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(54) **SLIDING DOORS FOR CLEAN ROOMS**

(57) The present invention belongs to the field of doors and accessories thereof, more precisely to the field of sliding doors for clean rooms. The invention relates to sliding doors for use in clean rooms.

The sliding doors according to the invention comprise a door frame, in which at least one door leaf is mounted, said door leaf being movable on a sliding guide using at least one movably mounted trolley with wheels, wherein said movement of the door leaf is enabled with a drive unit with a motor. The essence of the invention is in that the tubular sliding guide of the doors is oval shaped or the cross-section of the guide is shaped as an oval, respectively, thus increasing the contact surface of wheels that ensure movement of door leaf. Consequently, friction and wear of the wheels is reduced, which means that fewer particles are created. Preferably, the sliding guide is made from stainless steel that has the lowest wear. The improved sliding guide particularly reduces creation of unwanted particles due to wear of the wheels, while at the same time the door leaf is further away from the sliding guide, which gives more space and access for cleaning that is essential for door maintenance.

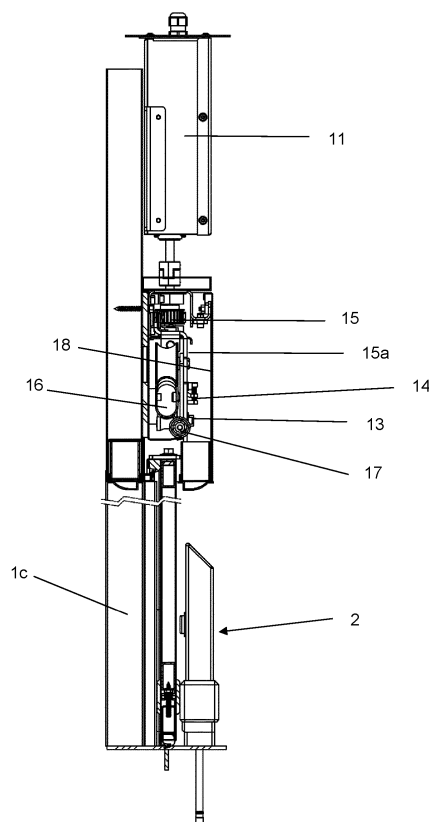


Figure 2

## Description

### Technical field

**[0001]** The present invention belongs to the field of doors and accessories thereof, more precisely to the field of sliding doors for clean rooms. The invention relates to sliding doors for use in clean rooms.

### Background of the invention and the technical problem

**[0002]** A clean room is a closed space, the interior of which has controlled number of particles in air, temperature and relative air moisture, air flow inside the space, pressure difference between the clean room and the external environment and microbiological burden of the space. Their classification according to ISO standards is done based on the number of particles in a cubic meter. In a typical urban environment, the external air comprises approximately 35000000 particles in each m<sup>3</sup>, wherein these particles have a size of at least 0.5 μm, which corresponds to ISO 9 clean room. In contrast, ISO 1 clean room does not allow any particles larger than 0.5 μm and only 12 particles per m<sup>3</sup>, with size of 0.3 μm or smaller. Clean rooms are usually used in dedicated industrial manufacturing plants or in scientific-research institutes, where cleanliness of rooms is of particular importance. Clean rooms are especially common in the production of pharmaceutical products, integrated circuits, LCD, OLED and microLED displays and similar products.

**[0003]** Due to requirements for clean rooms the importance of constructional materials used in manufacturing of clean rooms as well as their cleaning and maintenance is high. The doors are the border between the clean room and the outside, thus, a key element that prevents the ingress of particles and other dirt, which are mostly brought by people, either when entering, or when cleaning and maintaining the premises. The basic guidelines for all elements of clean rooms are:

- that the elements meet all GMP standards,
- cleaning and maintenance of said elements is as easy as possible, and
- maintenance is possible to the greatest extent possible without interfering with the clean room itself.

**[0004]** Several sliding doors with low air permeability for use in clean rooms are available in the market, said doors mostly being made from similar basic elements, such as door leaf, door frame, seal, sliding guide, drive, and automatics. In addition to the basic parts, some other components are also important, for example a cover mask that covers the sliding guide, wheels or rollers that ensure the movement of the leaf along the sliding guide, and the floor guide that prevents the swinging of the door leaf.

