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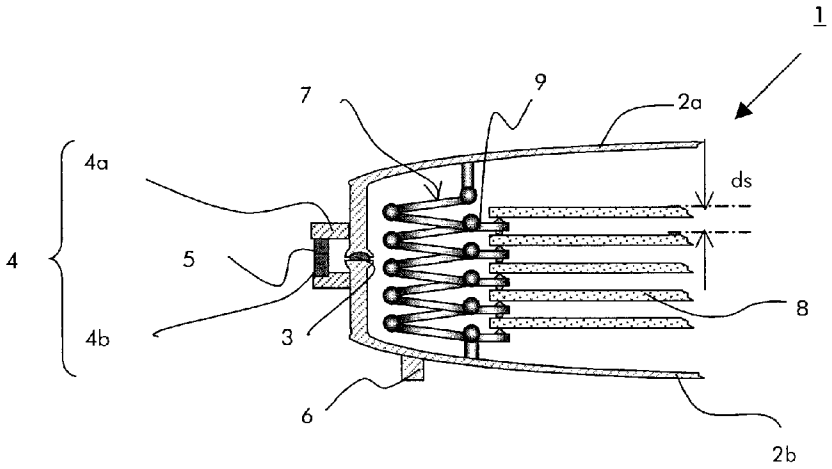
(54) **Title:** A SEALED ENCLOSURE FOR TRANSPORTING AND STORING SEMICONDUCTOR SUBSTRATES



(57) **Abstract:** The present invention relates to a sealed enclosure for transporting and storing semiconductor substrates, the enclosure comprising a sealed container and support means placed inside the container and including trays for supporting substrates. The container comprises two touching half-shells that can be spaced apart in order to open the container, and each end of said support means is secured mechanically to a respective one of said half-shells. The total height of said means varies depending on whether the container is opened or closed, the trays being separated from one another by equal distances. Said support means preferably comprise an alternation of segments and bail joints having end segments that are mechanically connected to respective ones of the half-shells. Under such circumstances, the total height of said support means varies by the alternation of segments and bail joints moving concertina-like.

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A SEALED ENCLOSURE FOR TRANSPORTING AND STORING SEMICONDUCTOR SUBSTRATES

The present invention relates to the field of substrate transport and storage, in particular during the various steps of fabricating microelectronic components, e.g. for making the components of micro-electrical mechanical systems (MEMS) or of opto-micro-electrical mechanical systems (MOEMS). The invention relates more particularly to a sealed enclosure for transporting and storing such substrates, which are generally in the form of glass masks of polygonal shape or of semiconductor-material wafers of circular shape, such as silicon wafers.

Between the various fabrication steps, substrates are transported and stored in sealed enclosures containing a controlled atmosphere that protects them from the pollution present in the atmosphere of white rooms. Usually, the enclosures contain one substrate (a silicon wafer having a diameter of 200 millimeters (mm) or of 300 mm) or a plurality of substrates in a stack. At present, the sealed enclosures commonly used contain one to 25 substrates. Each substrate rests on an individual support and the substrates are separated from one another by a space that is minimized in order to obtain storage enclosures of small dimensions.

Such sealed enclosures are coupled with inlet/outlet interfaces of fabrication equipment with the help of an airlock and robotic means. A first robot transports the substrate from the transport sealed enclosure to a load chamber. The load chamber is put to low pressure. Thereafter the robot of the transfer chamber transports the substrate from the load chamber to a process chamber. The space available under the substrate, when placed in the load chamber or in the transport enclosure, must be sufficient to allow the arm of the robot initially to pass under the substrate. Thereafter, the arm must be capable of rising sufficiently for the substrate to rest

no longer on its support but instead on the robot's arm, which can then move the substrate towards the process chamber.

It will be understood that sealed enclosures capable of satisfying the above-mentioned constraints are large in volume. Unfortunately, the space available for storage in a white room is small because of the cost of making and maintaining a white room. The quantity of enclosures, and thus of substrates, that can be stored therein is limited. It would therefore be appropriate to reduce the size of such sealed enclosures.

