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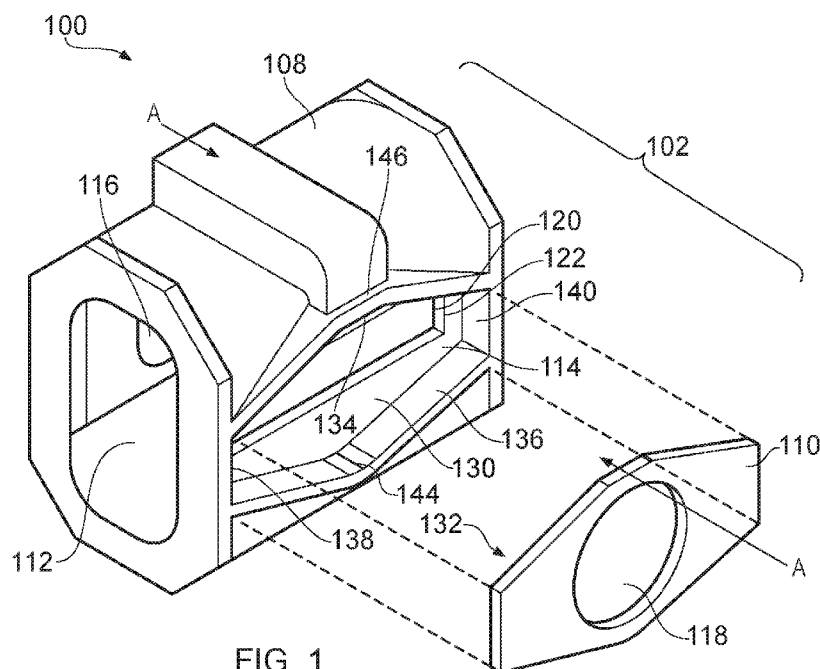
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(54) Title: VACUUM PUMP EXHAUST SYSTEM



(57) Abstract: A vacuum pump exhaust system comprising: a housing (102) having an inlet (122) via which a pumped gas is received and an outlet (118) via which the pumped gas is expelled; and an aftercooler plenum (114) defined between the inlet (122) and the outlet (118); wherein at least a portion of a bottom surface (136) of said aftercooler plenum (114) is recessed, thereby to define a recessed portion; and a lowest point (144) of the recessed portion is contiguous with the outlet (118).

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VACUUM PUMP EXHAUST SYSTEM

FIELD OF THE INVENTION

The present invention relates to vacuum pump exhaust systems, and more
5 particularly to vacuum pump exhaust systems which comprise aftercooler
plenums for housing aftercoolers for cooling pumping gases prior to being
exhausted from the vacuum pump.

BACKGROUND

10 Vacuum pumps are used in various technical processes to pump gases
out of process chambers, thereby to create low-pressure conditions for the
respective processes.

In many applications, it is desirable to cool the gases being pumped prior
to their being processed or used. Conventionally, such cooling is typically
15 accomplished by passing the pumped gas through an aftercooler plenum of a
vacuum pump, i.e. a chamber or plenum that comprises an aftercooler.

SUMMARY OF THE INVENTION

The present inventors have realised that liquid may be present in a fluid
20 (e.g. a gas) that is pumped by a vacuum pump. For example, the present
inventors have realised that cooling of process gases by aftercoolers tends to
cause vapour in the pumped gas to condense within the aftercooler plenum,
thereby to form liquid.

For some processes, this liquid may be flammable, corrosive, or otherwise
25 hazardous. As such, it is undesirable that the liquid builds up within the pump, for
example in the aftercooler plenum or sump.

Accordingly, there is provided a self-draining or passively-draining
aftercooler plenum. Advantageously, liquid and other debris that collects within

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the aftercooler plenum tends to drain from the aftercooler plenum without the need for sumps or active liquid removal means for collecting and removing liquid.

In an aspect, there is provided a vacuum pump exhaust system comprising a housing having an inlet via which a pumped gas is received and an outlet via
5 which the pumped gas is expelled, and an aftercooler plenum defined between the inlet and the outlet. At least a portion of a bottom surface of said aftercooler plenum is recessed, thereby to define a recessed portion. A lowest point of the recessed portion is contiguous with the outlet.

The bottom surface may be a surface selected from the group of surfaces
10 consisting of a sloped surface, a tapered surface, a substantially V-shaped surface, and a substantially U-shaped surface.