**[0005]** The problem of existing sliding doors for clean rooms is the sliding guide, selected materials and com-

ponents directly connected to said sliding guide, namely rollers, the cover mask, motor and automation position, the floor guide and protection of the doors, the door leaf. The sliding guide is an extruded profile with appropriate grooves along which the door leaf moves via wheels. Because the profile is sharp, this results in friction and increased wear of the wheels and consequently leads to creation of unwanted particles, which then fall freely into the clean room. The cover mask that covers the sliding guide does not prevent particles from falling into the clean room. An additional issue of contamination of the clean room are other elements of the door, which are not directly connected to the wheels needed for moving the sliding door. The floor guide, which is installed and fixed in the floor itself, can be damaged and thus dislocated from its base, which can also lead to contamination of the room. Installation of the drive and automation, which are located next to the sliding guide, can be problematic for maintenance, as in case of a malfunction, intervention in the clean room is necessary. Finally, cleaning is also challenging, as for example the door leaf can only be cleaned when the door is dismantled, which means that the clean room will be contaminated during dismantling and subsequent cleaning.

**[0006]** The above-mentioned problems represent a starting point for development of improved sliding doors for clean rooms with low air permeability performance. The technical problem is thus a constructional design of sliding doors that will solve the above-mentioned problems of known doors in an efficient manner, so that as few particles as possible will be able to enter the clean room and cleaning as well as maintenance of the door can be performed without interference with the clean room.

### Prior art

**[0007]** Patent application WO2005085575 describes automatic sliding doors comprising at least one guide, which is stationary installed on a wall, at least one automatic unit, which is stationary installed on the wall and which comprises a drive for the doors and at least one trolley with at least one roller. The trolley is movable along the guide using said roller(s). The guide is designed as a profile that can be cut based on needs. The automatic unit is designed as standard unit with fixed length corresponding to the door width. This solution differs from the present invention in the shape of the said guide. The disadvantage of the guide described in WO2005085575 is that it comprises several components, between which impurities can accumulate.

### Description of the solution to the technical problem

**[0008]** The aim of the invention is optimization of the sliding doors construction, particularly the sliding guide and its components. The technical problem is solved as defined in the independent claim, while the preferred em-

bodiments are defined in dependent claims.

**[0009]** The sliding doors according to the invention comprise a door frame in which at least one door leaf is attached, said door leaf is slidably movable on a sliding guide using at least one movably mounted trolley with wheels, wherein movement of the door leaf is enabled with a drive unit with a motor. The belt, which ensures movement, is on the side without the motor mounted in a counter-wheel for guiding the belt and preventing its disengagement or lack of tension. Doors usually have one or two leaves, wherein the components of the invention are the same or function in the same way in both versions.

**[0010]** The essence of the invention is in that the tubular sliding guide has an oval cross-section, which increases the contact surface of wheels that enable movement of the door leaf. Consequently, friction and wear of the wheels is decreased, thus leading to less generated particles. Preferably, the sliding guide is made from stainless steel that has a low wear. The sliding guide is further preferably provided with press-in grooves for fitting and sealing the door, said grooves are arranged to receive the wheels, to which the door leaf is mounted. The function of said grooves is sealing, while the grooves itself have no impact on the wear of wheels, as the latter has the same contact surface as in guides without grooves. The improved sliding guide particularly ensures decreased formation of unwanted particles resulting from wear of the wheels. Further, the guide allows an increased distance of the door leaf from the guide, which results in a larger space and easier access for cleaning that is one of key activities in door maintenance.

**[0011]** The sliding doors according to the invention are preferably provided with a cover mask arranged to cover the sliding guide. The cover mask is shaped as an approximate letter C, so that its vertical part is aligned with a wall or a ceiling, when the doors are installed, while the cover mask itself is easily removable using hinges, preferably made from PE plastic material. Said plastic hinges do not comprise movable particles, thus allowing easier cleaning and reduced possibility for contamination of clean rooms. In this way easier access to the guide and cleaning is enabled. At the same time, the surface of the cover mask is levelled with the wall or the ceiling, thereby eliminating a surface on which dust particles could accumulate.

