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(71) Applicant (*for all designated States except US*): **THE BOC GROUP PLC** [GB/GB]; Chertsey Road, Windlesham, Surrey GU20 6HJ (GB).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **BREWSTER, Barrie, Dudley** [GB/GB]; Boc Edwards, York Road, Burgess Hill, West Sussex RH15 9TT (GB).

(74) Agent: **BOOTH, Andrew, Steven**; The Boc Group Plc, Chertsey Road, Windlesham, Surrey GU20 6HJ (GB).

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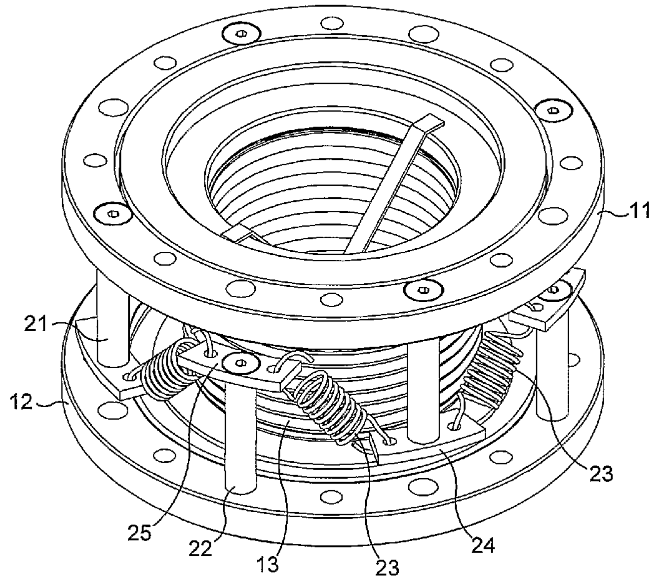
(54) Title: VIBRATION DAMPER




(57) Abstract: A pre-compressed vibration damper is provided for inhibiting transfer of vibration to an apparatus during the evacuation thereof by a pump.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# VIBRATION DAMPER

The present invention relates to vibration dampers.

Vibration dampers are used to reduce the vibration transmitted from a high-vacuum pump, for example, a turbomolecular pump, to apparatus to be evacuated during a pumping operation. Vibration dampers are particularly advantageous when vacuum pumps are used to evacuate apparatus which is sensitive to mechanical vibration. For example, vibrations transmitted to an evacuated Scanning Electron Microscope could lead to inaccuracies in measurements being taken by the microscope, and vibrations transmitted to a process tool could cause anomalies in products being manufactured within.

With reference to Figure 2, a vibration damper 0 is typically connected between the fluid exhaust 9 of the apparatus 7 to be evacuated and the fluid inlet 10 of the vacuum pump 8. Figure 1 illustrates the configuration of a known vibration damper 0 in more detail. The damper 0 includes two flanges 2,3 each welded to a respective end of a steel bellows 4. Each flange 2, 3 has an aperture 2a, 2b formed therein, the apertures 2a, 2b being axially aligned. The bellows 4 defines a flow path 4a through the damper 0 for fluid pumped from the apparatus 7 by the pump 8.

A mechanical support 5 is provided to prevent the bellows 4 collapsing under compression when the fluid in the flow path 4a is at low pressure that is, under vacuum and external forces due to atmospheric pressure act to compress the damper 0. In the example shown in Figure 1, the mechanical support 5 is provided by an elastomeric cylinder surrounding the bellows 4 between the flanges 2, 3.

Interlinking members 6a, 6b are provided to prevent the bellows 4 from extending under the weight of the pump 8 suspended from flange 3 when the apparatus is not under vacuum. In the example shown in Figure 1, member 6a is in the form of a V-shaped metallic strap welded to the top of flange 2, and member 6b is in the form of a similar strap welded to the bottom of flange 3 so that the members 6a, 6b are linked. In the illustrated example, when the damper 0 is not connected to any other components, the members 6a, 6b are not in contact.

The parameter governing transmission of vibration from the pump 8 to the apparatus 7 is the stiffness (k) of the damper 0. Bellows 4 are typically chosen to define the flow path 4a in view of their low inherent axial stiffness, so as to cause minimal transmission of vibration to the apparatus 7. The interlinking straps 6a, 6b are not in contact when under vacuum conditions, where the damper 0 experiences compressive loading. Consequently, the primary route for vibration transmission is through the mechanical support 5.

Vibration dampers positioned between the apparatus 7 and the pump 8, as shown in Figure 2, are subject to a large static force acting on the lower end of pump 8 which acts to force the pump 8 towards the apparatus 7, this force being associated with the pressure difference between atmospheric and vacuum conditions. This force must be borne by the mechanical support 5 of the damper 0. However, when known elastomeric mechanical supports 5 are exposed to such loading conditions, their hyperelasticity, reflected in a non-linear progressive stiffness characteristic, causes them to become increasingly stiff or rigid. Under such compressive loading conditions, the increased rigidity enhances transmission of vibration to the apparatus 7 rather than reducing it. Furthermore, known elastomeric mechanical supports 5 typically experience failure in a buckling mode.

It is an object of the present invention to provide a vibration damper that substantially reduces the problems associated with these prior art vibration dampers.

According to one aspect of the present invention, there is provided a vibration damper for inhibiting transfer of vibration to an apparatus during the evacuation thereof by a pump, the damper comprising a bellows arrangement for isolating from the ambient atmosphere, fluid drawn from the apparatus by the pump, and means for limiting axial compression of the bellows arrangement during use of the damper, wherein the damper is axially pre-compressed.

In practical terms, the permitted magnitude of the extension of the damper is governed by the flexibility of the bellows, the space available in the location of the apparatus and the flexibility of the peripheral equipment attached to the vacuum pump. This is typically 5 to 10 mm. Since the magnitude of the static force exerted on the pump is also predetermined, the stiffness characteristic of the damper is restricted. In the simplest, the relationship between force and displacement may be linear as shown at 19 in Figure 6 such that the stiffness has a constant value. In known prior art systems as discussed above, the mechanical support is formed from an elastomeric material. Such materials have a hyperelastic load/deformation relationship such that they have a progressive stiffness characteristic. This type of relationship is represented at 20 in Figure 6. It can be seen that in the typical loading regime (denoted F) the stiffness curve 20 has become steep indicating an increased value of stiffness. It is desirable that the stiffness characteristic associated with the damper, when loaded, is small by design, as represented at 18 in Figure 6, such that transmission of vibration to the apparatus is minimised. However, overall permitted extension of the damper 1 is predetermined as discussed above, so pre-compression of the damper prior to installation between the apparatus and the pump can provide a much higher stiffness characteristic at lower displacement, represented at 17 in Figure 6, such that the required applied load can be borne by the damper whilst not exceeding the extension limits. Therefore, a mechanical support of much lower stiffness, and consequently better vibration transmission properties, can be provided.

