

- 1 -

MOLECULAR DRAG PUMPING MECHANISM

The present invention relates to a molecular drag pumping mechanism, and in particular to a Siegbahn pumping mechanism.

5

Molecular drag pumping mechanisms operate on the general principle that, at low pressures, gas molecules striking a fast moving surface can be given a velocity component from the moving surface. As a result, the molecules tend to take up the same direction of motion as the surface against which they strike, which urges the molecules through the pump and produces a relatively higher pressure in the vicinity of the pump exhaust.

These pumping mechanisms generally comprise a rotor and a stator provided with one or more helical or spiral channels opposing the rotor. One type of molecular drag pumping mechanism is a Siegbahn pumping mechanism, which comprises a rotating planar element opposing a disk-like stator element defining spiral channels that extend from the outer periphery of the stator towards the centre of the stator.

Figure 1 is a cross-sectional view of part of a vacuum pump including a multi-stage Siegbahn pumping mechanism. The vacuum pump comprises a drive shaft 10 supported by sets of bearings 12 for rotation about longitudinal axis 14 by motor 16. An impeller 18 is mounted on the drive shaft 10 for rotation therewith. The impeller 18 comprises a plurality of rotor elements 20 of the Siegbahn pumping mechanism, the rotor elements 20 being in the form of planar, disk-like members extending outwardly from the drive shaft 10, substantially orthogonal to the axis 14. A plurality of stator elements 22 of the Siegbahn pumping mechanism are located between the rotor elements 20. As illustrated in more detail in Figure 2, each stator element 22 comprises a plurality of walls 24, 25 located on each respective side thereof. The walls 24 define a plurality of spiral flow channels 26 on one side of the stator element

30

- 2 -

22, and the walls 25 define a plurality of spiral flow channels 27 on the other side of the stator element 22.

5 The spiral flow channels 26 are configured to generate a pumping action with rotation of the drive shaft 10, and thus with rotation of the rotor element located adjacent the flow channels 26, that creates a gas flow on one side of the stator element 22 from the outer rim 28 of the stator element 22 towards a central aperture 30 of the stator element 16. Conversely, the spiral flow channels 27 are configured to generate a pumping action that creates a gas
10 flow, on the other side of the stator element 22, from the central aperture 30 backs towards the outer rim 28 of the stator element 22, from which the gas flows towards the next stage of the pumping mechanism.

During pump assembly, the impeller 18 is mounted on the drive shaft 10, and
15 the stator elements 22 are progressively assembled between the rotor elements 20 of the impeller 18. In one known assembly technique, each stator element 22 is divided into two semi-annular sections 32, 34 by diametrically sectioning the stator element 22. The two sections 32, 34 of each stator element 22 are radially inserted between a respective pair of rotor
20 elements 20 of the impeller 18 so that the sections 32, 34 re-form the annular stator elements 22, with the outer rim 28 of one stator element 22 resting on the outer rim 28 of the adjacent stator element 22. A casing 36 is then assembled about the stator elements 22 in order to retain the stator elements 22 relative to the impeller 18.

25 The sectioning of the stator elements 22 creates an air gap 40 between the sectioned faces of the two sections 32, 34 of each stator element 22 in the assembled vacuum pump. This air gap 40 opens a leakage path, indicated by arrows 42 in Figures 1 and 2, between the flow channels 27, 25 through the
30 thickness of the stator element 22, and about the stator element 22, that is, between the stator element 22 and the casing 36. In order to minimise the size of the air gap 40 between the sections 32, 34 of the stator elements 22,

- 3 -

expensive wire erosion techniques are used to section the stator elements 22, reducing the size of the air gap to between 100 and 150 μm . However, we have found that the presence of an air gap of this size can still severely compromise the compression of the Siegbahn pumping mechanism.

5

In a first aspect, the present invention provides a Siegbahn pumping mechanism comprising a rotor element and a stator element located proximate the rotor element, one of the rotor element and the stator element comprising a plurality of walls extending towards the other of the rotor element and the stator element and defining a plurality of spiral channels, the stator
10 element comprising a plurality of sections and means for bringing the sections into contact.

By providing means for bringing the sections of the stator element into
15 contact, the size of the air gap between the sections can be reduced, and therefore the rate at which gas leaks between the sections of the stator element can be reduced. This can significantly improve the gas compression of the pumping mechanism.

20 For example, a rigid slide ring or a chain may be located around the sections of the stator element in order to bring the sections together. Alternatively, the means for bringing the sections into contact may be conveniently provided by a means for urging the sections together. For example, a resilient member may be located about the periphery of the sections for urging the sections into
25 contact. This resilient member may comprise an O-ring sealing element encircling the sections. Having the means for bringing the sections into contact located about the periphery of the sections can also provide a seal extending about the stator element for engaging the inner surface of a casing located about the Siegbahn pumping mechanism, and thereby inhibiting gas
30 flow between the casing and the stator element.