**[0012]** For trapping particles that may be created during opening and closing, at least one particle catcher is provided, wherein the cover mask functions as the first catcher that covers the sliding guide along its entire length. Said mask is shaped so as to prevent created plastic particles from falling from the wheels into the clean room. The shape of the first particle catcher, which is at the same time the cover mask, is essentially shaped as the letter C, depending on the mounting of the catcher, wherein the vertical part of the letter C is a straight surface, and the upper part is arranged to engage with the hinge, preferably made from PE plastic, and the bottom

part is placed below the sliding guide in order to efficiently catch possible particles. The bottom part extends into the interior of the door construction and is usually larger than the upper part, which functions as attachment to the doors. The straight vertical part is easily cleaned and maintained, while the access to the bottom part with possibly trapped particles is possible upon removal of the cover mask or its opening, respectively.

**[0013]** More particle catchers may be provided, either shaped as an approximate letter C, or approximate letter S or L. A second particle catcher is a drive covering plate, which is shaped similarly as the first particle catcher, i.e., under the guide is a suitable bottom part, which retains particles that may be generated during door operation. Preferably a third particle catcher is installed under the drive pulley and a fourth particle catcher under the counter-wheel. By increasing the number of particle catchers more particles are trapped and prevented from entering the clean room.

**[0014]** The sliding doors according to the invention are further provided with improved seals that prevent creation of air pockets. The shape of the seal in cross-section is approximately rectangular or square, wherein the bottom part has a corner with a protruding part that is directed towards to opposite corner of the bottom part. The shape of this seal prevents the impurities to accumulate in places that are challenging to clean and further allows easier cleaning. The seals are made from any suitable material, which has been approved for this use by the FDA.

**[0015]** Preferably, the sliding doors with the improved guide according to the invention are designed so that the automatic assembly and the drive assembly are installed in the technical zone, i.e., in the space above the doors, when they are installed. Any interference with automatics and the drive does not require entering the clean room, which simplifies maintenance and repairs. Interference in the clean room is particularly unwanted, so the present invention solves this problem with the especially shaped sliding guide and with different placement of the drive and automatics assembly. The drive assembly comprises a housing with a cover, inside which the assembly includes a motor, preferably a BLCD motor, a drive axis with a bearing and its housing, a clutch for transmission between the motor and the drive axis, as well as an electromagnetic coil with a sensor for locking the drive axis. The drive assembly is through the drive axis and the clutch further connected to a wheel with installed belt, which drives the trolley with door leaves. The automatic assembly (also called control or automatics) is connected to the drive assembly through conductors (cables, wires) and serves for automatic operation of doors. This assembly comprises a housing, a power source, batteries, protection elements, control electronics, relays, connection clamps and conductors.

**[0016]** For additional prevention of interference with the clean room and prevention of impurities entering the clean room, the door mounting into the floor is optimized. Instead of the usual floor guide and additional pillars from

stainless steel, an adjustable elevated floor pillar is provided, said floor pillar protecting the doors and the floor guide. Such construction decreases the number of elements fixed into the floor. The floor guide is designed with a separate floor plate attached into the floor, wherein said floor pillar is attached with a floor guide. In case of damage to the floor pillar the floor plate remains intact, thus preventing contamination of the clean room. The breaking force of the pillar may be defined with various mountings of the pillar and the materials used for mountings, for example inox, HPL, PE and similar. The mounting may be achieved with a screw and a breakable plate and additional screws, which via anchors ensure reliable mounting. The guide made from PE plastic along which the door slide is attached to the pillar as a ring, having a sliding function as well as covering for the mounting screws. Thus, cleaning is improved and easier.

**[0017]** The door leaf is shaped in a manner allowing full surface cleaning. The doors according to the invention has several modes of operation, namely:

- automatic summer (full opening),
- automatic winter (partial opening),
- one-way summer (full opening),
- one-way winter (partial opening),
- closed/locked (doors are closed/locked),
- open (doors are open),
- stop (motor disengaged, manual opening of doors enabled), and
- cleaning, wherein the doors are fully opened and manual movement of doors is enabled.

**[0018]** The control of the operation mode choice and operation in the selected operation mode is performed by the automatics in any known manner. In cleaning mode, the doors can be manually or automatically opened to the fully open position past the slider, wherein the door leaf may be inclined for approx. 10°. The following steps are performed for cleaning:

- a) selecting cleaning mode,
- b) doors are automatically opened to the fully open position - past the floor pillar,
- c) doors can be inclined for approx. 10° using wheels of the trolley, which allows cleaning of seals and edges of the door leaf, respectively,
- d) doors can be manually moved along the guide, as the drive unit is inactive in this mode of operation,
- e) selection of a different mode of operation after finished cleaning, wherein the doors operate in the selected mode of operation and automatically move into a suitable position.