The housing may comprise: a first end wall comprising the inlet; a second end wall comprising the outlet, the second wall being opposite to the first end wall; and a bottom wall extending between the first end wall and the second end wall, the bottom wall defining the bottom surface. The walls of the housing may
15 at least partially define the aftercooler plenum for receiving an aftercooler. The housing may further comprise: a top wall extending between the first end wall and the second end wall, the top wall being opposite to the bottom wall; a first side wall extending between the first end wall and the second end wall and between
20 the top wall and the bottom wall; and a second side wall extending between the first end wall and the second end wall and between the top wall and the bottom wall, the second side wall being opposite to the first side wall. The lowest point of the recessed portion may be substantially equidistant between the first side wall and the second side wall. The top wall may define a top surface of the aftercooler
25 plenum. At least a part of said top surface may be recessed, thereby to define a further recessed portion. An uppermost point of the further recessed portion may be contiguous with the outlet. The uppermost point of the further recessed portion may be substantially equidistant between the first side wall and the second side wall. The second end wall may be formed from a removable cover that is
30 removably attached to the rest of the housing.

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In a further aspect, there is provided a vacuum pump comprising the vacuum pump exhaust system of any preceding aspect.

The vacuum pump may further comprise a pumping chamber comprising a pumping chamber inlet, a pumping chamber outlet, and pumping means
5 configured to pump fluid into the pumping chamber inlet and out of the pumping chamber outlet. The pumping chamber outlet may be in fluid communication with the inlet of the vacuum pump exhaust system.

The vacuum pump may further comprise an aftercooler housed within the aftercooler plenum.

10 The vacuum pump may be a vacuum pump selected from the group of vacuum pumps consisting of: a booster pump, a Roots pump, a positive displacement pump, and a positive displacement rotary lobe pump.

The vacuum pump may be configured to pump fluid on a substantially horizontal direction.

15 In a further aspect, there is provided a kit comprising: a body portion comprising: a first end wall comprising an inlet; and a bottom wall extending from the first end wall and defining a bottom surface; and a cover. The cover is configured to be attached to the body portion thereby to form a second end wall
20 opposite to the first end wall such that the bottom wall extends between the first end wall and the second end wall. The cover comprises an opening. At least a portion of a bottom surface is recessed, thereby to define a recessed portion. When the cover is attached to the body portion thereby to form the second end wall, a lowest point of the recessed portion is contiguous with the opening in the cover.

25

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustration (not to scale) showing an exploded perspective view of a vacuum pump;

Figure 2 is a schematic illustration (not to scale) showing a side view cross
30 section of the vacuum pump; and

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Figure 3 is a schematic illustration (not to scale) showing a front view of the vacuum pump.

DETAILED DESCRIPTION

5 It will be appreciated that relative terms such as above and below, horizontal and vertical, top and bottom, front and back, and so on, are used herein merely for ease of reference to the Figures, and these terms are not limiting as such, and any two differing directions or positions and so on may be implemented rather than truly above and below, horizontal and vertical, top and bottom, and
10 so on.

Figure 1 is a schematic illustration (not to scale) showing an exploded perspective view of a vacuum pump 100.

Figure 2 is a schematic illustration (not to scale) showing a side view cross section of the vacuum pump 100, taken along line A-A shown in Figure 1.

15 Figure 3 is a schematic illustration (not to scale) showing a front view of the vacuum pump 100.

The vacuum pump 100 may be any appropriate type of vacuum pump, including, but not limited to, a vacuum pump selected from the group of vacuum pumps consisting of: a booster pump, a Roots pump, a Roots-type pump, a
20 positive displacement pump, and a positive displacement rotary lobe pump.

In this embodiment, the vacuum pump 100 comprises a housing 102 that houses a pumping means 104 and an aftercooler 106. The pumping means 104 and the aftercooler 106 are shown schematically in Figure 2.

The pumping means 104 may be any appropriate pumping means, for
25 example a pair of meshing lobes that rotate so as to move a fluid through the pump 100.

The aftercooler 106 may be any appropriate type of aftercooler, for example a liquid-cooled (e.g. water-cooled) aftercooler, or a gas-cooled (e.g. air-cooled) aftercooler.

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The housing 102 comprises a body portion 108 and a cover 110. In this embodiment, the cover 100 is removably attached to a front side of the body portion 108.

5 The body portion 108 of the housing 102 defines a pumping chamber 112 in which the pumping means 104 is located.

The body portion 108 and the cover 110 together define an aftercooler plenum 114 in which the aftercooler 106 is located.