According to another aspect of the present invention there is provided a vibration damper for inhibiting transfer of vibration to an apparatus during the evacuation thereof by a pump, the damper comprising a bellows arrangement for isolating from the ambient atmosphere, fluid drawn from the apparatus by the pump, the bellows arrangement extending about an axis and resistive means arranged about said axis and under tension in such a way that when the damper is subjected to an external axial force tending to compress the bellows arrangement, the resistive means is subjected to a tensile force, the resistance to extension of the resistive means opposing axial compression of the bellows arrangement.

A further problem associated with known vibration dampers is that in the event of pump failure through rotor seizure, they provide an inherent weakness which can be of safety concern. When a pump seizes, there is a large quantity of energy associated with the angular momentum of the rotor, which energy needs to be dissipated. In some circumstances, the rotor blades are stripped from the rotor thus causing most of the energy to be absorbed as the destruction and deformation of the internal components occurs, and hence the failure can be contained within the pump housing. However, in some pumps, such as those with a bell shaped rotor, the rotor is likely to be split into a small number of sections, each section having a significant quantity of rotational momentum with a large impulse. When each section collides with the pump housing, a large torque may be transmitted from the rotor to the pump housing. Consequently, the pump housing will tend to rotate. Since the apparatus to which the pump is attached will have a significant mass and will be unlikely to shift, the highest point of stress will be at the vibration damper where the apparatus and pump are joined together. Conventional vibration dampers have minimal resistance to such rotational loading and are damaged, resulting in the pump becoming detached from the apparatus and causing further damage or injury.

It is, therefore, a further object of the present invention to provide a vibration damper that inhibits any such rotational movement of the vacuum pump and, consequently, enhances safety of the system.

According to another aspect of the present invention there is provided a vibration damper for inhibiting transfer of vibration to an apparatus during the evacuation thereof by a pump, the damper comprising a bellows arrangement for isolating from the ambient atmosphere, fluid drawn from the apparatus by the pump, one end of the bellows arrangement being connected to a flange from which at least one member extends axially towards the other end of the bellows arrangement, and means for contacting said at least one member upon rotation of one end of the bellows arrangement relative to the other to inhibit relative rotational movement therebetween.

The invention is described below in greater detail by way of example only with reference to the accompanying drawings, in which

Figure 1 is a schematic cross section of a conventional vibration damper;

Figure 2 is a schematic representation of a vacuum system in which a vibration damper may be used;

Figure 3 is a schematic perspective view of a vibration damper according to one embodiment of the present invention;

Figure 4 is a schematic cross sectional representation of the of Figure 3;

Figure 5 is a flat sheet development of the external compression resisting means of the vibration damper illustrated in Figure 3;

Figure 6 is a graph indicating the type of stiffness characteristics that are desirable in a vibration damper of Figure 3;

Figure 7 is a schematic cross sectional representation of another embodiment of the present invention, with an alternative configuration of the compression resisting means;

Figure 8 is a flat sheet development of the compression resisting means of Figure 7;

Figure 9 is a schematic cross-sectional representation of an embodiment of a vibration damper with anti-rotation characteristics;

Figure 10 is a flat sheet development of the compression resisting means of Figure 9; and

Figure 11 is a schematic representation of a vacuum pump incorporating a vibration damper similar to that shown in Figure 7.

Figure 2 illustrates a generic vacuum system which is suitable for incorporating a vibration damper 1 of the present invention. As such, references will be made to components shown therein, in combination with subsequent drawings.

As shown in Figures 3, 4 and 5, vibration damper 1 comprises a first flange 11 for connecting the damper 1 to a flange of the fluid exhaust 9 of the apparatus 7 and a second flange 12 for connecting the damper 1 to fluid inlet 10 of the vacuum pump 8. The damper 1 further comprises a compliant gas barrier or shield 13, such as a convoluted bellows of a generally cylindrical form connected with a gas tight seal at either end to respective flanges 11, 12 in order to define a fluid flow path from the apparatus 7 to the vacuum pump 8. Within the confines of the bellows 13, two interlinking V-shaped straps 14, 15 are provided. One strap 14 is welded at either end to the first flange 11 at diametrically opposed positions. The other strap 15 is welded at either end to the second flange 12, also at diametrically opposed positions of the flange. The two straps 14, 15 meet and over lap at their central portions such that together they form a link that prevents the bellows from extending beyond a predetermined axial displacement. In contrast to the conventional damper illustrated in figure 1, the two linking straps 14, 15 are pre-tensioned such that the damper 1 is permanently compressed from its equilibrium position. In other words, in its inactive/unloaded state the damper 1 experiences a loading or pre-compression.

Extending around the bellows 13 is a resilient structure 16 that is able to withstand significant compressive loading. The configuration of this structure 16 has been designed to avoid buckling failure modes associated with a compressively loaded structure by forming an arrangement that deflects primarily in tension. As shown in Figures 3 and 5, in this example four support members 21 are connected to the first flange 11 and four additional support members 22 are connected to the second flange 12. These support members 21, 22 each extend axially towards the flange to which they are not directly connected. At the distal end of each support member 21, 22 is connected a circumferentially extending tab 24, 25. Attached to each end of a tab 24, 25 is a resistive element, in this embodiment in the form of a tension spring 23, typically a metal coil tension spring. Each tension spring 23 is attached at one end to a tab 24, tab 24 being indirectly attached to the first flange 11, and at the other end to a tab 25, tab 25 being indirectly attached to the second flange 12.

As the vacuum pump 8 evacuates apparatus 7 the pressure within the entire vacuum system, incorporating the apparatus 7, damper 1, pump 8 and any equipment in fluid communication therewith, reduces and a large static load acting on the pump 8, as a result of the difference between external atmospheric pressure and internal low pressure, becomes evident. This load causes a contraction in the length of the vacuum system and, consequently, shortens the axial length of the vibration damper 1. This compression of the damper 1 causes the flanges 11, 12 to move towards one another. As a result, tabs 24, 25 move axially away from one another and the springs 23 each act in tension such that a resistance to the compressive axial loading is experienced within the damper 1.