**[0019]** The sliding doors according to the invention may be installed in any clean room, wherein the sliding doors may have one or more, preferably two wings.

**[0020]** The invention will be described in further detail based on exemplary embodiments and figures, which

show:

|              |                                                                           |
|--------------|---------------------------------------------------------------------------|
| Figure 1     | The sliding doors with two door leaves according to a possible embodiment |
| 5 Figure 2   | Cross-section of the doors shown in figure 1 in the plane A-A             |
| Figure 3     | The sliding guide                                                         |
| Figure 4     | The cover mask and particle catcher                                       |
| Figure 5a    | The floor pillar                                                          |
| 10 Figure 5b | Cross-section of the floor pillar                                         |
| Figure 6     | The seal                                                                  |

**[0021]** Figure 1 shows two-leaves sliding doors 1 for clean rooms according to a possible embodiment, wherein the doors 1 comprise two leaves 1a, 1b, namely left leaf 1a and right leaf 1b, wherein the drive assembly 11 is installed above the guide 1c, the counter-wheel 12 is installed on the opposite side of the drive assembly 11. Figure 1 as well as figure 2 showing the cross-section of the doors 1 shown in figure 1 in the plane A-A depict the drive assembly 11, and the guide assembly comprising a smaller trolley 14, a larger trolley 13, both arranged to move the leaves 1a, 1b along the sliding guide 16, a belt 15 and its mounting 15a. The drive assembly 11 is mounted above the guide 1c of the doors, while the doors are installed into the floor using floor pillars 2.

**[0022]** Figure 3 shows the tubular sliding guide 16 of the doors, said guide having an oval shaped cross-section, which increases the contact surface of trolleys 13, 14 that ensure movement of the door leaves 1a, 1b. The length of the sliding guide 16 is adapted to the size of the doors, wherein the sliding guide is made from stainless steel.

**[0023]** For catching particles that may be generated during opening and closing of the doors, at least one particle catcher is provided, wherein said cover mask 18 functions as the first particle catcher. The cover mask covers the sliding guide along its entire length. It is shaped in a manner which prevents the plastic particles generated due to wear of rollers from freely falling into the clean room. The cover mask 18 is shaped as a letter C (figure 4) and its vertical part 18b is aligned with the wall or the ceiling, once the doors are installed, while its bottom part 18c extends into the interior of the door construction and is generally larger than the upper part 18a configured to allow mounting on the door. The flat vertical part 18b is easily cleaned and maintained, while the access to the bottom part 18c with possible particles is enabled by removing or opening the cover mask 18. The cover mask itself is easily removable and can be opened using hinges 18d, preferably made from PE plastic. The PE plastic hinges do not have any movable parts and thus decrease the possibility of clean room contamination as well as allow easier cleaning. Further, such construction allows easier access to the guide and cleaning possibilities, while the levelled surface of the cover mask to the wall or ceiling decreases the number of surfaces, which are prone to particle accumulation. A console 20

for locking the mask may also be provided, said console being arranged to lock a suitable locking system for clean rooms.

**[0024]** The second particle catcher 19a is the cover of the drive having a similar shape as the first catcher, i.e., a suitable bottom part is present below the guide in order to catch any particles that may be generated during door operation. The third particle catcher 19b is mounted below the drive pulley, while the fourth catcher (not shown in the figure) is mounted below the counter-wheel.

**[0025]** For additional prevention of interference with the clean room and for preventing impurities from entering the clean room the mounting of the doors is achieved with adjustable elevated floor pillar provided with a slider as shown in figure 5. The function of the pillar is protection of doors and the floor guide.

**[0026]** The pillar 2 has a base body 21 with anchors 23 installed into the floor, wherein on the base body 21 a secondary covering sliding guide 27 is mounted with screws 25, said secondary guide allowing guiding of door leaves in case the pillar is broken. The interior of the covering sliding guide 27 is provided with a breakable plate 26 mounted on a surface of a tube 28 with a screw 24. The covering sliding guide made from PE is installed as a ring on the pillar 2, while said guide further functions as a sliding guide and covers screws 24 and 25. The pillar can be further provided with a door lock, which is essentially a mechanical lock for locking the doors in open or closed state. It is provided to improve protection during sterilization of the clean room, as unauthorized access is not possible. In addition, said door lock protects the doors during installation and building works, as manual closing of the doors is not allowed, due to the doors being mechanically locked in an open state. Said lock comprises a mounting plate which is attached to the pillar with two screws. A rotating lock installed on the mounting plate, said rotating lock being connected to a threaded spindle with a screw, wherein a locking mechanism is mounted with a multi-level thread on the said threaded spindle, so as to allow rotation of the threaded spindle during rotation of the lock, thus pushing the locking mechanism from or into the pillar, depending on the direction of the rotation.

