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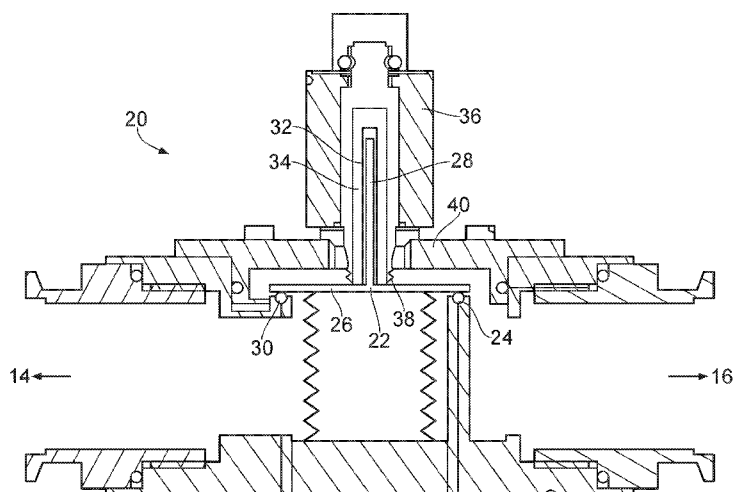


FIG. 2

(57) Abstract: A protection valve (20) isolates gas flow between an upstream vacuum chamber (14) and a downstream vacuum pump (16). The protection valve comprises a valve seat (24); a valve member (22) which in a first valve condition seals against the valve seat to prevent gas flow and in a second valve condition is spaced from the seat to allow gas flow; an actuator (36) comprising an actuator member (34) co-operable with the valve member and having a first actuator position which causes the valve member to seal against the valve seat in the first valve condition, the actuator member having a second actuator position in which the actuator member allows the valve member to move between first and second valve conditions responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump.

PROTECTION VALVE

The present invention relates to a protection valve for a vacuum system.

Referring to Figure 1 there is shown a vacuum system 10 comprising a protection
5 valve 12 for isolating gas flow between an upstream vacuum chamber 14 and a
downstream vacuum pump 16.

The vacuum chamber 12 may comprise a processing tool for processing a product
in a vacuum. By way of example, the product may be a semiconductor wafer or a flat
panel display. In other examples, the vacuum chamber may be used for food packaging
10 or processing, in paper processing or production, or analytical apparatus, for example a
mass spectrometer or an X-ray photoelectron spectrometer. The vacuum pressure
required may be low vacuum (or high pressure) in the region of 0.5 atmospheres or 500
mbar, medium vacuum in the region of 1 mbar to 10^{-3} mbar, or high vacuum (or low
pressure) in the region of 10^{-3} mbar or lower.

15 There are various different vacuum pumping solutions available on the market for
evacuating a vacuum chamber to a required vacuum pressure. By way of example,
vacuum pumps having roots or claw type pumping mechanisms are often used, or screw
type pumping mechanisms. Turbo molecular pumping mechanisms are frequently
adopted when lower pressures are required (e.g. 10^{-2} mbar and lower). Scroll pumping
20 mechanisms have broad utility for producing roughing vacuum (low vacuum) and also
pressures as low as e.g. 10^{-3} mbar, depending on the particular scroll pumping
configuration. There may be required multiple pumps in series and/or parallel for

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generating the required pressure and the required pumping capacity. Booster pumps which have low compression and high pumping capacity are useful for example in parallel with a compression pump. In the context of this application, references to vacuum pump include one or more vacuum pumps arranged to provide the required
5 vacuum pressure.

One problem with these vacuum systems is upstream migration of particulates or contaminants from the vacuum pump to the vacuum chamber. Particulates may take the form of dust generated for example by abrasion of tip seals in a scroll pump or lubricant for bearings which leaks into the flow path. Other contaminants may be gaseous, for
10 example where it is desirable to avoid cross contamination between vacuum chambers, or even where it is required to avoid the upstream migration of ambient air or water vapour.

Therefore a protection valve 12 is provided to isolate gas flow between the upstream chamber 14 and the downstream vacuum pump 16. A protection valve prevents, or at least substantially restricts flow, from a high pressure region on one side of
15 the valve to a low pressure region on an opposing side of the valve. Predominantly the purpose of the valve is to restrict upstream migration of particulates, contaminants or gaseous species, caused by upstream flow generated by a pressure difference from a higher downstream pressure to a lower upstream pressure, especially at or during pump start-up or if there is an unexpected pump shut-down (causing an increase in downstream
20 pressure in the absence of pumping).