Patent document US-2002/018 703 describes an installation comprising a process chamber connected to a transfer chamber communicating with load chambers, each containing a cassette for temporary storage of semiconductor substrates. The load chambers are connected by substrate transport means to a shelf having storage compartments for receiving the substrates. A robot transfers the substrate from the storage compartment to the cassette situated in the load chamber. A mechanism included in the cassette comprises a plurality of trays and means for supporting the trays and guiding their displacement. To insert and/or extract a substrate into and/or from the cassette, the tray supporting the substrate is moved away from the other trays by support and guide means that move away the stacked trays on either side of the selected tray. A locking device locks the tray in a position such that it is spaced apart from the adjacent trays situated above it and below it. The tray is thus accessible for manipulation by the robot.

In addition, the sealed enclosure must enable a controlled atmosphere to be conserved around the substrates in order to avoid them being contaminated during the transport and storage stages. Wafers can remain for several weeks in the semiconductor fabrication unit between the various process steps. Throughout this

time, the semiconductor substrates need to be protected against any risk of pollution coming from the white room, and also from the substrate itself. That is one of the reasons why provision is made to transport and store them in sealed enclosures under a controlled atmosphere.

An object of the present invention is to propose a sealed enclosure structure for semiconductor substrate transport and storage while nevertheless presenting space around the substrate enabling it to be inserted into and/or extracted from the enclosure by the robotic means commonly used in existing installations.

In addition, the enclosure of the invention must enable a controlled atmosphere to be conserved around the substrates in order to prevent them being contaminated during transport and storage stages, by ensuring sufficient sealing in a manner that is simple and inexpensive.

Finally, the transport enclosure must be capable of coupling with the loading/unloading interfaces of common fabrication equipment.

The present invention provides a sealed enclosure for transporting and storing semiconductor substrates, the enclosure comprising a sealed container and support means placed inside said container and including trays for supporting said substrates, the enclosure being characterized in that said container comprises two touching half-shells that move apart to open said container, and in that each end of said support means is mechanically secured to a respective one of said half-shells.

Thus, the total height of the support means varies depending on whether the container is open or closed, the trays being spaced apart by equal distances.

The sealed enclosure of the present invention has the advantage of being compact once closed, thereby facilitating storage and transport. Because of its small inside volume, controlling its atmosphere is simpler,

particularly with respect to pollution. In addition, its weight and its manufacturing costs are reduced, and it requires an interface of small size with the installation.

In a particular embodiment, the support means include alternating segments and ball joints. More preferably, the alternation of segments and ball joints has a segment at each end, each of said end segments being mechanically connected to a respective one of said half-shells.

Advantageously, every other ball joint carries a tray on which a said substrate rests. Under such circumstances, the total height of the support means preferably varies by a concertina movement of the alternating segments and ball joints.

The half-shells making up the container are joined together via a flexible gasket. On retracting, the support means compress said flexible gasket in order to seal said container.

In order to make the enclosure easier to manipulate, the container includes at least one handle and/or a locking device. The locking device preferably co-operates with the handle.

The present invention also provides a method of extracting a substrate from an enclosure as described above. The low-pressure enclosure is placed in a load chamber that is likewise at low pressure. The method comprises the following steps:

- increasing the distance between the trays by moving the half-shells apart;
- introducing robotic means between two contiguous trays;
- lifting the substrate placed above the robotic means;
- extracting the robotic means together with the substrate; and

· reducing the distance between the remaining trays by uniting the half-shells.

The present invention also provides a method of inserting a substrate in an enclosure as described above. The low-pressure enclosure is placed in a load chamber at low pressure. The method comprises the following steps:

· increasing the distance between the trays by moving the half-shells apart;

· inserting robotic means carrying the substrate between two contiguous trays;

· placing the substrate on the tray located beneath the robotic means;

· extracting the robotic means; and

· reducing the distance between the trays by uniting the half-shells.

Other characteristics and advantages of the present invention appear from the following description of embodiments given by way of non-limiting illustration and from the accompanying drawings, in which:

· Figure 1 is a fragmentary diagrammatic view in vertical section of the transport and storage enclosure of the invention in the storage position;

· Figure 2 is a fragmentary diagrammatic view in vertical section of the Figure 1 enclosure while a substrate is being inserted or extracted;

· Figures 3A, 3B, and 3C are fragmentary diagrammatic views in section showing a substrate being extracted from an enclosure of the invention for transfer into a process chamber;

· Figure 4 shows a particular embodiment of the invention; and

· Figure 5 is a diagrammatic horizontal section view of the transport and storage enclosure of the invention.