In order to inhibit transmission of the oscillating force associated with vibrations of the pumping mechanism to the apparatus 7, the vibration damper 1 needs to be compliant. In other words, it must have as low a value of stiffness (commonly designated "k") as possible. Hence the choice of the bellows configuration for the gas barrier 13, since such a component has a very low value of axial stiffness. The stiffness characteristic under loading is, therefore dominated, by the resisliant structure 16. By subjecting the damper 1 to an initial loading (or pre-compression) the initial load v displacement characteristic 17 is very steep, see Figure 6, which corresponds to a large effective stiffness value as it is dominated by the pre-compression means, here the interlinked straps 14, 15. Once the axial compressive displacement goes beyond the initial pre-compressed limit such that the linked straps 14, 15 return to equilibrium and lose contact with one another, the considerably lower value of stiffness characteristic 18 becomes active. This lower stiffness value (represented by the shallow gradient at 18 in Figure 6) is dominated by the tension springs 23 in the resistant structure 16, with some contribution (typically approximately 20%) from the bellows 13.

In some conventional vibration dampers the axial length of the damper is large and conductance losses experienced can become significant. In the vibration damper of Figure 3 such losses are not significant, however there are some applications where it is desirable to improve the configuration in order to achieve an even higher quality vacuum. It is widely known that improvements in conductance of a vacuum system are achieved by maintaining large diameter openings of short length. A damper 30 representing an improved conductance is exemplified in Figures 7 and 8.

In this damper 30, spring support members 36 are attached to one flange 31 only, the support members 36 protruding through clearance holes 37 in the other flange 32. The support members 36 are provided with shoulders 35, formed by an increased diameter portion 34 of each support member 36, beyond which the second flange 32 is prevented from passing. This mechanism effectively provides pre-compression of the damper 1 without the need for straps 14, 15 which enables the fluid flow path to be cleared of obstacles.

Springs 38 are attached from the distal end of members 34 to the bottom surface (as shown in Figure 8) of flange 32. Consequently, all of the springs 38 are located beneath the flanges 31, 32. This simplification creates shorter space between the flanges 31, 32 of damper 30 than the space between the flanges 11, 12 of damper 1. By decreasing the distance between the flanges, the conductance of the damper 30 is improved. Furthermore, for the same cross section of vibration damper 30, (when compared to damper 1 of the earlier embodiment) a larger diameter bellows component 39 can be introduced to further enhance the conductance value of the damper 30, thus leading to an improved quality vacuum.

Figures 9 and 10 illustrate another example of a damper 40 which is similar to the damper 1 illustrated in Figures 3, 4 and 5. However, the circumferentially extending tabs 24, 25 of damper 1 illustrated in Figure 3 have been replaced by complete rings 46, 47 in damper 40. These interference rings 46, 47 perform the same function as tabs 24, 25 in that they form attachment points for springs 45 to enable the damper to resist compressive axial loading through a tensile mode. In addition the interference rings 46, 47 are provided with clearance holes 48, 49 through which support members 43, 44 extend.

In normal operation of the vacuum system, all movement within the vacuum damper 40 is in the axial direction and no contact is made between support members 43 and interference ring 47 or between support members 44 and interference ring 46 due to the provision of clearance holes 48, 49. However, if the vacuum pump 8 seizes in such a way that angular momentum is transferred to a housing of the pump 8 to cause it to rotate relative to the apparatus 7, each interference ring 46, 47 will start to rotate and will, therefore come into contact with respective support members 44, 43. In order for the pump 8 to rotate further, each of these support members 44, 43 must deform. Such deformation takes more energy out of the system and therefore reduces the likelihood that the vacuum pump 8 will be separated from the apparatus 7. Hence, further destruction or injury may be avoided.

Returning now to Figure 8, it may be noted that in the event of a vacuum pump seizure flange 32 with clearance holes 37 would act as the interference rings 46, 47 in Figures 9 and 10, in combination with support members 36.

The components of the vibration damper may be directly incorporated into the body of a pump 50 as illustrated in Figure 11 to provide an integrated unit with all of the aforementioned advantages. The pump 50 comprises a stator 51 and a rotor 52 in a known configuration. An inlet component 54 of the pump is separated from the remainder of the housing of the pump 50, as shown in Figure 11, to allow a compliant structure to be inserted therebetween to couple the inlet 54 to the remainder of the housing to inhibit transmission of vibration from the pump 50 to the apparatus (not shown) which is to be evacuated in operation of the pump. A gas barrier or shield is provided by a compliant steel bellows component 53 as in the aforementioned damper 1 to separate the atmospheric conditions external to the pump with the vacuum conditions internal to the pump. At one end, the bellows component 53 is directly connected to the stator 51 of the pump 50 and at the other end it is connected to the inlet component 54 of the pump. As discussed earlier in the description, in operation, the length of the vacuum system will tend to be compressed. In this embodiment, resistance to compression is provided by tension springs 55. These springs are connected, at respective ends, to the stator 51 of the pump 50 and to the inlet component 54 such that as the pump 50 experiences compressive forces the springs 55 are extended. In this way, the possibility of a failure of components in operation, in a buckling mode, is avoided.

In summary, the present invention provides a pre-compressed vibration damper which enables a much lower stiffness value to be incorporated into the design of the damper. This lower stiffness value is desirable in order to inhibit vibration being transmitted from the vacuum pump to the apparatus being evacuated.

Furthermore, the typical compression resistance structure has been replaced by an equivalent structure that experiences tensile deflection rather than compressive deflection such that buckling forces are avoided.

Finally, a damper is provided which presents improved safety of the vacuum system in use by provision of a rotation inhibiting configuration such that the possibility of reducing destruction of the system during pump failure is improved.

# CLAIMS

1. A vibration damper for inhibiting transfer of vibration to an apparatus during the evacuation thereof by a pump, the damper comprising a bellows arrangement for isolating from the ambient atmosphere, fluid drawn from the apparatus by the pump, and means for limiting axial compression of the bellows arrangement during use of the damper, wherein the damper is axially pre-compressed.

2. A vibration damper according to Claim 1, wherein the bellows arrangement is integral with the pump.

3. A vibration damper according to Claim 1 or Claim 2, wherein one end of the bellows arrangement is directly attached to the pump.