The present invention aims to provide an improved isolation valve, and vacuum system including such a valve and vacuum pumping arrangement.

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The present invention provides a protection valve for protecting an upstream vacuum chamber from a downstream vacuum pump, the protection valve comprising: a valve seat; a valve member which in a first valve condition seals against the valve seat to prevent gas flow and in a second valve condition is spaced from the seat to allow gas flow; an actuator comprising an actuator member co-operable with the valve member and having a first actuator position which causes the valve member to seal against the valve seat in the first valve condition, the actuator member having a second actuator position in which the actuator member allows the valve member to move from first to second valve conditions responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump.

Additionally in such a protection valve or in a vacuum system comprising such a protection valve, the actuator member may have a second actuator position in which the actuator member allows the valve member to move between first and second valve conditions (to close the valve or open the valve) responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump. For example, the valve may be opened at one pressure differential and closed at a different pressure differential, which may be higher than the first pressure differential.

A control for operating the actuator is preferably responsive to operation of a downstream vacuum pump so that the actuator is activated responsive to operation of the downstream vacuum pump to actuate the actuator member to the second actuator position.

The actuator may be deactivated responsive to operation of the downstream vacuum pump to allow the actuator member to move to the first position.

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An actuator biasing member may be arranged to bias the actuator member to the first position when the actuator is deactivated.

The actuator biasing member may be connected between the actuator and a fixed part of the valve.

5 A valve biasing member may be arranged to bias the valve member to the second valve condition spaced from the valve seat to allow gas flow when the biasing force of the valve biasing member exceeds the pressure difference between the upstream vacuum chamber and the downstream vacuum pump.

10 The actuator member may comprise a sleeve which receives a shaft of the valve member for sliding movement.

The actuator may comprise a solenoid which is energised to cause movement of the actuator member.

15 The invention also provides a vacuum system comprising a vacuum pumping arrangement for evacuating an upstream vacuum chamber and a protection valve for protecting such a vacuum chamber from upstream gas flow from the vacuum pumping arrangement, the protection valve comprising: a valve seat; a valve member which in a first valve condition seals against the valve seat to prevent gas flow and in a second valve condition is spaced from the seat to allow gas flow; an actuator comprising an actuator member co-operable with the valve member and having a first actuator position which
20 causes the valve member to seal against the valve seat in the first valve condition, the actuator member having a second actuator position in which the actuator member allows

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the valve member to move from first to second valve conditions responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump.

The system may comprise a control for controlling activation of the actuator and the vacuum pumping arrangement.

5 The control may be arranged to initiate operation of the vacuum pumping arrangement and protection valve coterminously.

In order that the present invention may be well understood, an embodiment thereof, which is given by way of example only, will now be described with reference to the accompanying drawings, in which:

10 Figure 1 is a schematic representation of a vacuum system;

Figure 2 shows an isolation or protection valve of the vacuum system in one condition in which gas flow is prevented;

Figure 3 shows the isolation valve in another condition in which gas flow is prevented; and

15 Figure 4 shows an isolation valve in a still further condition in which gas flow is allowed.

Referring to Figures 2 to 4 there is shown a protection valve for a vacuum system as shown in Figure 1 and as described above.

Previously, a protection valve for such a vacuum system 10 comprises a valve
20 member which is fixed relative to an actuator member of a solenoid, whereas in the present invention in its most general terms, a valve member is moveable relative to an

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actuator member. In the prior art, when the vacuum pump is activated the solenoid is activated to move the valve member to a spaced apart position from a valve seat to allow gas flow through the valve. The problem with this arrangement is that when the vacuum pump is activated the pressure downstream of the valve may be at low vacuum, or
5 atmosphere, and the upstream pressure may be at higher vacuum, and in these circumstances when the valve is opened, the pressure difference causes upstream gas flow into the vacuum chamber. Continued operation of the vacuum pump reduces downstream pressure until it is reduced below upstream pressure, at which point gas flow is caused in a downstream direction away from the vacuum chamber. However, the transient period
10 of upstream gas flow may undesirably transport particulates, contaminants or gaseous species to the vacuum chamber. The isolation, or protection, valve described in relation to Figures 2 to 4 prevents or reduces the occurrence of such upstream gas flow and therefore selectively isolates or protects upstream processing from undesirable contaminants during pressure conditions that would otherwise degrade processing
15 performance or otherwise affect the upstream chamber.