10 The housing 102 comprises a pump inlet 116 at a rear side of the housing 102 and a pump outlet 118 at a front side of the housing 102, opposite to the rear side of the housing 102. In particular, the body portion 108 of the housing comprises an opening at its rear side that forms the pump inlet 116. Also, the cover 110 comprises an opening therethrough that forms the pump outlet 118. In this embodiment, the opening through the cover 110 that forms the pump outlet 118 is a substantially circular opening through a central portion of the cover 110.

15 The pumping chamber 112 and the aftercooler plenum 114 are fluidly connected between the pump inlet 116 and the pump outlet 118. More specifically, the pump inlet 116 is an inlet to the pumping chamber 112, i.e. a pumping chamber inlet. The pumping chamber 112 further comprises a pumping chamber outlet 120 opposite to the pump inlet 116. The pumping chamber outlet 20 120 forms, or is fluidly connected to, an inlet of the aftercooler plenum 114, hereinafter referred to as the "plenum inlet" 122. The pump outlet 118 is an outlet of the aftercooler plenum 114, and is defined by the cover 110 which further defines a side of the aftercooler plenum 114 opposite to the side on which the plenum inlet 122 is located.

25 In this embodiment, the aftercooler plenum 114 is defined by a rear wall 130, a front wall 132, a top wall 134, a bottom wall 136, a first side wall 138, and a second side wall 140.

The rear wall 130 is defined by an internal surface of the base portion 108 of the housing 102.

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The front wall 132 is positioned opposite to the rear wall 130. The front wall 132 is defined by the cover 110. In particular, a front surface of the aftercooler plenum 114 that is defined by the front wall 132 is a rear, or internal, surface of the cover 110.

5 The top wall 134 extends between the rear wall 130 and the front wall 132. The top wall 134 is defined by an internal surface of the base portion 108 of the housing 102.

 The bottom wall 136 extends between the rear wall 130 and the front wall 132. The bottom wall 136 is defined by an internal surface of the base portion
10 108 of the housing 102. The bottom wall 136 is positioned opposite to the top wall 134.

 The first side wall 138 extends between the rear wall 130 and the front wall 132 and between the top wall 134 and the bottom wall 136. The first side wall 138 is defined by an internal surface of the base portion 108 of the housing 102.

15 The second side wall 140 extends between the rear wall 130 and the front wall 132 and between the top wall 134 and the bottom wall 136. The second side wall 140 is defined by an internal surface of the base portion 108 of the housing 102. The second side wall 140 is positioned opposite to the first side wall 138.

 The bottom wall 136 defines a bottom surface of the aftercooler plenum
20 114. In this embodiment, the bottom wall 136 comprises a recess or is recessed. In particular, in this embodiment, the bottom wall 136 is recessed with respect to the horizontal (i.e. a horizontal line 142 passing through the pump 100, as shown in Figure 3). Thus, the bottom surface of the aftercooler plenum 114 is recessed or comprises a recess.

25 In particular, in this embodiment, the bottom surface of the aftercooler plenum 114 is substantially V-shaped, for example when viewed from the front as shown in Figure 3. In other words, the bottom surface of the aftercooler plenum 114 slopes downwards from both of the side walls 138, 140 to a lowest point or line (i.e. the vertex 144) of the bottom surface between the two side walls 138,
30 140.

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The vertex 144 of the V-shaped bottom surface may be sharp, or may be curved. In some embodiments, the vertex 144 is substantially equidistant from the first side wall 138 and the second side wall 140.

In this embodiment, the vertex 144 is a lowermost point or line on the
5 bottom surface of the aftercooler plenum 114, i.e. when the pump is oriented horizontally as shown in the Figures.

In this embodiment, the vertex 144 is substantially contiguous with the outlet 118. The vertex 144 may be considered to abut, share a boundary with, join, be connected to, or be coincident with the opening 118. Thus, when viewed
10 from the front, as shown in Figure 3, the vertex 144 is coincident with a perimeter of the outlet 118, or lies within an area bounded by the perimeter of the opening 118.