4. A vibration damper according to Claim 3, wherein said one end of the bellows arrangement is directly attached to a flange integral with the housing of the pump.

5. A vibration damper according to Claim 3 or Claim 4, wherein the other end of the bellows arrangement is attached to a flange for connecting the pump to the apparatus.

6. A vibration damper according to Claim 1, comprising means for connecting the damper between the apparatus and the pump.

7. A vibration damper according to Claim 6, wherein the connection means comprises first and second flanges each attached to a respective end of the bellows arrangement and connectable to a respective one of the pump and the apparatus.

8. A vibration damper according to any preceding claim, wherein the bellows arrangement defines at least part of a flow path for fluid drawn from the apparatus by the pump.

9. A vibration damper according to any preceding claim, wherein the damper is axially pre-compressed by means for limiting axial extension of the bellows arrangement.

10. A vibration damper according to Claim 9, wherein the extension limiting means is attached to at least one end of the bellows arrangement.

11. A vibration damper according to Claim 9 or Claim 10, wherein the extension limiting means comprises first and second co-operating members each attached to a respective end of the bellows arrangement.

12. A vibration damper according to Claim 11, wherein each member comprises a V-shaped member attached to diametrically opposed locations on the respective end of the bellows arrangement such that the members co-operate to draw the ends of the bellows arrangement together so as to pre-compress the damper.

13. A vibration damper according to Claim 11 or Claim 12 when dependent from Claim 7, wherein each member is connected to the respective end of the bellows arrangement via a respective flange.

14. A vibration damper according to Claims 7 and 9, wherein the extension limiting means comprises an axially extending member attached to one of the flanges and engaging the other flange to pre-compress the damper.

15. A vibration damper according to Claim 14, wherein the axially extending member passes through an aperture located in the other flange, a distal part of the axially extending member engaging the other flange.

16. A vibration damper according to any preceding claim, wherein the means for limiting axial compression comprises resistive means arranged under tension in such a way that when the damper is subjected to an external axial force tending to compress the bellows arrangement, the resistive means is subjected to a tensile force, the resistance to extension of the resistive means opposing axial compression of the bellows arrangement.

17. A vibration damper according to Claim 16, wherein the bellows arrangement extends about an axis and the resistive means is arranged about said axis.

18. A vibration damper for inhibiting transfer of vibration to an apparatus during the evacuation thereof by a pump, the damper comprising a bellows arrangement for isolating from the ambient atmosphere, fluid drawn from the apparatus by the pump, the bellows arrangement extending about an axis, and resistive means arranged about said axis and under tension in such a way that when the damper is subjected to an external axial force tending to compress the bellows arrangement, the resistive means is subjected to a tensile force, the resistance to extension of the resistive means opposing axial compression of the bellows arrangement.

19. A vibration damper according to any of Claims 16 to 18, wherein the resistive means is arranged about the damper.

20. A vibration damper according to Claim 16 or Claim 19 when dependent from Claim 2, wherein the resistive means is arranged about the pump.

21. A vibration damper according to Claim 20, wherein the resistive means is attached to the housing of the pump.

22. A vibration damper according to any of Claims 16 to 19, wherein the resistive means is arranged about the bellows arrangement.

23. A vibration damper according to any of Claims 16 to 22, wherein the resistive means comprises a plurality of resistive elements.

24. A vibration damper according to Claim 23, wherein each resistive element comprises a metal coil tension spring.

25. A vibration damper according to Claim 23 or Claim 24, wherein each of the resistive elements is inclined relative to a plane extending orthogonally to said axis.

26. A vibration damper according to any of Claims 23 to 25, wherein each resistive element is attached at one end to a first radially extending flange and at the other end to a second radially extending flange, the first and second radially extending flanges being axially separated.

27. A vibration damper according to Claim 26, wherein said one end of the resistive element is attached to the first radially extending flange via a support member.

28. A vibration damper according to Claim 27, wherein the support member extends through an aperture in the second radially extending flange.

29. A vibration damper according to Claim 27 or 28, wherein the other end of the resistive element is directly attached to the second radially extending flange.

30. A vibration damper according to any of Claims 27 to 29, comprising means for contacting the support member upon rotation of one flange relative to the other to inhibit relative rotational movement therebetween.

