member 38 and has an end, or tip, face 40 that is spaced from the major surface 36. The tip face 40 may be disposed generally parallel to the major surface 36 and defines
25 a free end of the fixed scroll wall 34. The base member 38 may be a part of the pump housing 12 as illustrated by Figure 1 or a separate member disposed within the pump housing. The orbiting scroll 28 comprises a spiralling, or involute, scroll wall 42. The scroll wall 42 extends perpendicularly from a major surface 44 defined by a first side of a generally circular base member 46. The scroll wall 42 has an end, or tip,
30 face 48 that is spaced from the major surface 44 and defines a free end of the orbiting scroll wall 28. The tip face 48 may be disposed generally parallel to the major surface 44. The fixed and orbiting scrolls 26, 28 are nested so that the orbiting scroll wall 42

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co-operates, or meshes, with the fixed scroll wall 34 during orbiting movement of the orbiting scroll 28. Relative orbital movement of the scrolls 26, 28 causes successive volumes of gas to be trapped in pockets defined between the scrolls and pumped from the inlet 30 to the outlet 32.

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Referring additionally to Figure 2, the scroll pump 10 may be a dry pump in which the scrolls 26, 28 are not lubricated. In order to prevent, or at least reduce, back leakage via respective gaps 50, 52 between the tip faces 40, 48 of the scroll walls 34, 42 and the opposed major surfaces 36, 44 of the base members 38, 46, respective base seals 54, 56 are provided to close the gaps 50, 52.

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Still referring to Figure 2, the base seal 54 is provided on the major surface 36 of the base member 38 between adjacent turns of the fixed scroll wall 34. In the illustrated example, the base seal 54 at least substantially covers the major surface 36 between the adjacent turns of the fixed scroll wall 34. Similarly, the base seal 56 is provided on the major surface 44 of the base member 46 between adjacent turns of the orbiting scroll wall 42. In the illustrated example the base seal 56 at least substantially covers the major surface 44 between the adjacent turns of the orbiting scroll wall 42. Although not essential, at least one of the base seals 54, 56 may be provided with a seal biaser 58, 60 disposed between the base seal and the respective major surface 36, 44. The or each seal biaser 58, 60 is configured to bias the respective base seal 54, 56 away from the respective major surface 36, 44. The or each seal biaser 58, 60 may assist in pressing the respective base seal 54, 56 against the opposing tip face 40, 48.

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Referring to Figure 3, the scroll pump 10 is provided with a bearing system 66, 68 to support the drive shaft 14. The bearing system may comprise two bearing units 66, 68 that are disposed at axially spaced apart locations along the drive shaft 14. The bearing units 66, 68 may each comprise one or more rolling bearings. In the illustrated example, each bearing unit 66, 68 comprises a single rolling bearing. The rolling bearing 66 is disposed at the end 14(1) of the drive shaft 14 that is located furthest from the orbiting scroll 28 and the rolling bearing 68 is disposed adjacent the eccentric member 18.

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- 5 -

The end 14(1) of the drive shaft has a reduced diameter portion to define an abutment face 70 disposed perpendicular to the longitudinal axis 16. The bearing unit 66 seats on the reduced diameter portion 14(1) against the abutment face 70. The bearing unit
5 66 is pressed against the abutment face 70 by an orbiting scroll biaser 72. The orbiting scroll biaser may comprise one or more resilient bodies. The orbiting scroll biaser 72 may, for example, comprise one or more resilient members such as a C or Belleville washer(s). The orbiting scroll biaser 72 may be held against the bearing unit 66 by a cap 74 secured to the pump housing 12. In other examples, the orbiting
10 scroll biaser 72 may be held in place by a clamping plate that may be secured to, or integral with, the pump housing 12.

The drive shaft 14 has a second reduced diameter portion adjacent the eccentric member 18 to define an abutment face 76. The bearing unit 68 is seated on the
15 second reduced diameter portion in engagement with both the abutment face 76 and an end face of the eccentric member 18 so that an axial thrust provided by the orbiting scroll biaser 72 is transmitted to the eccentric member via the bearing units 66, 68 and the drive shaft 14. Optionally, a second orbiting scroll biaser 78 may be provided to act directly on the bearing unit 68. The second orbiting scroll biaser 78 may be
20 pressed against the bearing unit 68 by an annular member 80 that is secured to or an integral part of the pump housing 12. The second orbiting scroll biaser 78 may comprise one or more resilient bodies. The second orbiting scroll biaser 78 may, for example, comprise one or more resilient members such as a C or Belleville washer(s).