Referring to Figures 2 to 4 in more detail, a protection valve 20 is shown which comprises a valve member 22 and a valve seat 24. The valve member is shown in a first valve condition in Figure 2 in which it seals against the valve seat to prevent gas flow between the upstream vacuum chamber 14 and a downstream vacuum pump 16. The
20 arrows in Figure 2 do not show flow but rather the direction of the vacuum chamber and the vacuum pump in relation to the valve. The valve member comprises a valve plate, or pad, 26 and a valve shaft 28. The valve seat comprises an O-ring seal 30 located in a circular channel of the valve seat. The plate seals against the valve seat when the valve

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member is in a first (sealing) valve condition and in a second (flow) valve condition is spaced from the seat to allow gas flow. The valve member is shown in the first valve condition in Figures 2 and 3 and in the second valve condition in Figure 4.

5 The valve shaft 28 is received for sliding movement in a bore 32 of an actuator sleeve member 34 of an actuator 36. The valve shaft is arranged to slide in the bore between first (upper) and second (lower) valve member positions in the bore. The terms upper and lower are used in the context of the orientation of the valve shown in the drawings and are useful for explanation, although it will be appreciated that the valve may have different orientations in use.

10 In this example, the actuator is formed by a solenoid. The actuator sleeve member 34 is formed by an armature which can be actuated by energising a solenoid coil located in part 36. Other arrangements for causing movement of the actuator member will be apparent to those skilled in the art after reading this specification. Energising the coil causes the actuator member to slide relative to the actuator, which in this example
15 causes the actuator member to move in a direction away from the valve seat. Typically the actuator is activated to cause movement of the actuator member away, or distal, from the valve seat when the vacuum pump 16 is activated. In this regard, the pump and actuator may be controlled by the same electronic control system, or equally the actuator and the vacuum pump may be provided as an integrated unit with a single control system.
20 But, in known vacuum systems, when the pump is activated the protection valve is opened prior to there being a downstream pressure differential towards the vacuum pump and therefore in these conditions, contaminants may flow up upstream to interfere with or degrade processes in an upstream vacuum chamber.

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In the embodiment, the arrangement provides that the isolation valve is opened only when there is a downstream pressure differential sufficient to maintain contaminants downstream of the valve. Alternatively the protection valve may be opened a short period of time prior to generation of a downstream pressure differential such as to cause
5 contaminants to be drawn downstream of the protection valve without the contaminants migrating sufficiently upstream to affect or degrade processing. In its most general terms, the valve is responsive to the upstream and downstream pressure differential.

In the illustrated example, an actuator biasing member, or spring, 38 biases the actuator member to a first actuator position, or a lower position in the orientation shown
10 in Figure 2. In this embodiment the actuator biasing member is connected between the actuator member and a valve housing 40 or another fixed part of the valve.

The actuator member is activated to move to a second (upper) position but when not activated is biased by the spring 38 to the first position. In the first (lower) actuator position, the actuator member co-operates with the valve member to cause it to move to
15 the first valve member position to seal against the valve seat. In other words, when the valve is not activated the isolation valve is sealed because the actuator member is biased to act against the valve member to move the valve member into or maintain the valve member in a first sealing condition.

When activated the actuator member is moved to a second actuator position, an
20 upper position as shown in the orientation of Figures 3 and 4. In the second actuator position, the valve member is not constrained by the actuator member from movement between a first (sealing) condition and a second (flow) condition. In the second actuator

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position the valve member can slide within the actuator sleeve between the first (lower and sealed) condition and the second (upper and flow) condition.

Referring to Figures 3 and 4, when the actuator member 34 is activated against the bias of the actuator biasing member 38 and is in the second (upper) position the shaft 28
5 of the valve member 22 can slide within the actuator member and move between the first valve sealing condition (Figure 3) and second valve flow condition (Figure 4) responsive to a pressure differential across the valve, or a pressure difference between the upstream vacuum chamber and downstream vacuum pump.

In the prior art, when a downstream vacuum pump 16 is activated the pressure
10 downstream of the valve 20 and at the pump inlet may be higher than the pressure upstream of the valve at a processing chamber outlet, and therefore the pressure differential across the valve may cause upstream migration of contaminants into the processing chamber. In the present arrangement, the valve 20 reduces upstream migration of contaminants because when the actuator member is activated to the second
15 position the valve member remains in a sealed condition until there is positive downstream pressure differential. Even if the vacuum system is arranged that the actuator is activated at the same time as the vacuum pump, for example if they have the same control, the valve member may be maintained in a sealing condition.