In operation, the vacuum pump 100 may operate in a so-called horizontal flow condition to pump a fluid (e.g. a gas) along a substantially horizontal
15 direction. In particular, the pumping means 104 pumps a fluid into the pumping chamber 112 via the pump inlet, as indicated in Figure 2 by an arrow and the reference numeral 150. The pumping means 104 then pumps the fluid through and out of the pumping chamber 112 into the aftercooler plenum 114 via the pumping chamber outlet 120 and the plenum inlet 122, as indicated in Figure 2
20 by an arrow and the reference numeral 152. The pumping means 104 then pumps the fluid through the aftercooler plenum 114, over or through the aftercooler 104, and out of the aftercooler plenum 114 via the pump outlet 118, as indicated in Figure 2 by an arrow and the reference numeral 154. The aftercooler 106 within the aftercooler plenum 114 cools the fluid passing over or through it. Thus, the
25 fluid exiting the pump 100 is cooled compared to the fluid entering the aftercooler. The gas leaving the pump may typically be hotter than when it entered the pump due to work done on the gas, even with aftercooling.

The fluid pumped by the pump 100 may comprise a liquid, e.g. in droplet or vapour form. This liquid be deposited within the aftercooler plenum 114. For
30 example, the cooling of the pumped gas by the aftercoolers may cause vapour in the pumped gas to condense within the aftercooler plenum, thereby to form liquid.

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This liquid tends to collect on the bottom surface (i.e. the bottom wall 136) of the aftercooler plenum 114 due to gravity. Advantageously, due to the V-shape of the bottom surface, i.e. due to the sloping of the bottom wall 136, this liquid tends to flow, due to gravity, towards the vertex 144 of the bottom wall 136, and thus out
5 of the outlet 118 of the pump 100.

For some processes, this liquid may be flammable, corrosive, or otherwise hazardous. Thus, the draining of the liquid from the pump tends to reduce build-up of the liquid within the pump, reducing the likelihood of corrosion or other damage to the pump, and/or reducing the risk of fire or explosion within the pump.

10 The aftercooler plenum 114, e.g. the exhaust plenum, of the vacuum pump 100 tends to be self-draining or passively-draining. Liquid that collects within the aftercooler plenum tends to drain from the aftercooler plenum without need for sumps or active liquid removal means for collecting and removing liquid.

Furthermore, advantageously the liquid that collects within the aftercooler
15 plenum tends to drain from the aftercooler plenum via the same outlet from which the pumped gas is pumped. Thus, advantageously, a need for additional drainage holes via which pumped gas (which could be flammable or otherwise hazardous) could undesirably escape from the pump tends to be reduced or eliminated.

Advantageously, the vertex 144 being substantially contiguous with the
20 outlet 118 provides that there is no lip or retaining wall between the bottom of the aftercooler plenum 114 and the outlet which could retain collected liquid and debris.

Advantageously, the above-described aftercooler plenum provides that liquids or debris tends to drain from the pump under gravity, either during
25 pumping or during a cleaning flush. The frequency with which the pump is cleaned may be reduced.

In some embodiments, an internal surface of at least a part of the aftercooler plenum may be coated with an anti-corrosion coating, such as a corrosion-inhibiting paint or surface treatment. Examples of such coatings
30 include, but are not limited to, a electrophoretic dip coating on cast iron, or anodising on cast aluminium.

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In this embodiment, the top wall 134 defines a top surface of the aftercooler plenum 114. In this embodiment, the top wall 134 comprises a recess or is recessed. In particular, in this embodiment, the top wall 134 is recessed with respect to the horizontal (i.e. the horizontal line 142). Thus, the top surface of the aftercooler plenum 114 is recessed or comprises a recess.

In particular, in this embodiment, the top surface of the aftercooler plenum 114 is substantially V-shaped. More specifically, when viewed from the front as shown in Figure 3, the top surface of the aftercooler plenum 114 has the shape of an inverted-V, i.e. a circumflex or caret. In other words, the top surface of the aftercooler plenum 114 slopes upwards from both of the side walls 138, 140 to a highest or uppermost point or line (i.e. a further vertex 146) of the top surface between the two side walls 138, 140.

The further vertex 146 of the inverted-V shaped top surface may be sharp, or may be curved. In some embodiments, the further vertex 146 is substantially equidistant from the first side wall 138 and the second side wall 140.

In this embodiment, the further vertex 146 is an uppermost point or line on the top surface of the aftercooler plenum 114, i.e. when the pump is oriented horizontally as shown in the Figures.

In this embodiment, the further vertex 146 is substantially contiguous with the outlet 118. The further vertex 146 may be considered to abut, share a boundary with, join, be connected to, or be coincident with the opening 118. Thus, when viewed from the front, as shown in Figure 3, the further vertex 146 is coincident with a perimeter of the outlet 118, or lies within an area bounded by the perimeter of the opening 118.

Advantageously, the inverted-V shaped top wall 134 and the further vertex 146 being substantially contiguous with the outlet 118 tends to allow for the aftercooler plenum 114 to be self-draining when “upside-down”, i.e. both in the orientation shown in the Figures, and also when flipped 180°.