25 Still referring to Figure 3, the orbiting scroll 28 is provided with a bearing housing 82 and a bearing 84 housed in the bearing housing. The bearing housing 82 projects from a second side 86 of the orbiting scroll base member 46 that is disposed opposite the first side (which first side defines the major surface 44). The bearing housing 82 may be an annular member that is integral with the base member 46 or a body secured
30 to the base member.

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The bearing 84 has an axial centre line, or axis of rotation, that is at least substantially in line with the axis 20 of the eccentric member 18. The bearing 84 is engaged by the eccentric member 18 to connect the orbiting scroll 28 with the scroll driver 14, 18. The bearing 84 is a single rolling bearing and is seated between the eccentric member 18 and base member 46 such that the axial thrust provided by the orbiting scroll biaser 72 (and the optional orbiting scroll biaser 78 when provided) is transmitted from the eccentric member 18 to the orbiting scroll 28 via the bearing 84. The axial thrust provided by the or each orbiting scroll biaser 72, 78 is arranged to resiliently push the orbiting and fixed scrolls 26, 28 together.

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The orbiting scroll 28 is provided with at least one balancing mass 88 arranged such that the orbiting scroll has a centre of mass disposed in a plane 90 that extends through the bearing 84 transverse to the axial centre line of the bearing. In the illustrated example, the plane 90 is disposed at least substantially perpendicular to the centre line of the bearing 84. In the illustrated example, the plane 90 also extends through the bearing housing 82 at least substantially parallel to the base member 46. The or each balancing mass 88 may be spaced from and connected with the second side 86 of the orbiting scroll base member 46, or the bearing housing 82, by a connecting structure 94 that has a relatively low, or in some examples a negligible, influence on the location of the centre of mass of the orbiting scroll 28. The connecting structure 94 may, for example, comprise one or more relatively narrow rods or the like.

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The bearing housing 82 has a free end 92 that is spaced apart from the second side 86 of the orbiting scroll base member 46 by a first distance and the or each balancing mass 88 has at least one end that is spaced from the second side 86 by a second distance that is greater than the first distance. The bearing 84 has a first side that faces the second side 86 of the base member 46 (and the fixed scroll 26) and a second side that faces away from the base member 46 (and the fixed scroll 26). The second side of the bearing 84 is spaced respective first distances from the second side 86 of the base member 46 and fixed scroll 26 and the or each mass body 88 has at least one

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end that is spaced from the second side 86 and fixed scroll 26 by respective second distances that are greater than the respective first distances.

Figure 4 is a plan view of the fixed scroll 26 with the base seal 56 omitted. The fixed scroll wall 34 may extend from the periphery of the base member 38 to its centre and have an inner end disposed adjacent a port 98 that is flow connected with the pump outlet 32. However, in some examples, the fixed scroll wall 34 may not extend to the centre of the base member 38 and may instead have its inner end located away from the centre a radial distance R1 that is between around 0.25 and 0.5 the radial distance R2 to the outer end of the scroll wall. Although not essential, the centre, or origin of the radii R1, R2 may be coincident with the centre of the base member 38 or the port 98. Although not shown in the drawings, the orbiting scroll wall 42 may be proportioned similarly to the fixed scroll wall so that both scroll walls 34, 42 have inner and outer ends disposed at substantially the same radial distances R1, R2 from the respective centres of their base members 38, 46. By increasing the radial distance R1 to around 0.25 to 0.5R2, the peak pressures generated between the scrolls 26, 28 when the pump is roughing may be reduced.

The force exerted by the orbiting scroll biaser, or biasers, has to be sufficient to overcome the pressure loads generated in use of the scroll pump that will tend to force the fixed and orbiting scroll apart. The force provided by the orbiting scroll biaser, or biasers, should be sufficient to balance this pressure loading and cause sufficient engagement between the base seals and opposed tip faces to provide a reliable seal. In particular, the orbiting scroll biaser, or biasers, should be configured to overcome the peak pressure to ensure that the tip faces 40, 48 maintain contact with the respective base seals 54, 56. If the biasing force has to be relatively high to overcome relatively high pressure generated forces during roughing, when the scroll pump is operating at ultimate and the pressure generated forces are correspondingly lower, there be a relatively large excess biasing force that has to be absorbed by the base seals. Since a typical scroll pump may operate at ultimate for around 90% of its working life, absorbing a relatively large excess biasing force may cause excessive wear of the base seals.