The valve member plate 26 seals against the valve seat 24 to prevent or resist fluid
20 flow in the first (lower) condition of the valve member 22 when the downstream fluid pressure generates a force on the valve member which is generally higher than the force generated by the upstream fluid pressure. In the embodiment, the downstream fluid pressure acts in a direction to urge the valve plate towards the valve seat to seal the valve.

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In the orientation shown the fluid pressure which acts downwardly on the valve plate 26 as shown by the arrows in Figure 3 is greater than the upstream fluid pressure acting upwardly on the valve plate. The valve member moves away or distal from the seat and allows fluid flow when the downstream pressure fluid pressure generates a force on the valve member which is generally less than the force generated by the upstream fluid pressure, as shown by the arrows in Figure 4. In this case, the downward fluid pressure on the valve plate is lower than upward fluid pressure to open the valve to allow fluid flow.

In the embodiment, there is a transition differential pressure at which the downstream fluid pressure on the valve plate 26 is equal to the upstream fluid pressure. When the vacuum pump continues to operate to evacuate the foreline downstream of the valve fluid pressure downstream of the valve is reduced, whereas fluid pressure upstream of the valve remains generally constant. Therefore the differential fluid pressure across the valve acting on the valve plate tends to open the valve by urging the valve plate away from the valve seat to allow fluid flow from the chamber 14 towards the pump 16.

It may be desirable to cause the valve to be opened to allow fluid flow other than at the transition differential pressure or to assist opening of the valve. In this embodiment, a valve member biasing member, or spring, 42 acts on the valve member to bias the valve member to a second open (upper) condition.

The valve member biasing member 42 is arranged (e.g. by selection of a spring constant k) to urge the valve member away from the valve seat (from the first condition to the second condition) to allow fluid flow at a predetermined pressure differential across

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the valve, which may be when there is an upstream or downstream pressure differential across the valve, which exceeds predetermined values.

In one example, the valve biasing member is arranged so that it causes the valve to open when an upstream pressure is a small amount below downstream pressure. In this way, the valve can be opened to draw contaminants downstream by reducing downstream pressure even though initially there may be an upstream pressure differential, although not sufficient to cause contaminants to cause contamination in the processing chamber.

There may be an inertia whereby the valve plate is not urged away from the valve seat at a transitional pressure differential (or forces which act against valve opening).

This inertia may be caused by material contact or friction or other local conditions which cause the valve plate to remain in contact with the valve seat at or close to the transitional pressure. This continued contact may occur at low pressures when the pressure differential, or gas force, is too low to overcome the inertia of the valve particularly in high vacuum applications. The valve member biasing member can be configured to overcome such inertia to open the valve at the transitional differential pressure.

Still further the valve biasing member can be configured to open the valve only when there is a downstream differential pressure above a predetermined value. This configuration may be preferred for example when it is particularly critical to avoid any upstream migration of contaminants, and in this case the valve is opened only when the downstream pressure differential is such as to restrict any or all migration.

A typical vacuum system as shown in Figure 1 comprises a control 15 for controlling operation of a vacuum pumping arrangement 16. In such systems the control

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operates both the vacuum pumping arrangement and the protection valve 12 such that activation of the vacuum pumping arrangement causes the protection valve to open. In embodiments of the invention a control is configured to control operation of the valve and is at least responsive to activation of a vacuum pumping arrangement so that the vacuum

5 pumping arrangement and protection valve are activated when required generally coterminously. Ordinarily, as described above, the control causes the valve to open when downstream pressure is not yet sufficient to avoid upstream migration of contaminants. However, in examples of the invention, coterminous operation of a vacuum pumping arrangement 16 and a valve embodying the invention by control 15 does not in itself

10 cause the valve to open. Instead, as described herein, the valve is placed in a condition where it can open to allow gas flow, but opening of the valve is dependent on upstream and downstream pressures across the valve. In typical known vacuum systems arranged to evacuate a chamber the actuator is activated responsive to operation of the downstream vacuum pump to actuate the actuator member to [move to] the second

15 position and in these known arrangements contaminants may migrate upstream to degrade processing performance.