In the above-embodiments, the bottom surface defined by the bottom wall of the aftercooler plenum is a V-shaped surface. However, in other embodiments, the bottom surface has a different shape such that at least a portion of the bottom

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surface of the aftercooler plenum is recessed, thereby to define a recessed portion, and a lowest point of this recessed portion is contiguous with the outlet. By way of example, the bottom surface may be a surface selected from the group of surfaces consisting of a sloped surface, a tapered surface, a substantially V-shaped surface, and a substantially U-shaped surface.

In the above-embodiments, the top surface defined by the top wall of the aftercooler plenum is an inverted-V shaped surface. However, in other embodiments, the top surface has a different shape. For example, in some embodiments, the top surface of the aftercooler plenum is not recessed and does not comprise a recessed portion. The top surface may, for example, be substantially flat. In some embodiments, the top surface has a different shape such that at least a portion of the top surface of the aftercooler plenum is recessed, thereby to define a recessed portion, and an uppermost point of this recessed portion is contiguous with the outlet. By way of example, the top surface may be a surface selected from the group of surfaces consisting of a sloped surface, a tapered surface, a substantially (inverted) V-shaped surface, and a substantially (inverted) U-shaped surface.

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REFERENCE NUMERAL LIST

- 100 – vacuum pump
- 102 – housing
- 104 – pumping means
- 5 106 – aftercooler
- 108 – body portion
- 110 – cover
- 112 – pumping chamber
- 114 – aftercooler plenum
- 10 116 – pump inlet
- 118 – pump outlet
- 120 – pumping chamber outlet
- 122 – plenum inlet
- 130 – rear wall
- 15 132 – front wall
- 134 – top wall
- 136 – bottom wall
- 138 – first side wall
- 140 – second side wall
- 20 142 – horizontal line
- 144 – vertex
- 146 – further vertex
- 150, 152, 154 – direction of fluid flow

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CLAIMS

1. A vacuum pump exhaust system comprising:
 - a housing having an inlet via which a pumped gas is received and an outlet via which the pumped gas is expelled; and
 - 5 an aftercooler plenum defined between the inlet and the outlet; wherein at least a portion of a bottom surface of said aftercooler plenum is recessed, thereby to define a recessed portion; and
 - a lowest point of the recessed portion is contiguous with the outlet.
- 10 2. The vacuum pump exhaust system of claim 1, wherein the bottom surface is a surface selected from the group of surfaces consisting of a sloped surface, a tapered surface, a substantially V-shaped surface, and a substantially U-shaped surface.
- 15 3. The vacuum pump exhaust system of claim 1 or 2, wherein:
 - the housing comprises:
 - a first end wall comprising the inlet;
 - a second end wall comprising the outlet, the second wall being opposite to the first end wall; and
 - 20 a bottom wall extending between the first end wall and the second end wall, the bottom wall defining the bottom surface; and
 - the walls of the housing at least partially define the aftercooler plenum for receiving an aftercooler.
- 25 4. The vacuum pump exhaust system of claim 3, wherein:
 - the housing further comprises:

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a top wall extending between the first end wall and the second end wall, the top wall being opposite to the bottom wall;

a first side wall extending between the first end wall and the second end wall and between the top wall and the bottom wall; and

5 a second side wall extending between the first end wall and the second end wall and between the top wall and the bottom wall, the second side wall being opposite to the first side wall.

5. The vacuum pump exhaust system of claim 4, wherein the lowest point of
10 the recessed portion is substantially equidistant between the first side wall and the second side wall.

6. The vacuum pump exhaust system of claim 4 or 5, wherein:
the top wall defines a top surface of the aftercooler plenum;
15 at least a part of said top surface is recessed, thereby to define a further recessed portion; and
an uppermost point of the further recessed portion is contiguous with the outlet.

20 7. The vacuum pump exhaust system of claim 6, wherein the uppermost point of the further recessed portion is substantially equidistant between the first side wall and the second side wall.

8. The vacuum pump exhaust system of any of claims 3 to 7, wherein the
25 second end wall is formed from a removable cover that is removably attached to the rest of the housing.

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9. A vacuum pump comprising the vacuum pump exhaust system of any of claims 1 to 8.

10. The vacuum pump of claim 9, further comprising

5 a pumping chamber comprising:

a pumping chamber inlet;

a pumping chamber outlet; and

pumping means configured to pump fluid into the pumping chamber inlet and out of the pumping chamber outlet; wherein

10 the pumping chamber outlet is in fluid communication with the inlet of the vacuum pump exhaust system.