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If the radial distance R1 is around 0.5 times the radial distance R2, the pressure generated force that has to be overcome by the orbiting scroll biaser, or biasers, may be considerably reduced when the scroll pump is operating at roughing pressures and by suitable selection of the orbiting scroll biaser, or biasers, the excess biasing force applied to the base seals when the scroll pump is operating at ultimate may be reduced accordingly. If the radial distance is around 0.25 times the radial distance R2, the pressure generated force may remain at least substantially constant at all inlet pressures. This allows the orbiting scroll biaser, or biasers, to be selected so as to provide a biasing force that is only a small amount greater than the pressure generated force that should be present under all operating conditions. Accordingly, the force absorbed by the base seals 54, 56 may be relatively small and constant, thereby minimising wearing of the seals.

Figure 5 shows features of another scroll pump 110. Many features or parts of the scroll pump 110 correspond to or are similar to features of the scroll pump 10. Such features or parts are indicated in Figure 5 using the same reference numerals as in Figures 1 to 3 and to save repetition of description may not be described again.

The scroll pump 110 differs from the scroll pump 10 in that the drive shaft 14 passes through the fixed scroll 26 to put the motor 22, 24 on the exhaust side of the pump. As with the example shown in Figures 1 to 3, although the fixed scroll base member 38 is shown as a part of the pump housing 12, it may be a separate part disposed within the pump housing.

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In this example the bearing system supporting the drive shaft 14 comprises two bearing units 66, 68 disposed at spaced apart locations along the length of the drive shaft. The bearing unit 68 disposed closest to the eccentric member 18 is seated in or on the fixed scroll base member 38. In this example, there is only one orbiting scroll biaser 72 and this is disposed between the base member 38 and the bearing unit 68. Although not shown, a second orbiting scroll biaser acting on the bearing unit 66 may be provided. In that case, the second orbiting scroll biaser would act on the scroll side

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of the bearing unit 68 in similar fashion to the orbiting scroll biaser 72. The or each orbiting scroll biaser causes the orbiting scroll 26 to be pulled towards the fixed scroll 28. The or each orbiting scroll biaser may comprise one or more resilient bodies. The or each orbiting scroll biaser may comprise one or more resilient members such as, for example, a C or Belleville washer(s).

In the example illustrated by Figure 5, the bearing 84 between the eccentric member 18 and the orbiting scroll 28 is housed in an aperture, or housing, 82 defined by the orbiting scroll base member 46 and the orbiting scroll 26 is provided with one or more balancing masses 88 configured such that the centre of mass of the orbiting scroll at least lies in the plane of the base member 46, which passes through the bearing 84 perpendicular to the axial centre line of the bearing. The balancing mass or masses 88 may be integral with or fixed directly to the second side 86 of the base member 46. A balancing mass 88 may for example be an annular projection provided on the base member 46. In other examples, the or each balancing mass may be supported on a connecting structure in similar fashion to the balancing masses shown in Figures 1 and 3.

As compared with conventional tip seals, the base seals provide a relatively large area to absorb the force exerted by the opposed tip faces and so the wear rate of the base seals may be correspondingly lower. Additionally, wear should be lower since the tip faces of the scroll walls only contact a fraction of the surface area of the respective base seals at any given orbiting position. For the same reason, peak temperatures due to frictional heating of the base seals may be reduced. Also, as wear occurs, the scrolls will simply move closer together under the influence of the orbiting scroll biaser or biasers. This is particularly advantageous if the pump is operated at high speeds where the wear rates are generally higher.

When a scroll pump such as the pumps 10, 110 is initially assembled, minor differences in the scroll wall height may result in small leakages across the base seals. This can be at least reduced by providing a seal biaser between at least one scroll and the respective base seal such as the seal biasers 58, 60 shown in Figure 2.