CLAIMS

1. A protection valve for protecting an upstream vacuum chamber from a downstream vacuum pump, the protection valve comprising:
 - a valve seat;
 - 5 a valve member which in a first valve condition seals against the valve seat to prevent gas flow and in a second valve condition is spaced from the seat to allow gas flow;
 - an actuator comprising an actuator member co-operable with the valve member and having a first actuator position which causes the valve member to seal against
 - 10 the valve seat in the first valve condition, the actuator member having a second actuator position in which the actuator member allows the valve member to move from first to second valve conditions responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump.
- 15 2. A protection valve as claimed in claim 1, wherein the actuator member has a second actuator position in which the actuator member allows the valve member to move between first and second valve conditions responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump.
- 20 3. A protection valve as claimed in claim 1 or 2, comprising a control for operating the actuator responsive to operation of a downstream vacuum pump so that the

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actuator is activated responsive to operation of the downstream vacuum pump to actuate the actuator member to the second actuator position.

4. A protection valve as claimed in claim 3, wherein the actuator is deactivated
5 responsive to operation of the downstream vacuum pump to allow the actuator member to move to the first position.
5. A protection valve as claimed in claim 4, comprising an actuator biasing member
arranged to bias the actuator member to the first position when the actuator is
10 deactivated.
6. A protection valve as claimed in claim 5, wherein the actuator biasing member is connected between the actuator and a fixed part of the valve.
- 15 7. A protection valve as claimed in any of the preceding claims, comprising a valve biasing member arranged to bias the valve member to the second valve condition spaced from the valve seat to allow gas flow when the pressure difference between the upstream vacuum chamber and the downstream vacuum pump exceeds a biasing force of the valve biasing member.
- 20 8. A protection valve as claimed in any of the preceding claims, wherein the actuator member comprises a sleeve which receives a shaft of the valve member for sliding movement.

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9. A protection valve as claimed in any of the preceding claims, wherein the actuator comprises a solenoid which is energised to cause movement of the actuator member.
- 5 10. A vacuum system comprising a vacuum pumping arrangement for evacuating an upstream vacuum chamber and a protection valve for protecting such a vacuum chamber from upstream gas flow from the vacuum pumping arrangement, the protection valve comprising:
- 10 a valve seat;
- a valve member which in a first valve condition seals against the valve seat to prevent gas flow and in a second valve condition is spaced from the seat to allow gas flow;
- an actuator comprising an actuator member co-operable with the valve member and having a first actuator position which causes the valve member to seal against
- 15 the valve seat in the first valve condition, the actuator member having a second actuator position in which the actuator member allows the valve member to move from first to second valve conditions responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump.
- 20 11. A vacuum system as claimed in claim 10, wherein the actuator member has a second actuator position in which the actuator member allows the valve member to move between first and second valve conditions responsive to a pressure difference between the upstream vacuum chamber and downstream vacuum pump.

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12. A vacuum system as claimed in claim 10 or 11, comprising a control for controlling activation of the actuator and the vacuum pumping arrangement.
- 5 13. A vacuum system as claimed in claim 12, wherein the control is arranged to initiate operation of the vacuum pumping arrangement and protection valve coterminously.

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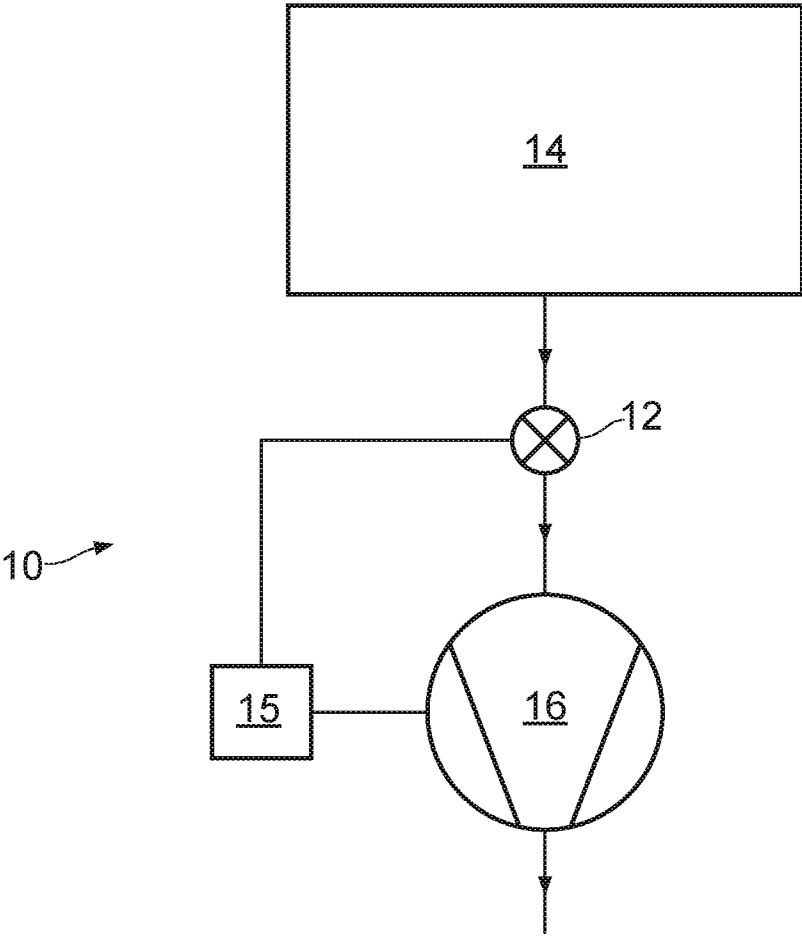