11. The vacuum pump of claim 9 or 10, further comprising an aftercooler housed within the aftercooler plenum.

15

12. The vacuum pump of any of claims 9 to 11, wherein the vacuum pump is a vacuum pump selected from the group of vacuum pumps consisting of: a booster pump, a Roots pump, a positive displacement pump, and a positive displacement rotary lobe pump.

20

13. The vacuum pump of any of claims 9 to 12, wherein the vacuum pump is configured to pump fluid on a substantially horizontal direction.

14. A kit comprising:

25 a body portion comprising:

a first end wall comprising an inlet; and

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a bottom wall extending from the first end wall and defining a bottom surface; and

a cover; wherein

the cover is configured to be attached to the body portion thereby to form
5 a second end wall opposite to the first end wall such that the bottom wall extends between the first end wall and the second end wall;

the cover comprises an opening;

at least a portion of a bottom surface is recessed, thereby to define a recessed portion; and

10 when the cover is attached to the body portion thereby to form the second end wall, a lowest point of the recessed portion is contiguous with the opening in the cover.

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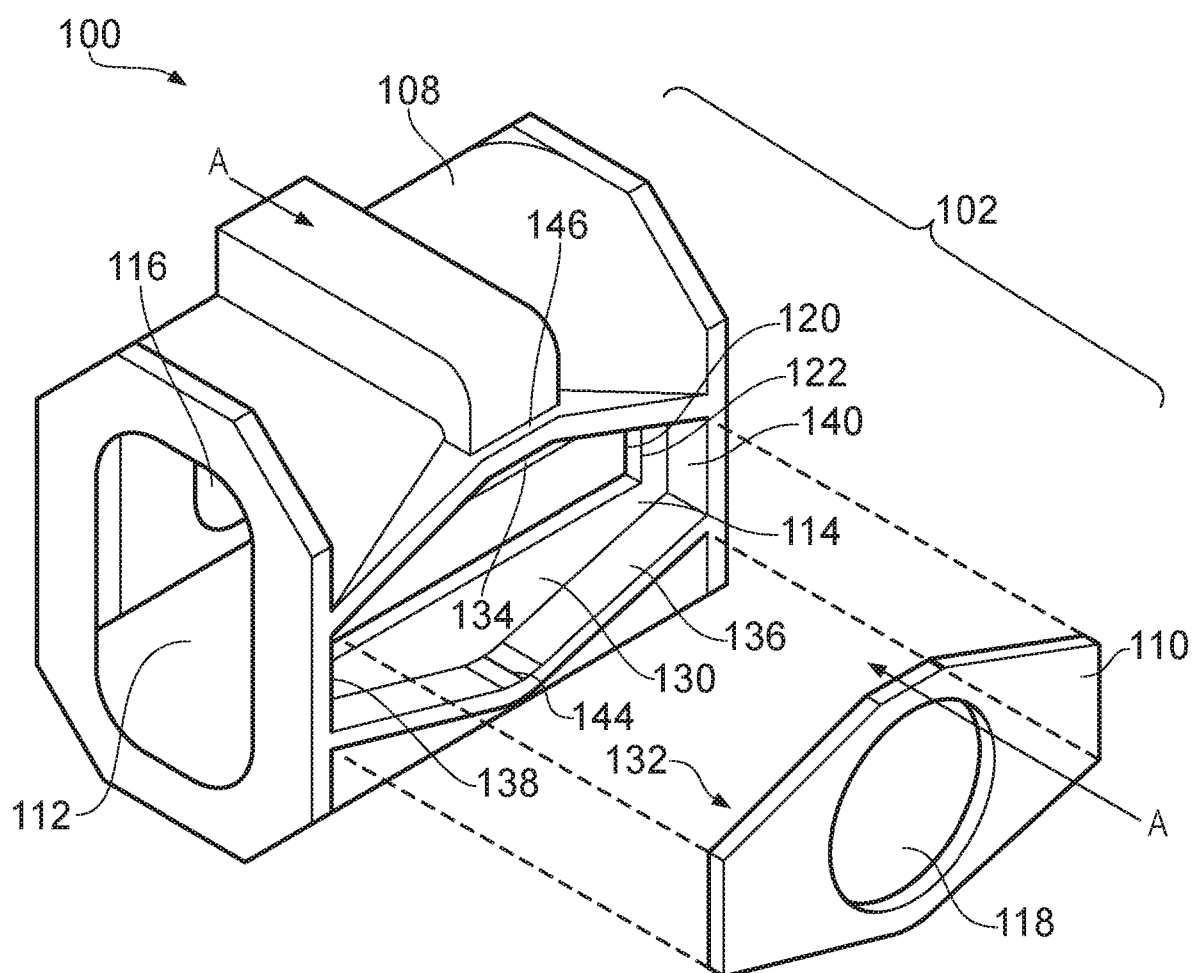