31. A pump comprising a vibration damper according to any of Claims 1 to 5 and 8 and 29.

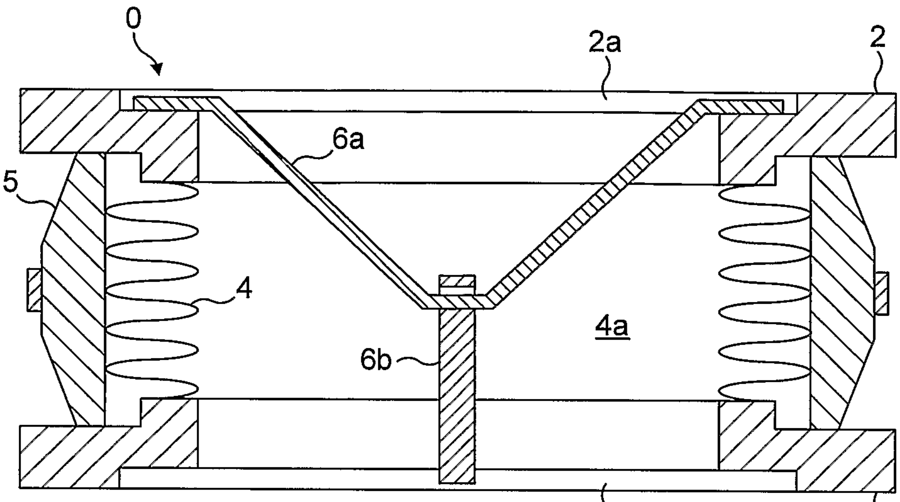


FIG. 1
PRIOR ART

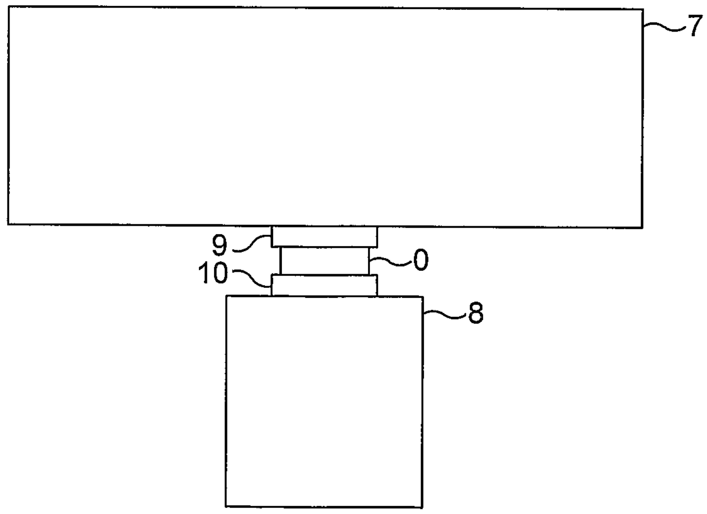


FIG. 2
PRIOR ART

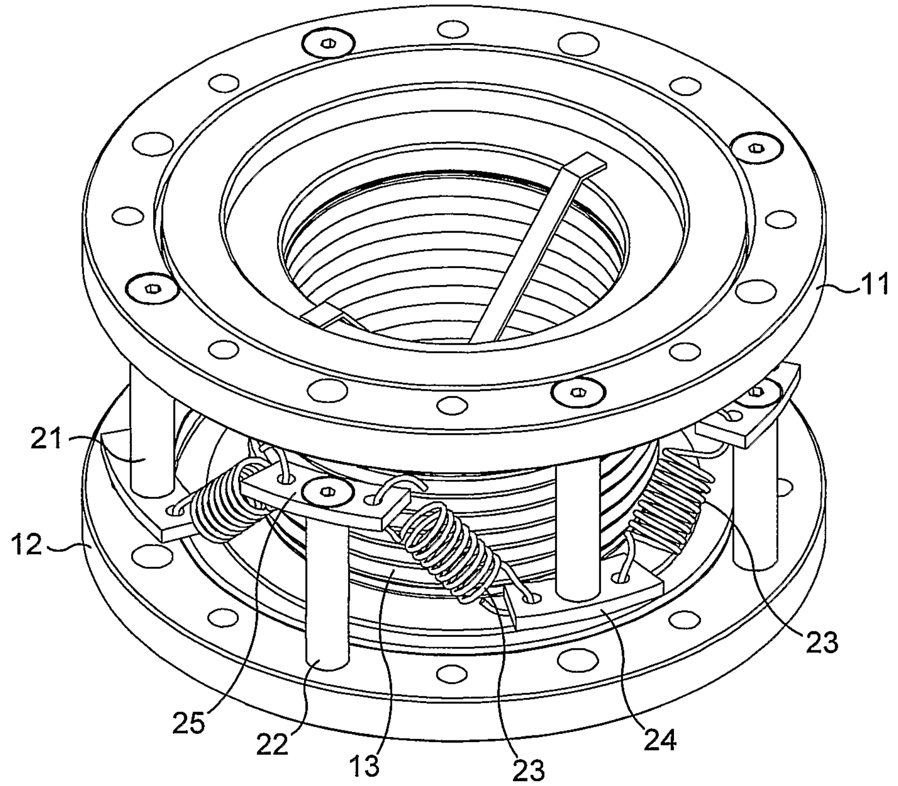


FIG. 3

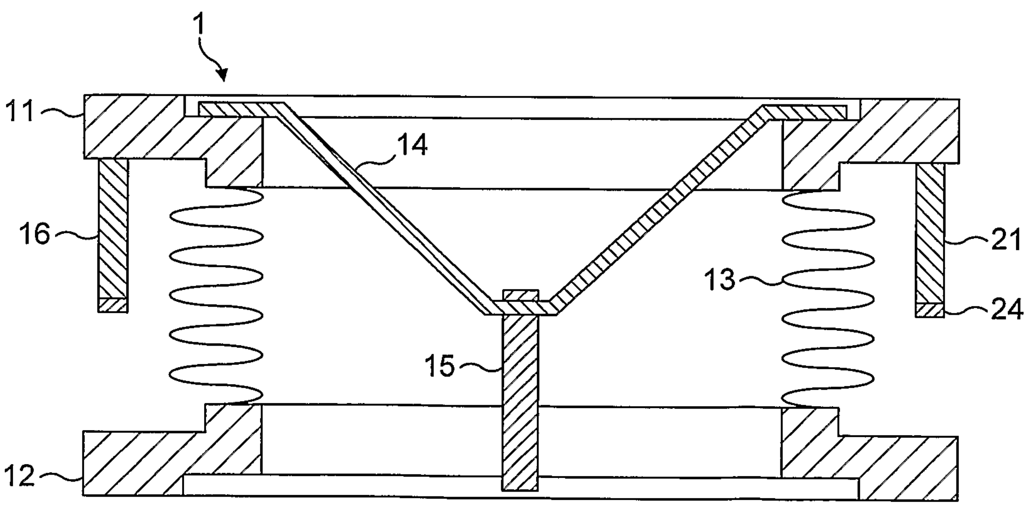


FIG. 4

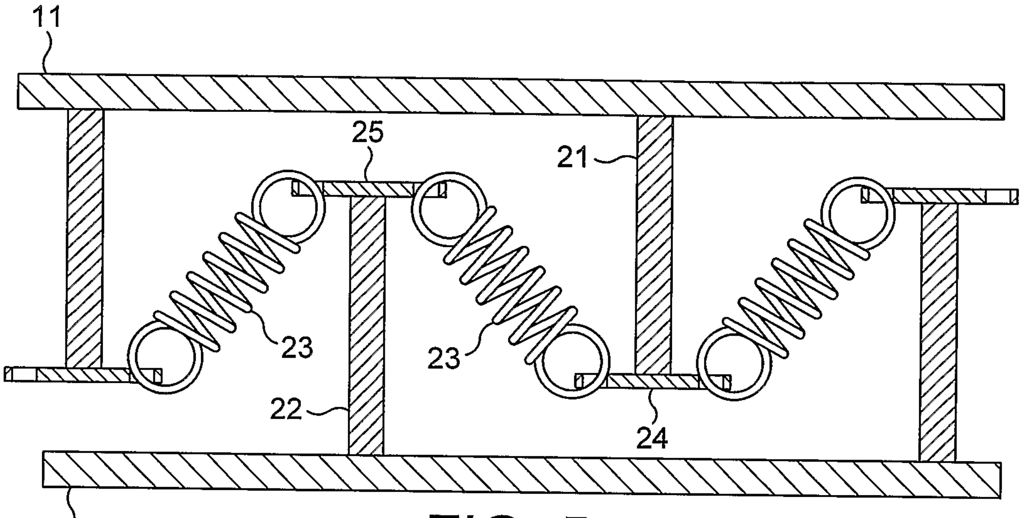

FIG. 5

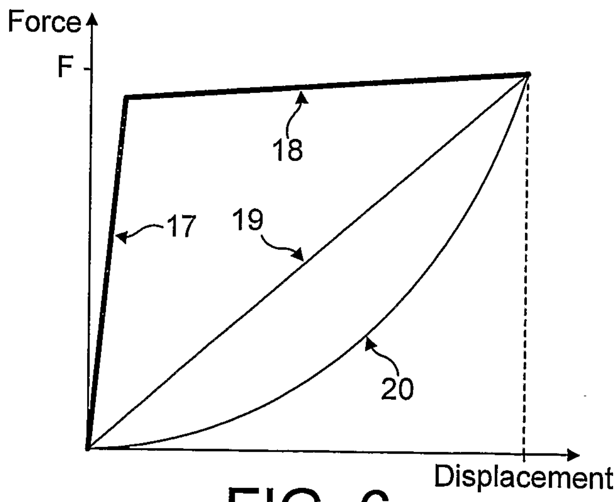

FIG. 6

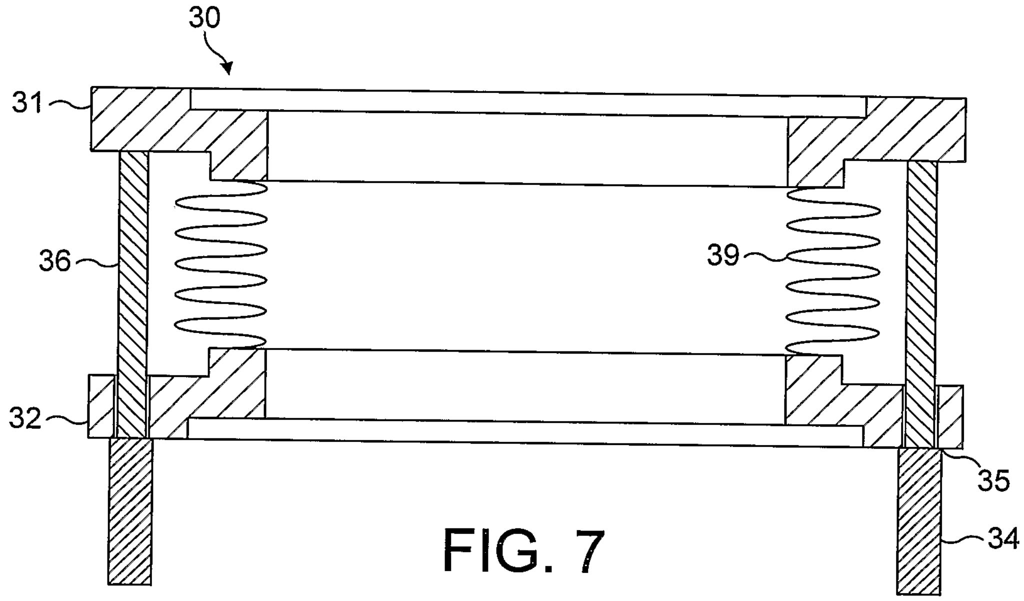


FIG. 7

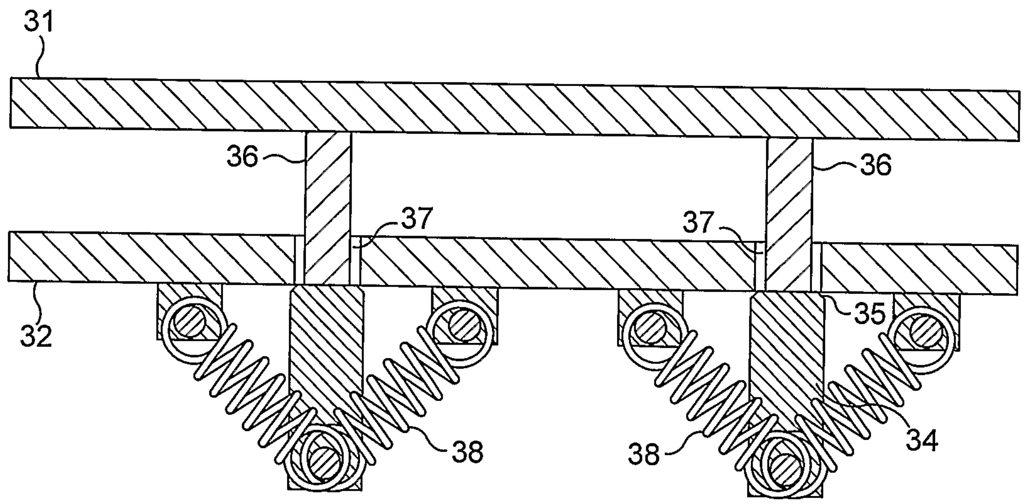


FIG. 8