- 4 -

Said one of the rotor element and the stator element may be produced by casting and/or by machining. The plurality of walls are preferably formed in the stator element, although alternatively the plurality of walls may be formed in the rotor element.

5

The present invention also provides a vacuum pump comprising at least one Siegbahn pumping mechanism as aforementioned. In a second aspect, the present invention provides a vacuum pump comprising a drive shaft, and a Siegbahn pumping mechanism comprising a rotor element located on the drive shaft and an annular stator element located about the drive shaft and proximate the rotor element, one of the rotor element and the stator element comprising a plurality of walls extending towards the other of the rotor element and the stator element and defining a plurality of spiral channels, the stator element comprising a plurality of sections and means for bringing the sections into contact.

15

The Siegbahn pumping mechanism may comprise a plurality of rotor elements located on the drive shaft and a plurality of stator elements located between the rotor elements, each stator element comprising means for bringing the sections of that stator element into contact. The means for bringing the sections of the, or each, stator element together may be as aforementioned in respect of the first aspect of the invention.

20

The vacuum pump may comprise at least one turbomolecular pumping stage upstream from the Siegbahn pumping mechanism. The vacuum pump may also comprise additional molecular drag and/or fluid dynamic stages downstream of the Siegbahn pumping mechanism. Examples of these downstream stages include Holweck, Gaede and/or regenerative pumping mechanisms.

25

30

Preferred features of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

- 5 -

Figure 1 is a cross-sectional view of part of a known vacuum pump comprising a Siegbahn pumping mechanism;

- 5 Figure 2 is a perspective view of a stator element of the mechanism of Figure 1; and

Figure 3 is a cross-sectional view of a part of an example of a vacuum pump comprising a Siegbahn pumping mechanism.

10

Figure 3 illustrates part of a vacuum pump. The vacuum pump comprises a drive shaft 100 supported by sets of bearings 102 for rotation about longitudinal axis 104 by motor 106. An impeller 108 is mounted on the drive shaft 100 for rotation therewith. The impeller 108 comprises a plurality of
15 rotor elements 110, 112, 114 of a Siegbahn pumping mechanism. In this example, the rotor elements are in the form of planar, disk-like members extending outwardly from the drive shaft 100, substantially orthogonal to the axis 104.

- 20 A plurality of stator elements of the Siegbahn pumping mechanism are located between the rotor elements. In this example, the Siegbahn pumping mechanism comprises three rotor elements 110, 112, 114 and two stator elements 120, 122, although any number of rotor elements and stator elements may be provided as required in order to meet the required pumping
25 performance of the vacuum pump.

- Each stator element 120, 122 is in the form of an annular stator element, and comprises a plurality of walls that extend towards an adjacent rotor element. For example, with reference to stator element 120, the stator element 120
30 comprises a plurality of walls 124, 125 located on each respective side thereof. The walls 124 extend towards rotor element 110, and define a plurality of spiral flow channels 126 on one side of the stator element. The

- 6 -

walls 125 extend towards rotor element 112, and define a plurality of spiral flow channels 127 on the other side of the stator element. Stator element 122 is configured in a similar manner to stator element 120.

- 5 The height of the walls of the stator elements 120, 122 decreases axially along the Siegbahn pumping mechanism, that is axially from the inlet 130 of the pumping mechanism towards the outlet 132 of the pumping mechanism, so that the volumes of the flow channels gradually decrease towards the outlet 132 to compress gas passing through the pumping mechanism.

10

Each stator element is sectioned into a plurality of sections which are assembled about the drive shaft 100. In this example, each stator element comprises two semi-annular sections. The stator elements may be sectioned by any suitable process, for example by wire erosion.

15

- To assemble the pumping mechanism, the impeller 108 is mounted on the drive shaft 100, and the stator elements 120, 122 are progressively assembled between the rotor elements of the impeller 18. The sections 140, 142 of the stator element 122 are first located between the rotor elements 20 112, 114, with the lower surface of the outer rim of the stator element 122 engaging the upper surface 134 of a housing 136 extending about the motor 106. The sections 140, 142 of the stator element 122 are then brought into contact by a resilient member 144 which is located about the outer periphery 146 of the stator element 122 and which urges the sections 140, 142 towards 25 the drive shaft 100 and thus into contact along the sectioned faces of the sections 140, 142. In this example, the resilient member 144 is provided by a resilient O-ring sealing member, preferably formed from elastomeric material. A groove may be provided about the periphery of the stator element 122 to facilitate location of the resilient member 144 thereabout.