FIG. 1

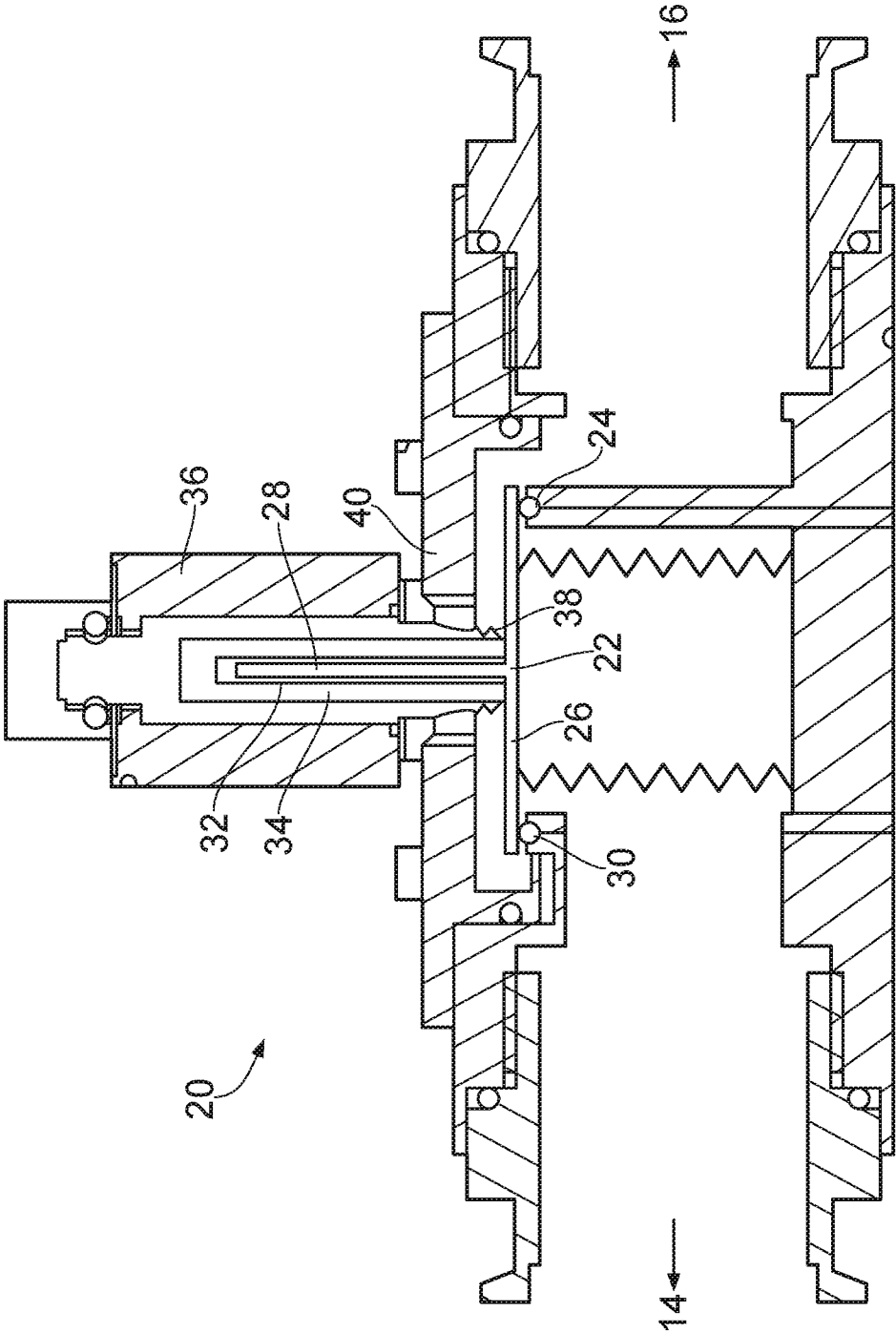


FIG. 2