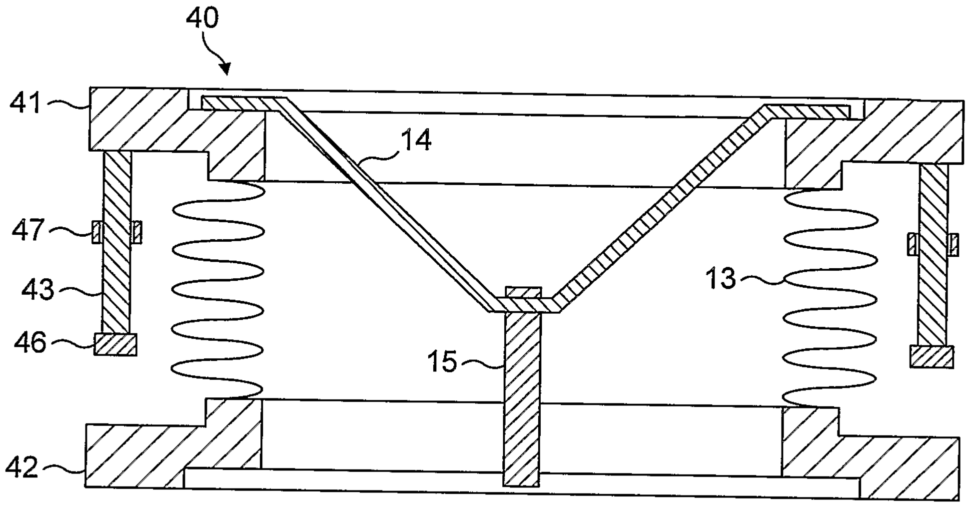


FIG. 9

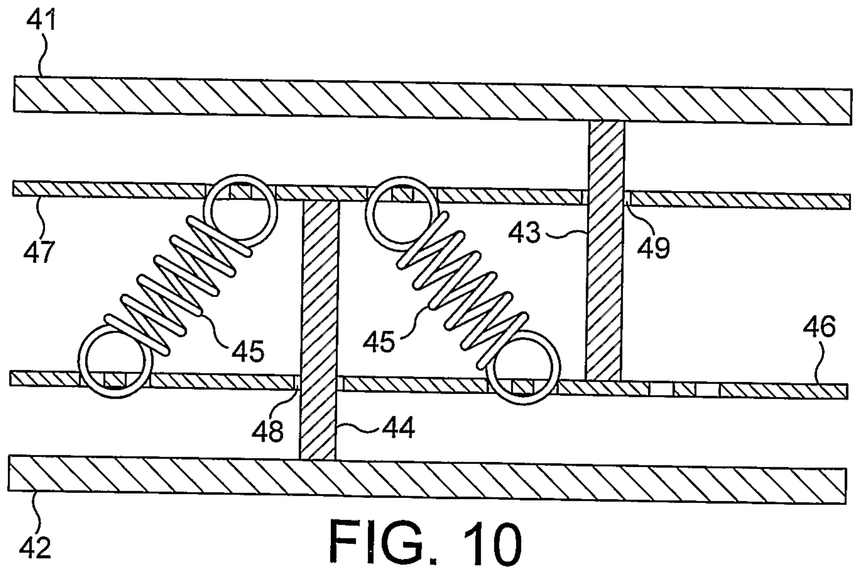


FIG. 10

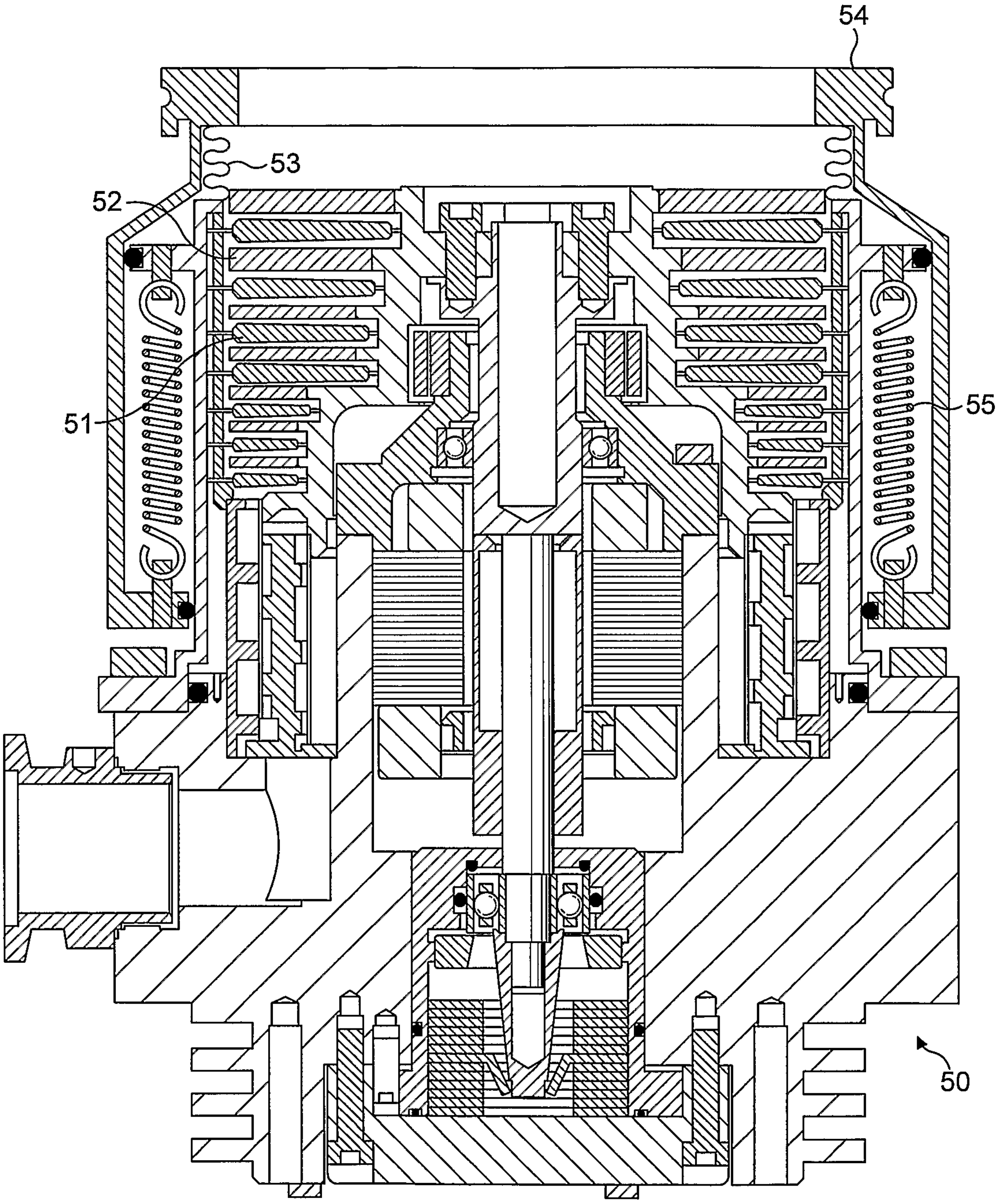


FIG. 11

# INTERNATIONAL SEARCH REPORT

International Application No
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**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 F04D29/66 F16F15/04 F16L27/11

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)
IPC 7 F16F F04D F16L H01J F04B

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 practical, search terms used)

EPO-Internal, PAJ, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 3 000 389 A (ALSAGER LESLIE E ET AL) 19 September 1961 (1961-09-19) the whole document | 1-11,13, 14,31 |
| X | PATENT ABSTRACTS OF JAPAN vol. 1998, no. 14, 31 December 1998 (1998-12-31) & JP 10 252963 A (TOOFURE KK), 22 September 1998 (1998-09-22) abstract | 1,6-10, 14,15 |
| A | WO 01/51817 A (LEYBOLD VAKUUM GMBH; ADAMIETZ, RALF; BEYER, CHRISTIAN; ENGLAENDER, HEI) 19 July 2001 (2001-07-19) the whole document | 1-31 |