30

The sections 150, 152 of the stator element 120 are then located between the rotor elements 110, 112, with the lower surface of the outer rim of the stator

- 7 -

element 120 engaging the upper surface of the outer rim of the stator element 122. The sections 150, 152 of the stator element 120 are then brought into contact by a resilient member 154 which is located about the outer periphery 156 of the stator element 120. Again, this resilient member 154 may be
5 provided by a resilient O-ring sealing member.

Following assembly of the Siegbahn pumping mechanism, and of any pumping mechanism located upstream from this pumping mechanism, such as a turbomolecular pumping mechanism, a casing 160 is assembled about
10 the stator elements 120, 122 in order to retain the stator elements 120, 122 relative to the impeller 108. As illustrated in Figure 3, the inner surface of the casing 160 engages the resilient members 144, 154.

During use of the pump, gas is conveyed into the Siegbahn pumping
15 mechanism through the inlet 130 thereof. The rotation of the rotor element 110 relative to the stator element 120 generates a pumping action that causes gas to flow along the flow channels 126 on one side of the stator element 120 from the outer rim of the stator element towards a central aperture 170 of the stator element 120. The rotation of the rotor element 112 relative to the stator
20 element 120 generates a similar pumping action that causes gas to flow on the other side of the stator element 120 along the flow channels 127 from the central aperture 170 back towards the outer periphery of the stator element 120, from which the gas flows into the flow channels of the stator element 122 to be pumped, in a similar manner, towards the outlet 132 of the pumping
25 mechanism.

The provision of the resilient members 144, 154 serves a number of purposes. Firstly, by bringing the sections of each respective stator element 120, 122 into contact, the leakage of gas between the sections can be
30 significantly reduced, thereby improving the compression of the Siegbahn pumping mechanism. Secondly, by providing an annular sealing member about each stator element and which contacts the inner surface of the casing

- 8 -

160 for the pumping mechanism, the leakage of gas between the stator elements and the casing can be inhibited.

What is claimed is:

1. A Siegbahn pumping mechanism comprising a rotor element and a stator element located proximate the rotor element, one of the rotor element and the stator element comprising a plurality of walls extending towards the other of the rotor element and the stator element and defining a plurality of spiral channels, the stator element comprising a plurality of sections assembled together and means for bringing the sections into contact to reduce a gap between the sections.
2. A pumping mechanism according to Claim 1, wherein the means for bringing the sections into contact comprises means for urging the sections into contact.
3. A pumping mechanism according to Claim 1 or Claim 2, wherein the means for bringing the sections into contact extends about the sections and forms a seal with a casing surrounding the rotor and stator elements.
4. A pumping mechanism according to any one of claims 1 to 3, wherein the means for bringing the sections into contact comprises a resilient member extending about the sections.
5. A pumping mechanism according to Claim 4, wherein the resilient member comprises an O-ring sealing element.
6. A vacuum pump comprising at least one Siegbahn pumping mechanism according to any one of claims 1 to 5.

7. A vacuum pump comprising a drive shaft, and a Siegbahn pumping mechanism comprising a rotor element located on the drive shaft and an annular stator element located about the drive shaft and proximate the rotor element, one of the rotor element and the stator element comprising a plurality of walls extending towards the other of the rotor element and the stator element and defining a plurality of spiral channels, the stator element comprising a plurality of sections assembled together and means for bringing the sections into contact to reduce a gap between the sections.
8. A vacuum pump according to Claim 7, wherein the means for bringing the sections together comprises means for urging the sections towards the drive shaft.
9. A vacuum pump according to Claim 7 or Claim 8, wherein the means for bringing the sections into contact extends about the sections and forms a seal with a casing surrounding the rotor and stator elements.
10. A vacuum pump according to any of Claims 7 to 9, wherein the means for bringing the sections into contact comprises a resilient member extending about the sections.
11. A vacuum pump according to Claim 10, wherein the resilient member comprises a resilient, O-ring sealing element.
12. A vacuum pump according to any of Claims 7 to 11, wherein the Siegbahn pumping mechanism comprises a plurality of said rotor elements located on the drive shaft and a plurality of said annular stator elements located between the rotor elements, each stator element comprising means for bringing the sections of that stator element into

contact.

13. A vacuum pump according to any of Claims 7 to 12, comprising at least one turbomolecular pumping stage upstream from the Siegbahn pumping mechanism.
14. A vacuum pump according to any of Claims 7 to 13, comprising at least one pumping mechanism downstream from the Siegbahn pumping mechanism.
15. A vacuum pump according to Claim 14, wherein said at least one pumping mechanism comprises at least one of a Holweck pumping mechanism, a Gaede pumping mechanism and a regenerative pumping mechanism.