FIG. 1

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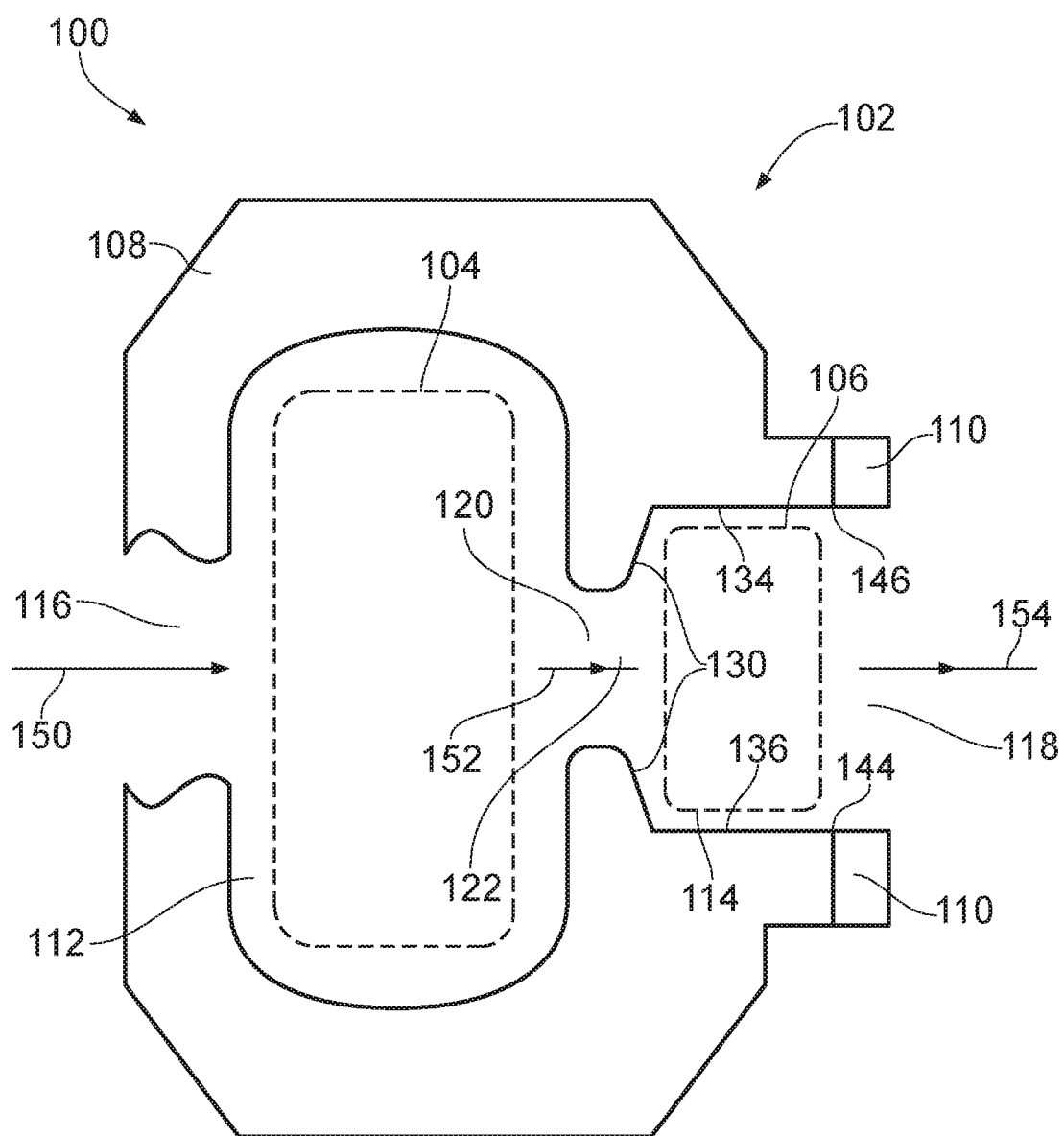