In an embodiment of the invention shown in Figure 1, there can be seen an enclosure 1 of the invention in its closed position for storage. Figure 2 shows the same enclosure 1 in the open position during an operation of

extracting or inserting a substrate wafer, while the enclosure 1 is inside a load/unload chamber of a fabrication and processing installation. Identical references designate the same elements as in Figure 1.

The enclosure 1 comprises a container 2 made up of a top half-shell 2a and a bottom half-shell 2b. The two half-shells 2a and 2b are in contact via a flexible gasket 3 which is compressed to seal the enclosure 1. The circularly arcuate shape of the half-shells 2a and 2b enables them to withstand better the pressure of the outside atmosphere. The enclosure 1 is provided with a manipulation handle 4 made up of two portions 4a and 4b connected respectively to the two half-shells 2a and 2b. The handle 4 is provided with a locking device 5 to prevent any untimely opening. The locking device 5 can be opened by a robot inside the load chamber of the processing installation once it is evacuated. The enclosure 1 may advantageously be provided with legs 6 for stabilizing it on a plane surface and facilitating its alignment during automatic manipulations.

Inside the enclosure 1, there are support means 7 for supporting substrate wafers 8. The support means 7 for supporting the substrate wafers 8 are flexible and capable of deploying when the enclosure 1 is opened, as shown in Figure 2, so as to provide accessibility to the substrate wafers 8 for standard robotic means. When the enclosure 1 is closed, the support means 7 fold so as to minimize their height.

The support means 7 comprise movable segments 7a interconnected by ball joints 7b, 7c. The set of movable segments 7a and of ball joints 7b, 7c uniting them is fastened by fastener segments 7d and 7e respectively to the top half-shell 2a and to the bottom half-shell 2b of the enclosure 1. While the enclosure 1 is being closed, the set of movable segments 7a and of ball joints 7b, 7c folds concertina-like so that every other ball joint 7b is offset towards the center of the enclosure 1, while

the ball joints 7c between them are offset outwards. The ball joints 7b that move towards the center of the enclosure 1 during closure carry trays 9. In the storage position, the enclosure 1 is closed and the trays 9 are spaced apart by a distance ds. Once the enclosure 1 has been opened for loading and/or unloading substrate wafers 8, the trays 9 are spaced apart at a distance dc that is much greater than ds.

A stud 10 is placed on each tray 9. The substrate wafers 8 rest on the studs 10 and they are held laterally by stop pieces 11. The studs 10 must present surfaces that are perfectly clean and free from polluting particles. A portion in relief 12 is placed under the tray 9 in register with the stud 10. The portions in relief 12 are flexible parts, e.g. of the spring type or else they are constituted by an elastic material such as a silicone or an elastomer. When the enclosure 1 is closed in the storage position, each portion in relief 12 bears resiliently against the substrate wafer 8 situated immediately beneath the tray 9 carrying the portion in relief. The portions in relief 12 thus enable the substrate wafers 8 to be held in stationary position in order to prevent any damage during displacement of the enclosure 1 and in order to prevent them deforming during storage periods. For the substrates 8 to be held properly, at least three trays 9 are required.

Figures 3A to 3C show the successive steps in unloading a substrate wafer. The enclosure 1 in the closed position and containing an atmosphere at low pressure is placed in the load/unload chamber 30 associated with the transfer chamber 31 of a fabrication or process installation for semiconductor substrates. The load chamber 30 contains a mechanical compression system 32 enabling the enclosure 1 to be opened and closed, and the transfer chamber 31 contains a manipulator robot 33 enabling the substrate 8 to be grasped and displaced. The compression system 32

comprises an extensible arm 32a having an end carrying means 32b for locking and/or unlocking the locking device 5 placed in the handle 4 of the enclosure 1, and associated means 32c for opening the enclosure 1 by raising the top half-shell 2a. The arms 32a and the associated means 32c are carried by a common base 32d fastened to the wall of the load chamber 30.