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 2 June 2005 | 30.06.05 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016 | Pirog, P |

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2005/000354

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 5 971 439 A (CWIK ET AL) 26 October 1999 (1999-10-26) column 7, line 16 - column 10, line 56; figure 1 | 1 |
| X | GB 1 541 294 A (EROMUE-ES HALOZATTERVEZO VALLALAT) 28 February 1979 (1979-02-28) the whole document | 1 |
| A | DE 79 33 066 U1 (INDUSTRIE-WERKE KARLSRUHE AUGSBURG AG, 7500 KARLSRUHE) 21 February 1980 (1980-02-21) the whole document | 1 |
| A | US 6 065 780 A (HIROSHIMA ET AL) 23 May 2000 (2000-05-23) figures | 1 |
| A | EP 1 270 949 A (BOC EDWARDS TECHNOLOGIES, LIMITED) 2 January 2003 (2003-01-02) figure 2 | 1 |
| A | WO 02/086325 A (LEYBOLD VAKUUM GMBH; BEYER, CHRISTIAN; HODAPP, JOSEF; ENGLAENDER, HEIN) 31 October 2002 (2002-10-31) abstract | 1 |
| A | PATENT ABSTRACTS OF JAPAN vol. 2003, no. 02, 5 February 2003 (2003-02-05) & JP 2002 303294 A (BOC EDWARDS TECHNOLOGIES LTD), 18 October 2002 (2002-10-18) abstract | 1 |
| A | PATENT ABSTRACTS OF JAPAN vol. 005, no. 127 (M-083), 15 August 1981 (1981-08-15) & JP 56 064195 A (JEOL LTD), 1 June 1981 (1981-06-01) abstract | 1 |
| A | US 5 090 746 A (HOLZHAUSEN ET AL) 25 February 1992 (1992-02-25) abstract | 1-31 |
| A | DE 78 05 710 U1 (INDUSTRIE-WERKE KARLSRUHE AUGSBURG AG, 7500 KARLSRUHE, DE) 10 December 1981 (1981-12-10) figure 1 | 1-31 |
| A | US 3 985 378 A (MULLER ET AL) 12 October 1976 (1976-10-12) figures | 1-31 |

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2005/000354

**Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-17,19-31

   A vibration damper for inhibiting transfer of vibrations to an apparatus during the evacuation thereof by a pump, the damper comprising a bellows arrangement, wherein the damper is axially pre-compressed.

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2. claim: 18

   A vibration damper for inhibiting transfer of vibrations to an apparatus during the evacuation thereof by a pump, the damper comprising a bellows arrangement, wherein the damper comprises resistive means arranged about an axis and under tension in such a way that when damper is subjected to an external axial force tending to compress the bellows arrangement, the resistive means is subjected to a tensile force.

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# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2005/000354

| Patent document cited in search report | | Publication date | Patent family member(s) | | | Publication date |
|---|---|---|---|---|---|---|
| US 3000389 | A | 19-09-1961 | NONE | | | |
| JP 10252963 | A | 22-09-1998 | NONE | | | |
| WO 0151817 | A | 19-07-2001 | DE | 10001509 | A1 | 19-07-2001 |
| | | | WO | 0151817 | A1 | 19-07-2001 |
| | | | EP | 1280998 | A1 | 05-02-2003 |
| | | | JP | 2003519761 | T | 24-06-2003 |
| | | | US | 6814550 | B1 | 09-11-2004 |
| US 5971439 | A | 26-10-1999 | AU | 6030598 | A | 07-08-1998 |
| | | | BR | 9806961 | A | 21-03-2000 |
| | | | EP | 0953124 | A1 | 03-11-1999 |
| | | | JP | 2001509243 | T | 10-07-2001 |
| | | | WO | 9831962 | A1 | 23-07-1998 |
| GB 1541294 | A | 28-02-1979 | HU | 173990 | B | 28-10-1979 |
| | | | DE | 2653192 | A1 | 05-01-1978 |
| DE 7933066 | U1 | 21-02-1980 | NONE | | | |
| US 6065780 | A | 23-05-2000 | JP | 3343581 | B2 | 11-11-2002 |
| | | | JP | 11125309 | A | 11-05-1999 |
| EP 1270949 | A | 02-01-2003 | JP | 2003003988 | A | 08-01-2003 |
| | | | EP | 1270949 | A1 | 02-01-2003 |
| | | | US | 2003007862 | A1 | 09-01-2003 |
| WO 02086325 | A | 31-10-2002 | DE | 10119075 | A1 | 24-10-2002 |
| | | | WO | 02086325 | A1 | 31-10-2002 |
| | | | EP | 1386082 | A1 | 04-02-2004 |
| | | | JP | 2004533582 | T | 04-11-2004 |
| | | | US | 2004135449 | A1 | 15-07-2004 |
| JP 2002303294 | A | 18-10-2002 | NONE | | | |
| JP 56064195 | A | 01-06-1981 | JP | 1347442 | C | 13-11-1986 |
| | | | JP | 61013115 | B | 11-04-1986 |
| US 5090746 | A | 25-02-1992 | FR | 2645939 | A1 | 19-10-1990 |
| | | | BR | 9001815 | A | 11-06-1991 |
| | | | DE | 4009215 | A1 | 25-10-1990 |
| | | | GB | 2230581 | A ,B | 24-10-1990 |
| | | | IT | 1239903 | B | 23-11-1993 |
| | | | JP | 3033590 | A | 13-02-1991 |
| DE 7805710 | U1 | 10-12-1981 | NONE | | | |
| US 3985378 | A | 12-10-1976 | DE | 2424004 | A1 | 27-11-1975 |
| | | | AT | 341842 | B | 27-02-1978 |
| | | | AT | 375975 | A | 15-06-1977 |
| | | | BR | 7503025 | A | 13-04-1976 |
| | | | CS | 174148 | B2 | 31-03-1977 |
| | | | DK | 213475 | A ,B, | 18-11-1975 |
| | | | FR | 2271491 | A1 | 12-12-1975 |
| | | | IT | 1048825 | B | 20-12-1980 |