**[0027]** The plastic slider ensures sliding and control is enabled with a console welded into the pillar 2.

**[0028]** The sliding doors according to the invention are further provided with improved seals 3, which prevent creation of air pockets. The shape of the seal is shown in figure 6 and has an approximately square cross-section, wherein the bottom part has a protruding element from one corner, said protruding element continuing towards the opposite corner of the bottom part. So shaped seal prevents the impurities from accumulating in spaces that are challenging to clean and further enables easier cleaning.

## Claims

1. Sliding doors for clean rooms, comprising a door frame, in which at least one door leaf is mounted, said door leaf being movable on a sliding guide using at least one movably mounted trolley with wheels, wherein said movement of the door leaf is enabled with a drive unit with a motor and a belt, said belt being mounted on the side without the motor to a counter-wheel for preventing disengagement or reduced tension, **characterized in that** the sliding guide is tubular with an oval cross-section.
2. Sliding doors for clean rooms according to claim 1, wherein the sliding guide of the doors is made from stainless steel.
3. Sliding doors for clean rooms according to claim 1 or claim 2, wherein the sliding guide of the doors is provided with grooves for positioning and sealing of doors, wherein said grooves are arranged to receive rollers to which door leaf is attached.
4. Sliding doors for clean rooms according to any of the preceding claims, wherein the doors are further equipped with a cover mask that covers the guide assembly, wherein the vertical part of the cover mask is aligned with a wall or a ceiling, when the doors are installed, said mask being easily dismantled using hinges, preferably made from PE plastic material.
5. Sliding doors for clean rooms according to the preceding claim, wherein the cover mask functions as a particle catcher arranged to catch particles created during opening and closing of the doors, wherein the cover mask is shaped as the letter C.
6. Sliding doors for clean rooms according to the preceding claim, wherein the cover mask (18) is shaped as letter C having a flat vertical part (18b), an upper part (18a) shaped so as to fit on the hinge, preferably from PE plastic, a bottom part (18c) located below the sliding guide (16) to allow catching of particles, wherein the bottom part (18c) extends into the interior of the door construction and is usually larger than the upper part (18a), which ensures attachment to the doors.
7. Sliding doors for clean rooms according to any of the preceding claims, wherein the doors are provided with one or more additional particle catchers selected in the group consisting of:
  - a second particle catcher, which is a cover plate of the drive having a similar shape as the cover mask, and/or
  - a third particle catcher installed below the drive pulley, and/or

- a fourth particle catcher installed below the counter-wheel.
8. Sliding doors for clean rooms according to any of the preceding claims, wherein the doors are provided with seals that prevent creation of air pockets, wherein the shape of the seal in cross-section is rectangular or square, wherein the one corner of a bottom part is provided with a protruding part directed towards the opposite corner of the bottom part.
9. Sliding doors for clean rooms according to any of the preceding claims, wherein the drive assembly comprises a housing with a cover, inside which the assembly includes a motor, preferably a BLCD motor, a drive axis with a bearing and its housing, a clutch for transmission between the motor and the drive axis, as well as an electromagnetic coil with a sensor for locking the drive axis, wherein the drive assembly is through the drive axis and the clutch further connected to a wheel with installed the belt, which drives the trolleys with door leaves.
10. Sliding doors for clean rooms according to any of the preceding claims, wherein the automatic assembly is connected to the drive assembly with wires and is arranged to enable automatized operation of doors, wherein the automatic assembly comprises a housing, a power supply, batteries, protective elements, control electronics, relays, connection clamps and wires.
11. Sliding doors for clean rooms according to any of the preceding claims, wherein mounting of the doors into the floor of the room is achieved with one, preferably two adjustable elevated floor pillars with a slider arranged to protect the doors and the floor guide, wherein the floor pillar (2) has a base body (21) with anchors (23) installed into the floor, wherein on the base body (21) a covering sliding guide (27) is mounted with screws (25), wherein interior of the covering sliding guide (27) is provided with a breakable plate (26) mounted on a surface of a tube (28) with a screw (24).
12. Sliding doors for clean rooms according to the preceding claim, wherein the pillar (2) is further provided with a mechanical lock for locking doors in a closed or open state, wherein said lock comprises a mounting plate attached to the pillar with screws and a rotating lock installed on the mounting plate, said rotating lock being connected to a threaded spindle with a screw, wherein a locking mechanism is mounted with a multi-level thread on the said threaded spindle, so as to allow rotation of the threaded spindle during rotation of the lock, thus pushing the locking mechanism from or into the pillar, depending on the direction of the rotation, while the plastic slider en-
13. Sliding doors for clean rooms according to any of the preceding claims, wherein the doors are single-leaf or double-leaf.
14. A clean room with the sliding doors according to any of the preceding claims.
15. The clean room according to claim 14, wherein the automatic assembly and the drive assembly are installed in a technical zone, i.e., in a space above the installed doors.
- sures sliding and control is enabled with a console welded into the pillar (2).