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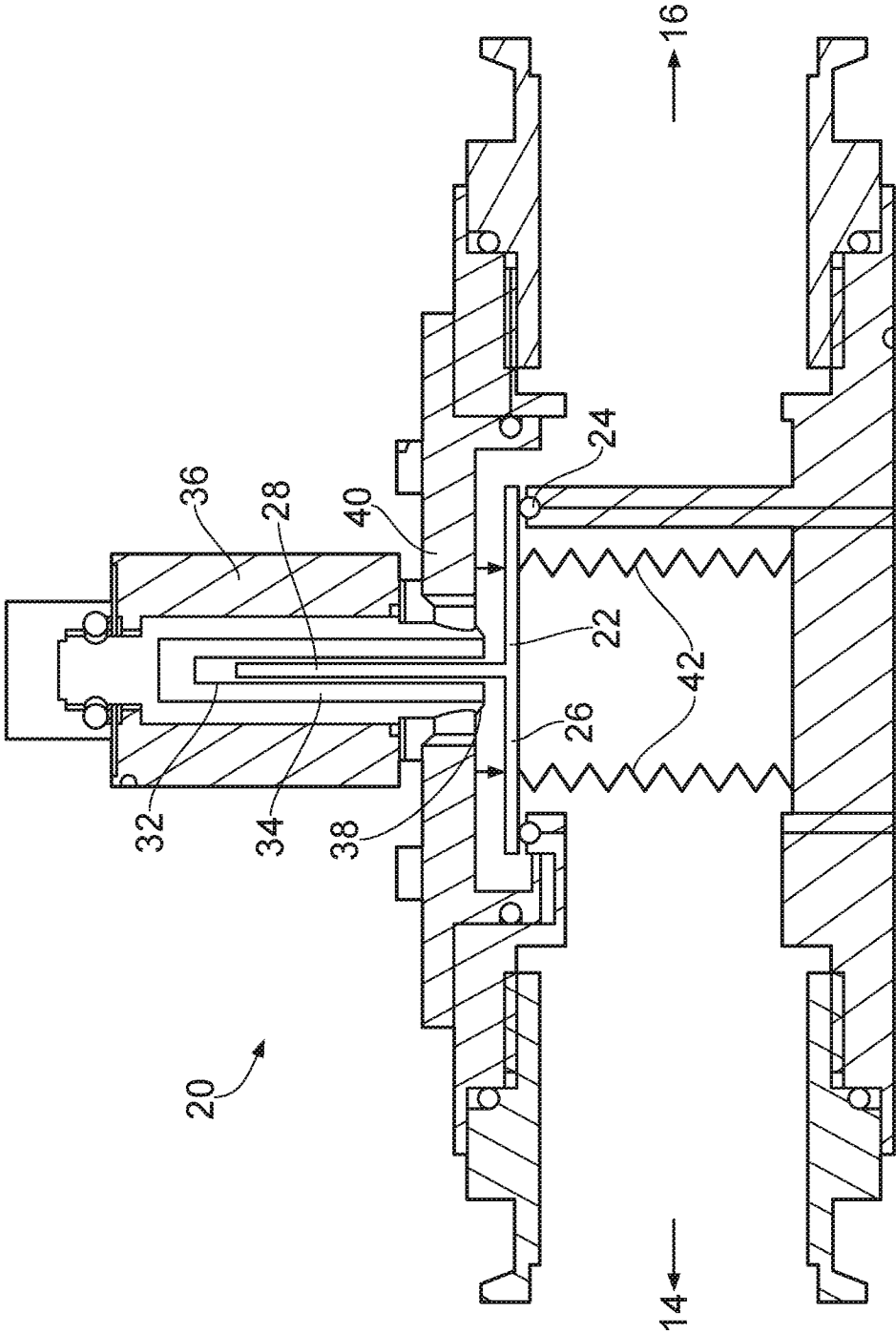