- 10 -

Although not limited to these materials, the base seals may be made of polytetrafluoroethylene (PTFE) and, if provided, the seal biasers may comprise a relatively thin layer of expanded PTFE or another suitable plastics foam.

- 5 Advantageously a PTFE base seal has self-lubricating properties to facilitate sliding of the scroll wall tip faces over the base seal. In some examples, the base seal material may be loaded with a dry lubricant such as graphite to facilitate the sliding of the tip face over the base seal.

- 10 The base seals may be generally planar bodies and may be produced from a sheet material by, for example, laser cutting or stamping. The base seal may have a generally circular outer periphery. The base seal may be provided with a spiral groove to receive the scroll wall of a scroll. The spiral groove may have a width at least substantially corresponding to the width of the scroll wall where it meets the
- 15 base member.

The base seals may be secured to the scrolls by adhesives or mechanical fasteners such as screws.

- 20 Although not limited to this example, the scrolls may be hard anodised aluminium scrolls. The tip faces of the scroll walls may be provided with a fine finish, for example, by polishing, to facilitate sliding over a base seal. The scroll wall tips may also be chamfered or radiussed to facilitate sliding.
- 25 Conventionally scroll pumps have multiple bearings between the scroll driver and the orbiting scroll plate. This is to provide stiffness and prevent metal to metal contact between the orbiting and fixed scroll. In the illustrated examples, there is only one bearing between the scroll driver and the orbiting scroll. This provides compliance to allow the orbiting scroll to sit better against the fixed scroll with at least substantially
- 30 no swash action generated by imperfections in the alignment of the drive shaft, eccentric member and orbiting scroll with respect to the fixed scroll. Providing the orbiting scroll with one or more balancing masses to put the centre of mass of the

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orbiting scroll in the plane of the single bearing between the scroll driver and orbiting scroll at least substantially prevents tipping of the orbiting scroll, which may occur if scroll driver acts on the orbiting scroll behind the centre of mass.

- 5 The orbiting scroll biasers described in connection with the illustrated examples should not be taken as limiting. In principle, the orbiting scroll biaser, or biasers, may comprise any suitable resilient body, or bodies, capable of providing the required biasing force. In other examples, an orbiting scroll biaser may comprise a plurality of compression springs disposed at spaced intervals around the periphery of the scroll driver 14, 18. Such compression spring may be trapped, or located, between one or more suitable planar members such as washers that may be provided with projections to assist in locating an end of a compression spring.

- 15 It will be understood that although the orbiting scroll biasers shown in the drawings act directly on the bearing units, in other examples spacers, or washers may be interposed between a biaser and a bearing unit and that such spacers, or washers, may be provided with formations to assist in locating the biasers.

- 20 Although not limited to these specifications, the provision of base seals with orbital scroll biasing may allow the production of scroll pumps with an operating capacity of 0.1 to 0.4 m³/hr and an ultimate pressure of 0.1 mbar. Such pumps may operate at speeds of 3000 to 5000 rpm and have scroll walls with a thickness less than 1.0 mm. The scroll wall thickness may be in the range 0.5 to 1.0 mm or 0.7 to 1.0 mm.

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Claims

1. A scroll pump comprising:
 - an orbiting scroll;
 - 5 a fixed scroll;
 - a scroll driver configured to impart an orbiting motion to the orbiting scroll relative to the fixed scroll; and
 - at least one orbiting scroll biaser acting on said scroll driver to force said fixed and orbiting scrolls together;
 - 10 wherein said orbiting scroll comprises an orbiting scroll base member having a first major surface from which an orbiting scroll wall extends towards said fixed scroll and said fixed scroll comprises a fixed scroll base member having a second major surface from which a fixed scroll wall extends towards said orbiting scroll,
 - said orbiting scroll wall has an orbiting scroll tip face that faces said second
 - 15 major surface and said fixed scroll wall has a fixed scroll tip face that faces said first major surface,
 - said orbiting scroll base member is provided with a first base seal disposed between adjacent turns of said orbiting scroll wall, said first base seal slidably engaging said fixed scroll tip face to seal between said first major surface and said
 - 20 fixed scroll tip face, and
 - the fixed scroll base member is provided with a second base seal disposed between adjacent turns of said fixed scroll wall, said second base seal slidably engaged by said orbiting scroll tip face to seal between said second major surface and said orbiting scroll tip face.
 - 25
2. A scroll pump as claimed in claim 1, wherein said first and second base seals cover the respective major surfaces between said adjacent turns of the respective scroll walls.
- 30 3. A scroll pump as claimed in claim 1 or 2, wherein at least one of said first and second base seals is provided with a seal biaser disposed between the base seal