FIG. 2

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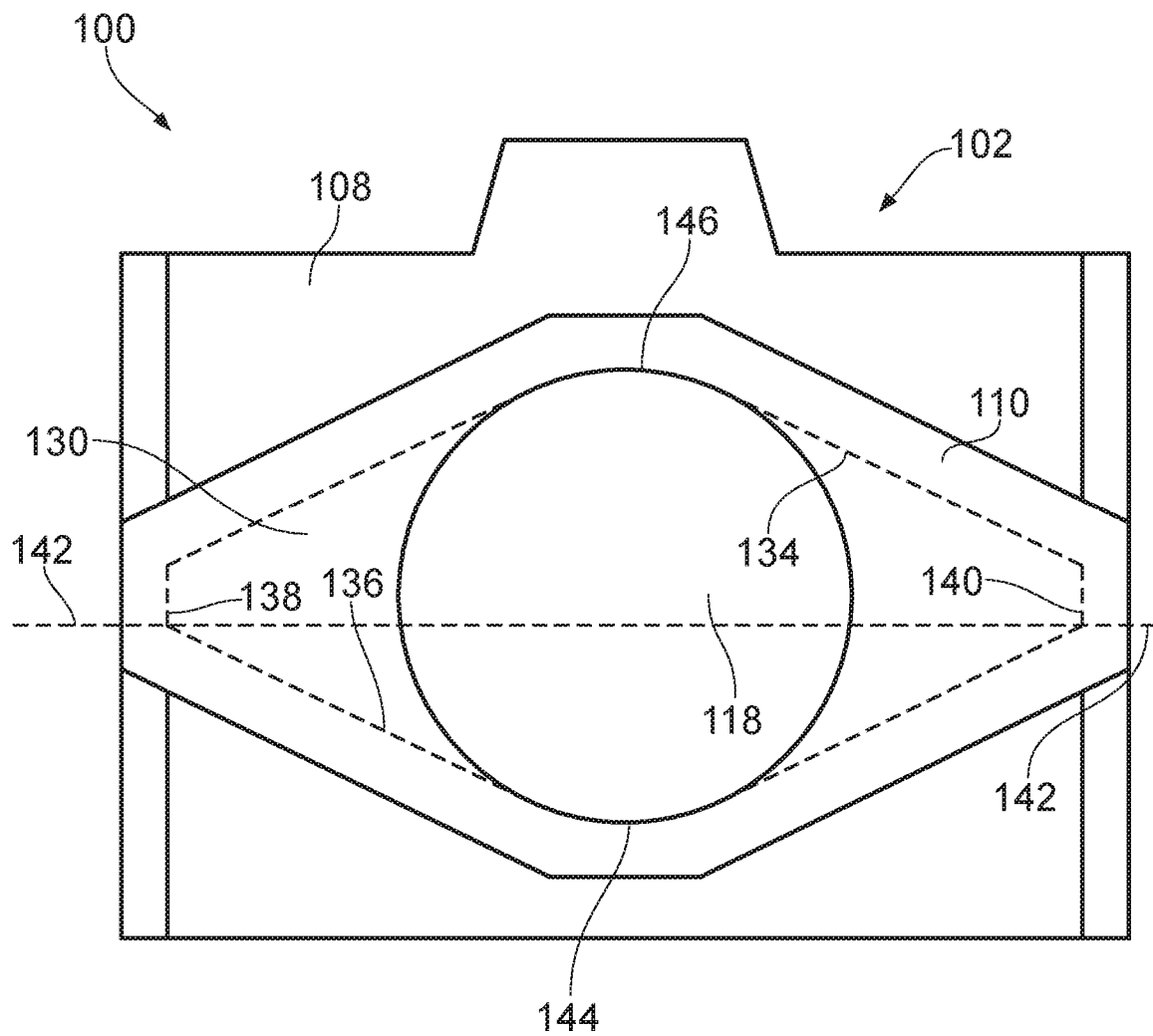


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2022/050297

A. CLASSIFICATION OF SUBJECT MATTER INV. F04C25/02 F04C29/04 F04C29/12 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) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 101 593 928 B1 (WOO SUNG VACUUM CO LTD [KR]; KIM DAVID [NZ]) 15 February 2016 (2016-02-15) figures 6, 7 -----	1-14
X	US 2003/035731 A1 (KIM DEOK-KYEOM [KR]) 20 February 2003 (2003-02-20) figures 1, 5 -----	1, 9-13
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Durante, Andrea

INTERNATIONAL SEARCH REPORT

Information on patent family members

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