There follows an explanation of how a substrate 8 is inserted, transported, and extracted using the transport and storage enclosure 1 of the present invention.

In order to load one or more substrates 8 into an empty enclosure 1, the enclosure 1 is opened at atmospheric pressure in the white room, and then placed in the load/unload chamber 30 of the installation. The load chamber 30 is closed and evacuated, thereby also evacuating the open enclosure 1. Once the enclosure 1 and the load chamber 30 have reached a pressure that is sufficiently low, the transfer chamber 31, which is also at low pressure, opens. The manipulator robot 33 has enough room to move one or more substrates into the enclosure. Once the substrate(s) 8 is/are placed inside the enclosure 1, a mechanical compressor system 32 of the actuator or spring type bears down on the transport enclosure 1, thereby:

· compressing the flexible support means 7 for supporting substrates 8 that are placed inside the enclosure 1 so that the two half-shells 2a and 2b come into contact with each other, meeting in sealed manner by virtue of the gasket 3, and being held together by means of the locking device 5; and

· holding the substrates 8 inside the enclosure 1 by a mechanical positioning and holding system comprising the portions in relief 12 and the studs 10 associated with the centering and holding pieces 11.

The size of the enclosure 1 is minimized by the applied compression, thereby making it easy to transport to a storage location or to any other compatible

equipment. The number of enclosures that can be stored in a given volume is thus substantially increased compared with the prior art.

Finally, with the enclosure 1 being held in compression by the mechanical compression system 32, the load chamber 30 is progressively returned to atmospheric pressure, thereby having the effect of keeping the enclosure 1 in the closed position because of the pressure difference between atmospheric pressure in the load chamber 30 and the low pressure inside the enclosure 1. The mechanical compression system 32 can then be deactivated since its effect is naturally compensated by the pressure difference. Nevertheless, in order to provide security against possible leaks, the mechanical compression system 32 can remain activated while the load chamber 30 is being opened, thus enabling the loaded enclosure 1 to be retrieved with low internal pressure. The sealing of the enclosure 1 is then maintained naturally by the pressure difference between the inside of the enclosure 1 which is at low pressure and the outside environment in the white room which is at atmospheric pressure. Two levels of security are put into place to avoid any leaks: firstly the locking device 5 enables the gasket 3 to be kept under compression as are the flexible support means 7 inside the enclosure 1, and secondly the stress exerted by the external atmospheric pressure in the white room which applies light mechanical compression all around the enclosure 1.

In order to unload one or more substrates 8, the closed enclosure 1, while maintained at low pressure and in compression by the locking device 5, is inserted into the load chamber 30 which is at the atmospheric pressure of the white room, as shown in Figure 3A. The load chamber 30 is then evacuated progressively. The enclosure 1 will expand little by little. So long as the pressure inside the chamber 30 is greater than the pressure inside the enclosure 1, pressure exerts a force

on the container 2 that opposes opening of the enclosure 1. The handle 4 is unlocked once the pressure inside the load chamber 30 is equal to the pressure inside the enclosure 1. The height to which the enclosure 1 opens is limited by the above-described compression system 32 acting as a high abutment (Figure 3B).

Once the enclosure 1 is in the open position, the manipulator robot 33 can come and find the substrates 8 that have become accessible. An arm of the manipulator robot 33 is inserted, as shown by arrow 34 in Figure 3A, between two trays which are spaced apart sufficiently for this to be possible. The arm lifts the substrate that is placed above it as shown by arrow 35 in Figure 3B. The manipulator robot 38 carrying the substrate then withdraws along arrow 36 shown in Figure 3C.

In a particular embodiment shown in Figure 4, the enclosure 1 is fitted with a pressure sensor 40 that measures the pressure inside the enclosure 1. The measurement is transmitted by a signal at radio frequency (RF). It serves to determine the exact moment the enclosure 1 opens and it can also serve to provide continuous monitoring of the environment inside the enclosure 1. The signal receiver may be positioned either inside the chamber 30 or outside the installation. In a variant, the system may also be fitted with temperature sensors, humidity sensors, and/or with sensors for measuring some other property of gas.