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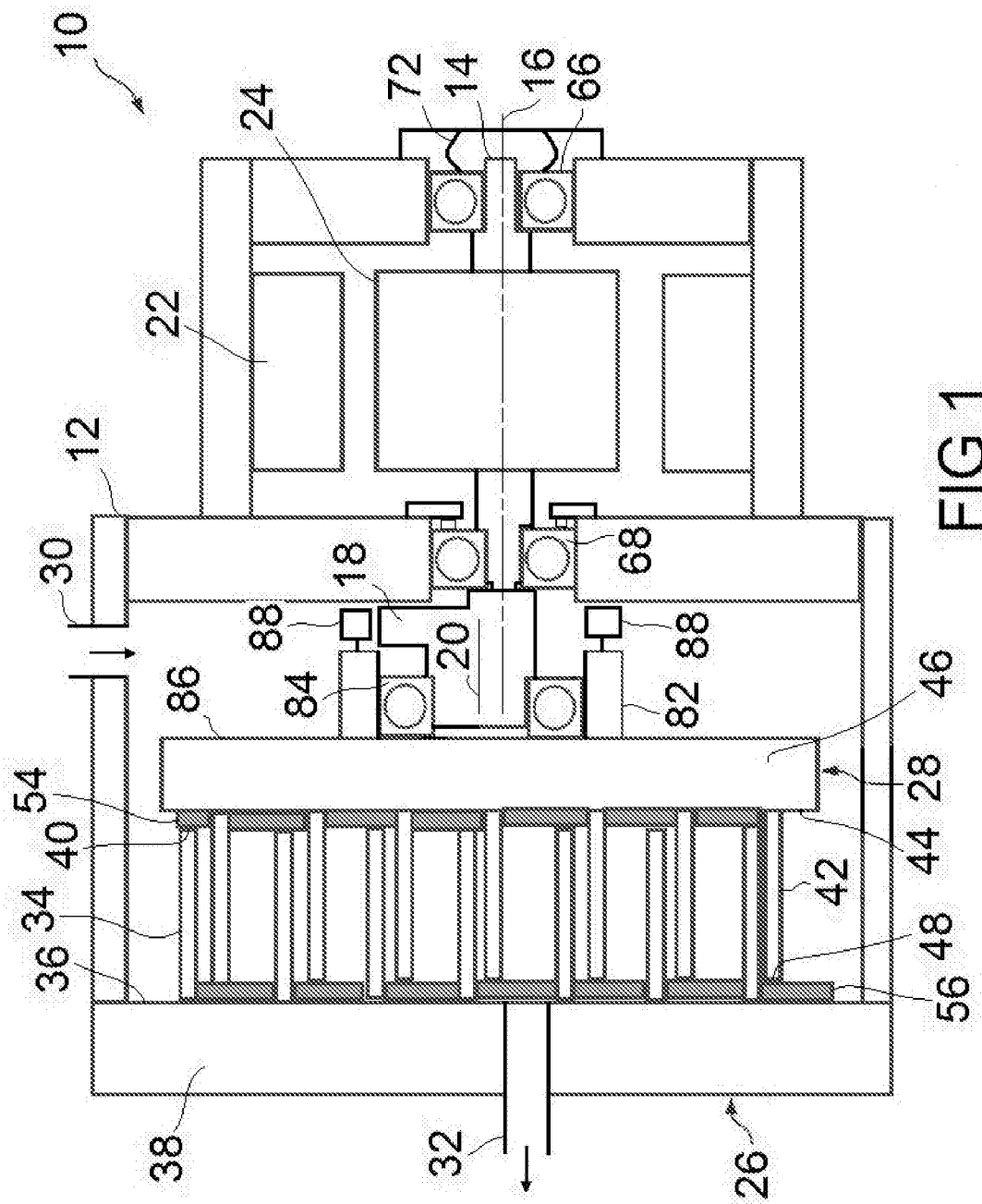
and the respective major surface to bias the base seal away from the respective major surface.