FIG. 3

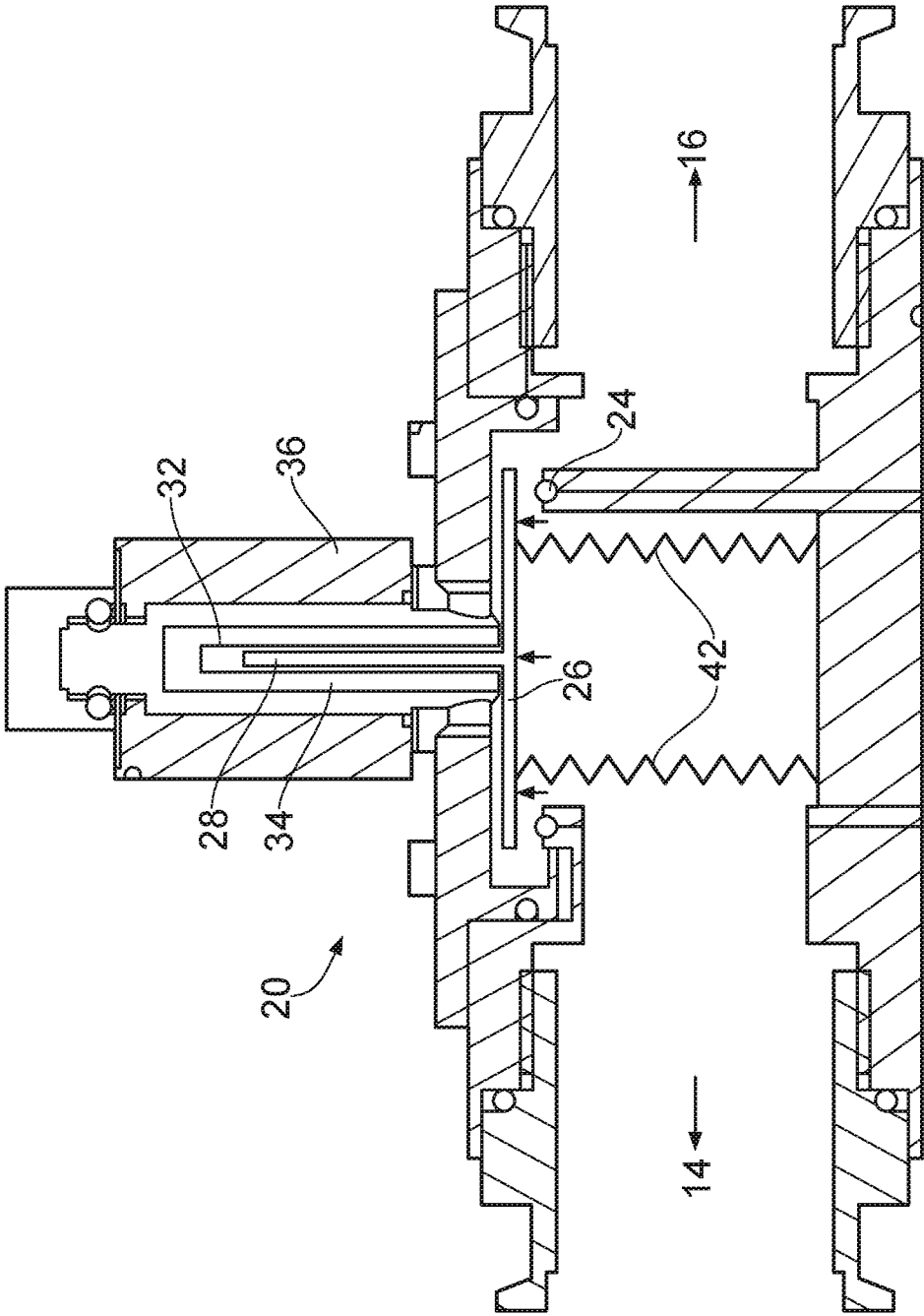


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2017/050948

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K15/18 F16K51/02
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)
F16K

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	US 2012/211096 A1 (HUANG HUAN-CHE [TW] ET AL) 23 August 2012 (2012-08-23) paragraphs [0032], [0035] - [0046], [0053] - [0055]; figures 3-5 -----	1-7,9-13
X	FR 2 865 787 A1 (BONNEL PIERRE [FR]) 5 August 2005 (2005-08-05) pages 1,2; figures 1,2 -----	1-3,8, 10,11



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012211096 A1	23-08-2012	TW 201235589 A US 2012211096 A1	01-09-2012 23-08-2012
FR 2865787 A1	05-08-2005	NONE	