Figure 5 is a horizontal section view of the enclosure 1 seen from above. The support means 7 are placed in a triangle configuration around the substrate 8 so as to hold it in place while the enclosure 1 is being manipulated. The arm of the manipulator robot 33 is placed on the side of the container 2 of the enclosure 1 that is remote from its handle 4 provided with the locking device 5. Once compressed, the gasket 3 projects into the inside of the enclosure 1 and contributes to holding the substrate 8.

WHAT IS CLAIMED IS:

1. A sealed enclosure for transporting and storing semiconductor substrates, the enclosure comprising a sealed container and support means placed inside said container and including trays for supporting said substrates, the enclosure being characterized in that said container comprises two touching half-shells that move apart to open said container, and in that each end of said support means is mechanically secured to a respective one of said half-shells.

2. An enclosure according to claim 1, in which the total height of said support means varies depending on whether said container is open or closed, said trays being spaced apart at equal distances.

3. An enclosure according to claim 1, in which said support means include alternating segments and ball joints.

4. An enclosure according to claim 3, in which said alternation of segments and ball joints has a segment at each end, each of said end segments being mechanically connected to a respective one of said half-shells.

5. An enclosure according to claim 3, in which the total height of said support means varies by the alternating segments and ball joints moving concertina-like.

6. An enclosure according to claim 3, in which every other ball joint carries a tray on which a said substrate rests.

7. An enclosure according to claim 1, in which said half-shells are united via a flexible gasket.

8. An enclosure according to claim 7, in which said support means compress said flexible gasket to seal said container.

9. An enclosure according to claim 1, in which said container includes at least one handle.

10. An enclosure according to claim 1, in which said container includes a locking device.

11. An enclosure according to claim 10, in which said container includes at least one handle and said locking device co-operates with said handle.

12. A method of extracting a substrate from a low-pressure enclosure placed in a low-pressure load chamber, said enclosure comprising a sealed container and support means placed inside said container and including trays for supporting said substrates, said container comprising two touching half-shells that move apart to open said container, each end of said support means being mechanically secured to a respective one of said half-shells, the method being characterized in that it comprises the following steps:

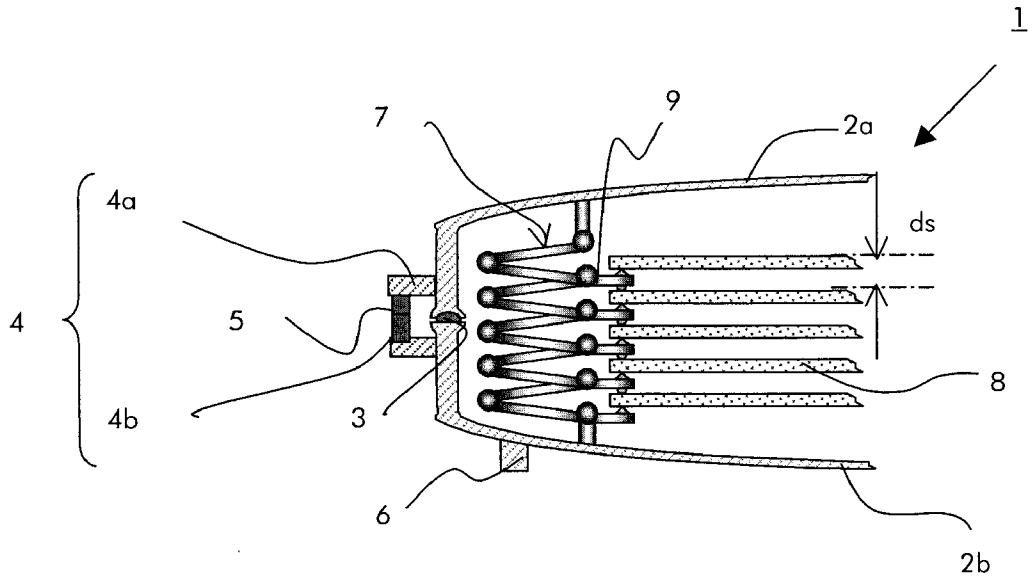
- increasing the distance between the trays by moving the half-shells apart;
- introducing robotic means between two contiguous trays;
- lifting the substrate placed above the robotic means;
- extracting the robotic means together with the substrate; and
- reducing the distance between the remaining trays by uniting the half-shells.