4. A scroll pump as claimed in claim 1, 2 or 3, wherein said scroll drive
5 comprises and a drive shaft and an eccentric member and further comprising a bearing system supporting said drive shaft at axially spaced apart locations.
5. A scroll pump as claimed in claim 4, wherein said bearing system comprises at
least two bearing units supporting said drive shaft, wherein said at least one
10 orbiting scroll biaser acts on at least one said bearing unit.
6. A scroll pump as claimed in claim 4, wherein said at least two bearing units
comprise a first bearing unit and a second bearing unit axially spaced apart
with respect to said first bearing unit, said bearing units each comprising at
15 least one rolling bearing.
7. A scroll pump as claimed in any one of the preceding claims, wherein said
orbiting scroll is connected with said scroll driver via a bearing carried by said
orbiting scroll and is provided with at least one balancing mass configured
20 such that the centre of mass of the orbiting scroll lies in a plane extending through the bearing and transverse to the axial centre line of the bearing.
8. A scroll pump as claimed in claim 7, wherein said bearing in said bearing
housing is a single rolling bearing.
25
9. A scroll pump as claimed in claim 7 or 8, wherein said orbiting scroll has a
first side that defines said first major surface and a second side disposed
opposite to and spaced from said first side and said at least one balancing mass
is connected with said second side such that said second side is disposed
30 between said first side and said at least one balancing mass.

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10. A scroll pump as claimed in claim 9, wherein said orbiting scroll comprises a bearing housing in which said bearing is housed, said bearing housing projects from said second side and said at least one balancing mass is configured such that said plane extends through said bearing housing parallel to said orbiting scroll base member.
11. A scroll pump as claimed in claim 10, wherein said bearing housing has an end that is spaced apart from said second side of said orbiting scroll base member by a first distance and said at least one balancing mass has at least one end disposed a second distance from said orbiting scroll base member that is greater than said first distance.
12. A scroll pump as claimed in any one of the preceding claims, wherein said bearing has a first side facing said fixed scroll base member and a second side facing away from said fixed scroll base member and spaced from said fixed scroll base member by a first distance and said at least one mass body has at least one end that is spaced from said fixed scroll base member a second distance that is greater than said first distance.
13. A scroll pump as claimed in any one of the preceding claims, wherein at least one of said fixed and orbiting scroll walls has an inner end disposed at a first radial distance $R1$ from an origin defined on the respective base member and an outer end disposed at a second radial distance from said origin and $R1$ is between $0.25R2$ and $0.5R2$.

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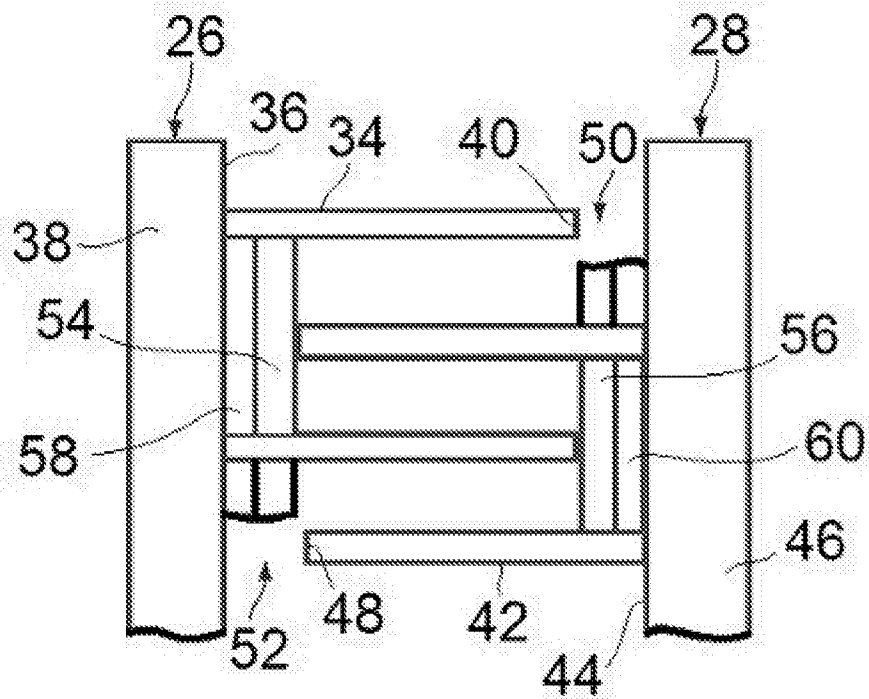