13. A method of inserting a substrate in a low-pressure enclosure placed in a low-pressure load chamber, said

enclosure comprising a sealed container and support means placed inside said container and including trays for supporting said substrates, said container comprising two touching half-shells that move apart to open said container, each end of said support means being mechanically secured to a respective one of said half-shells, the method being characterized in that it comprises the following steps:

- increasing the distance between the trays by moving the half-shells apart;
- inserting robotic means carrying the substrate between two contiguous trays;
- placing the substrate on the tray located beneath the robotic means;
- extracting the robotic means; and
- reducing the distance between the trays by uniting the half-shells.

FIG. 1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ds
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4b
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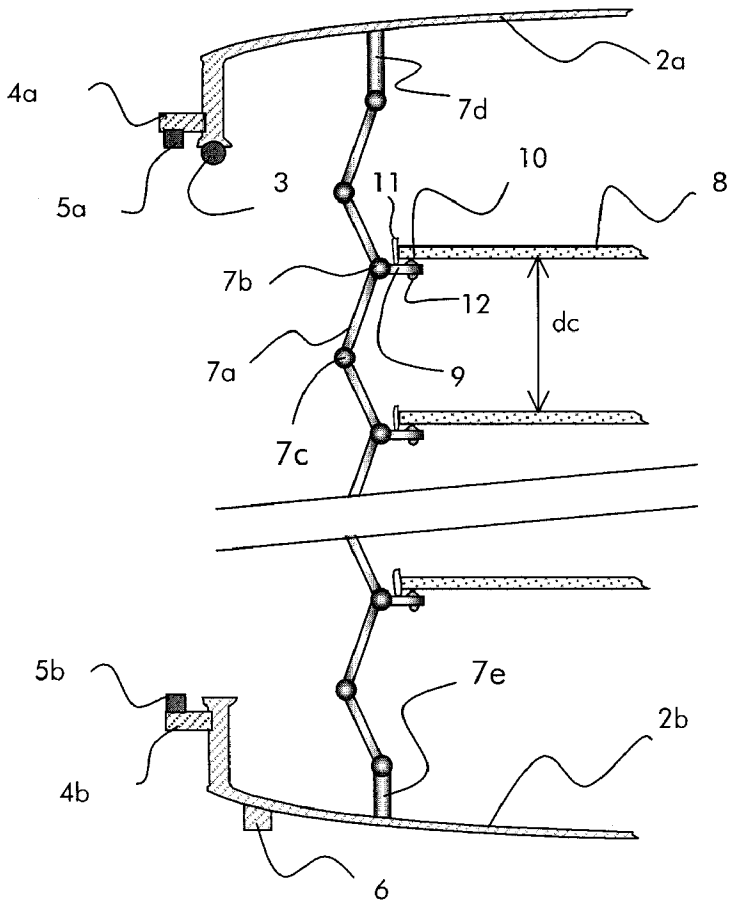
6
2b

FIG. 2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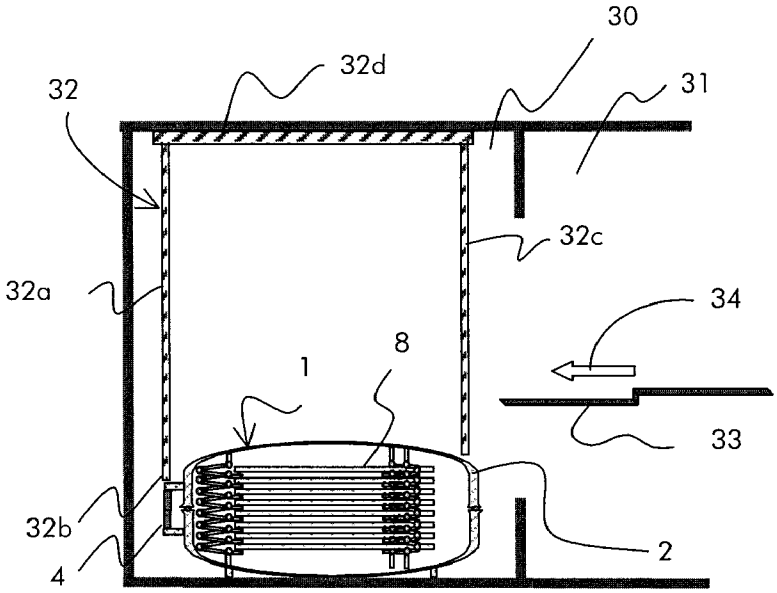
6