FIG 2

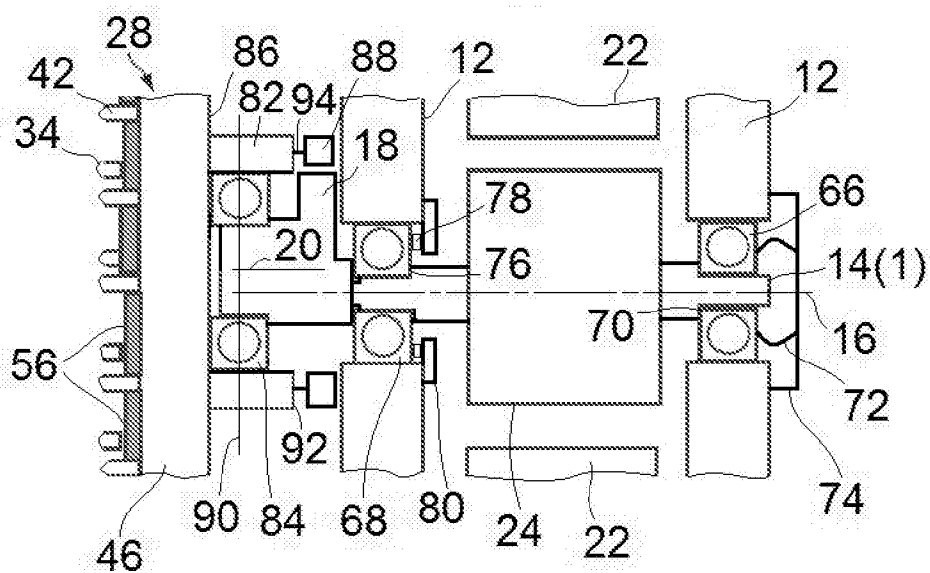


FIG 3

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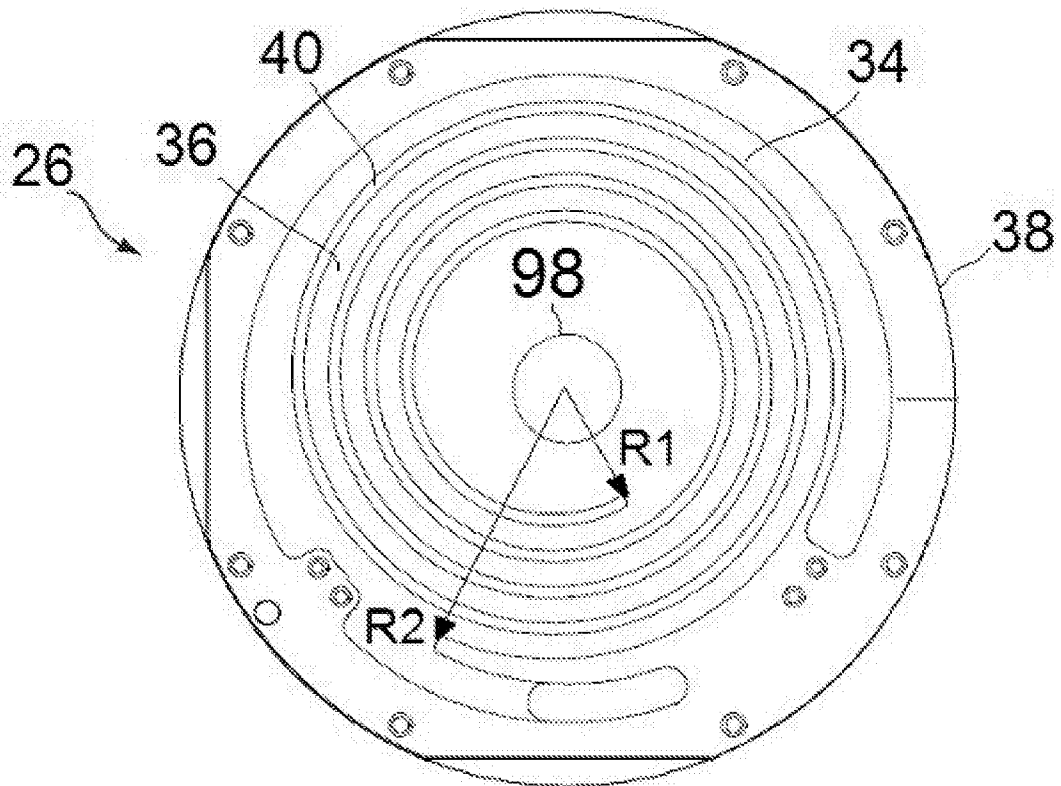