FIG. 3A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32c
32a
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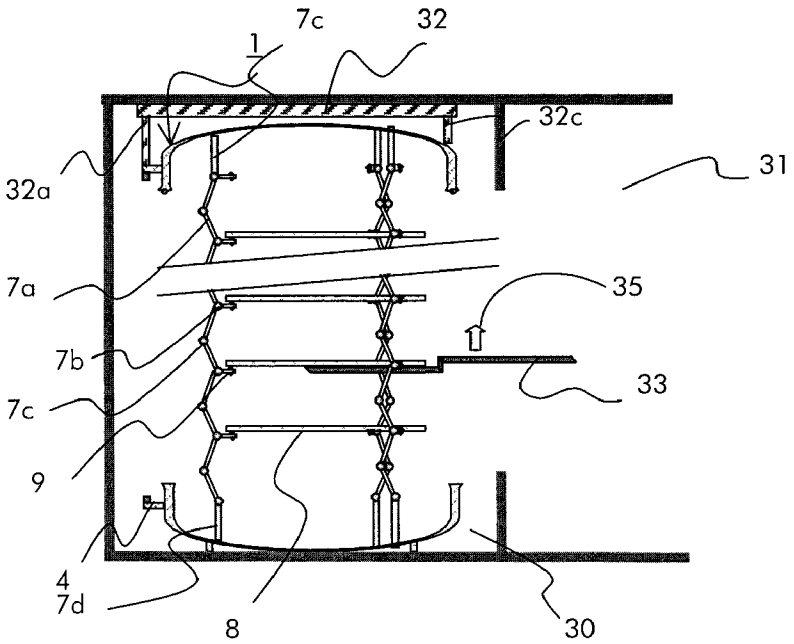
2
4

FIG. 3B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7b
33
7c
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4
7d
8
30

FIG. 3C

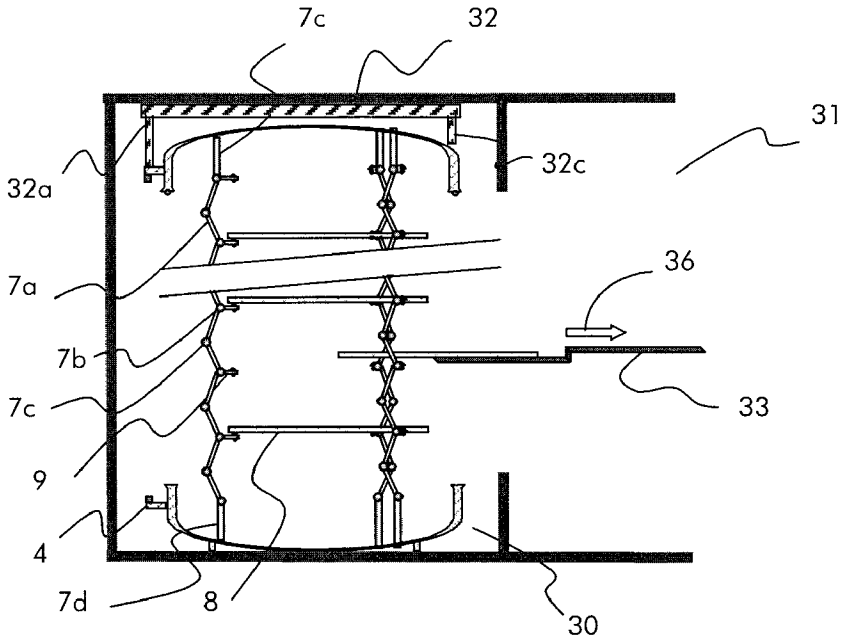


FIG. 4

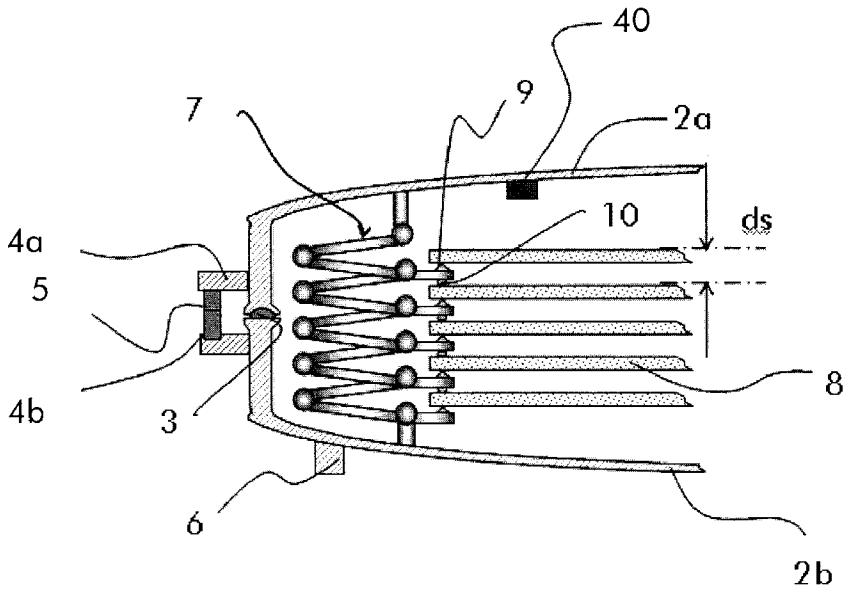
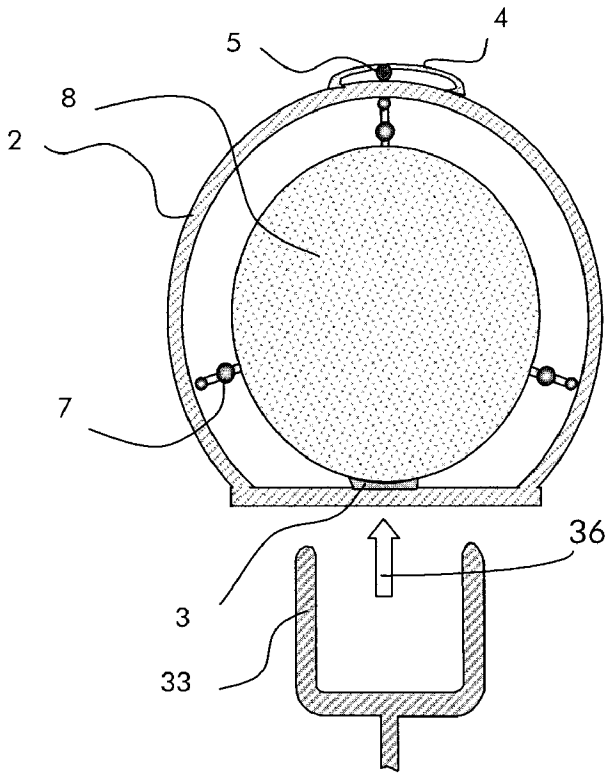


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/069454

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/677 H01L21/673 B65D25/10

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)
H01L B65D

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, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 255 797 A (KOS ET AL) 26 October 1993 (1993-10-26)	1,2,7-11
A	column 2, line 20 - column 5, line 15; figures 1,2	3-6,12, 13
X	US 4 129 211 A (CLEMENT ET AL) 12 December 1978 (1978-12-12)	1,2,7-11
A	column 3, line 44 - column 9, line 44; figures 1-7	3-6,12, 13
X	US 6 428 729 B1 (BHATT SANJIV M ET AL) 6 August 2002 (2002-08-06)	1,2,7-11
A	column 5, line 34 - line 62; figures 4,5,7	3-6,12, 13
X	US 6 704 998 B1 (BONORA ANTHONY C ET AL) 16 March 2004 (2004-03-16)	1,2,12, 13
A	column 2, line 15 - column 3, line 8; figure 1	3-11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
20 March 2007	12/04/2007

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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