FIG 4

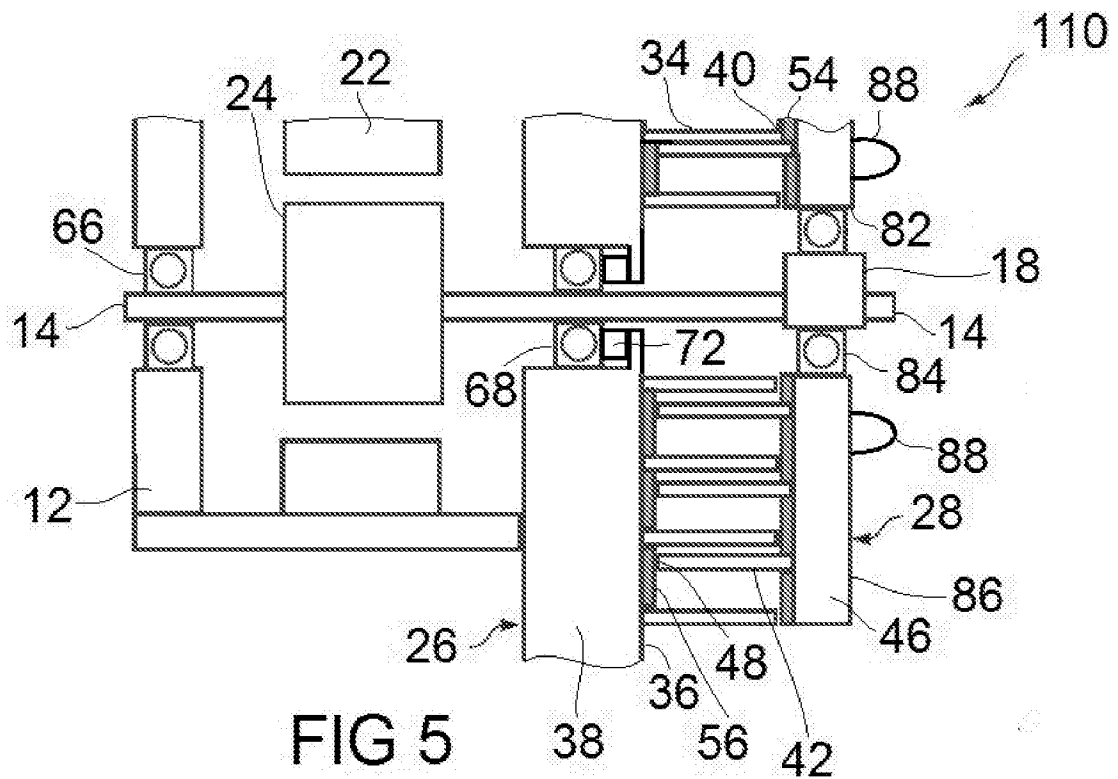


FIG 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2017/050688

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04C25/02 F04C27/00 F04C18/02
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04C

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

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

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 404 512 A2 (SANDEN CORP [JP]) 27 December 1990 (1990-12-27)	1-8,13
A	column 1, line 1 - line 5 column 5, line 50 - column 7, line 11 column 7, line 51 - column 8, line 11 column 8, line 29 - line 48 column 9, line 26 - line 53 column 11, line 27 - line 36 figures 1-5,14-16,17,22	9-12
A	----- WO 00/06906 A1 (VARIAN INC [US]) 10 February 2000 (2000-02-10) page 4, line 11 - page 7, line 30 figures ----- -/-	1-13



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

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