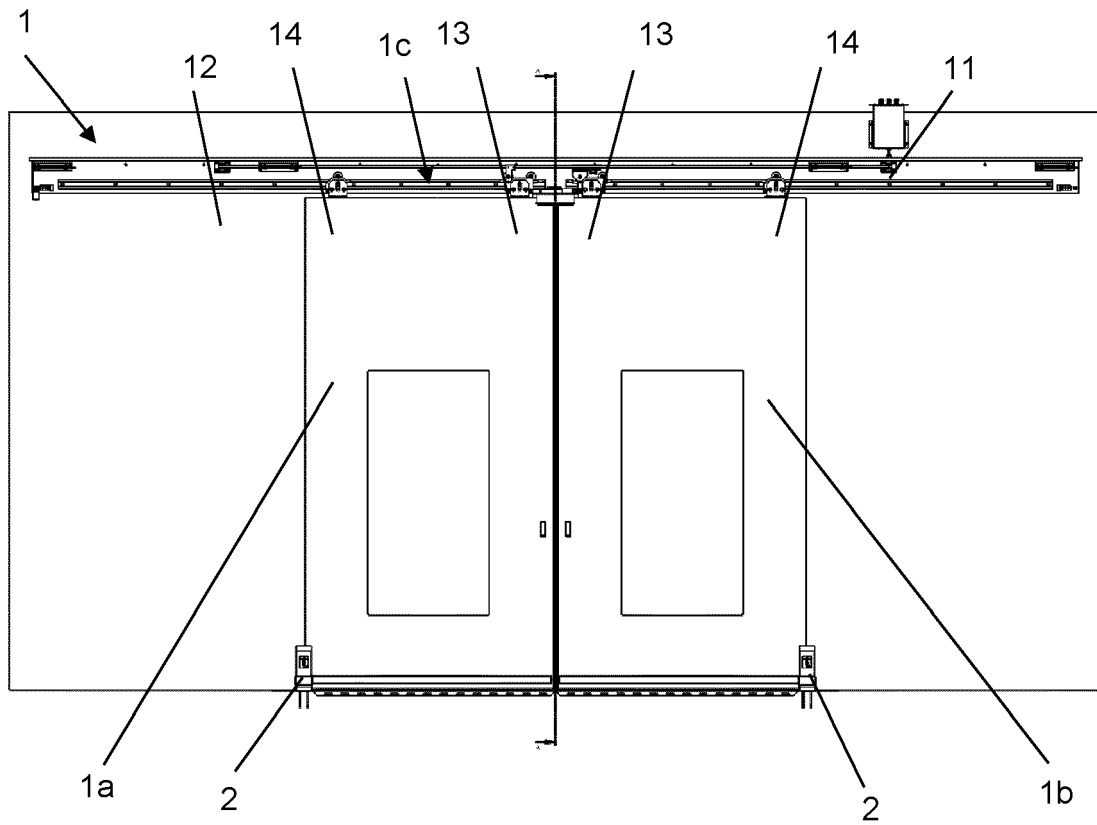


Figure 1

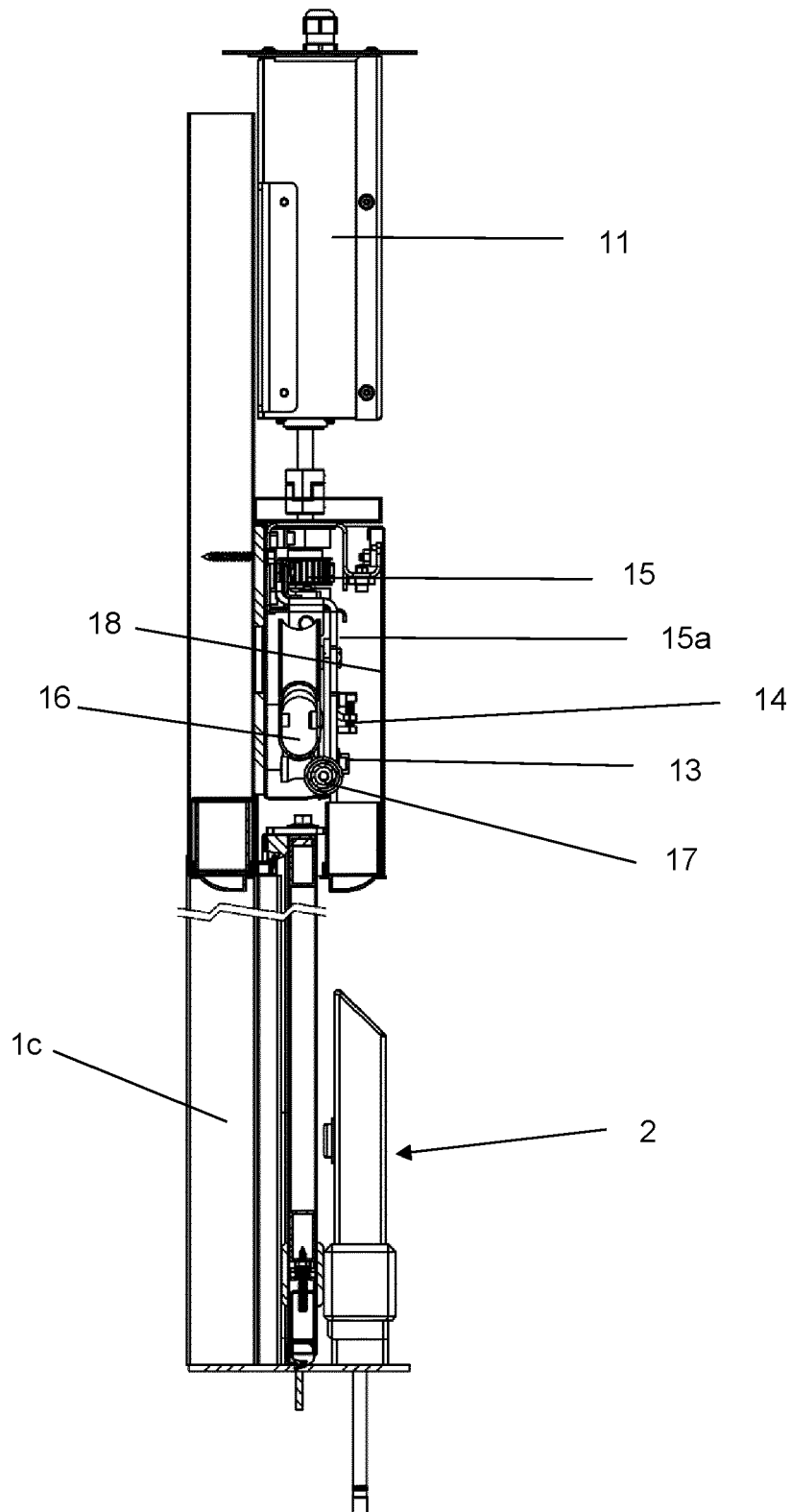


Figure 2

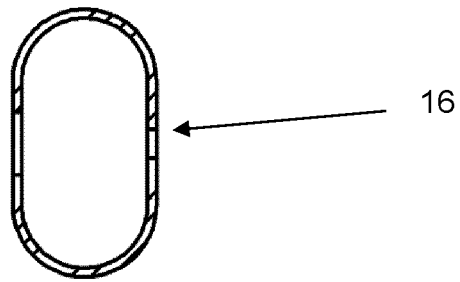


Figure 3

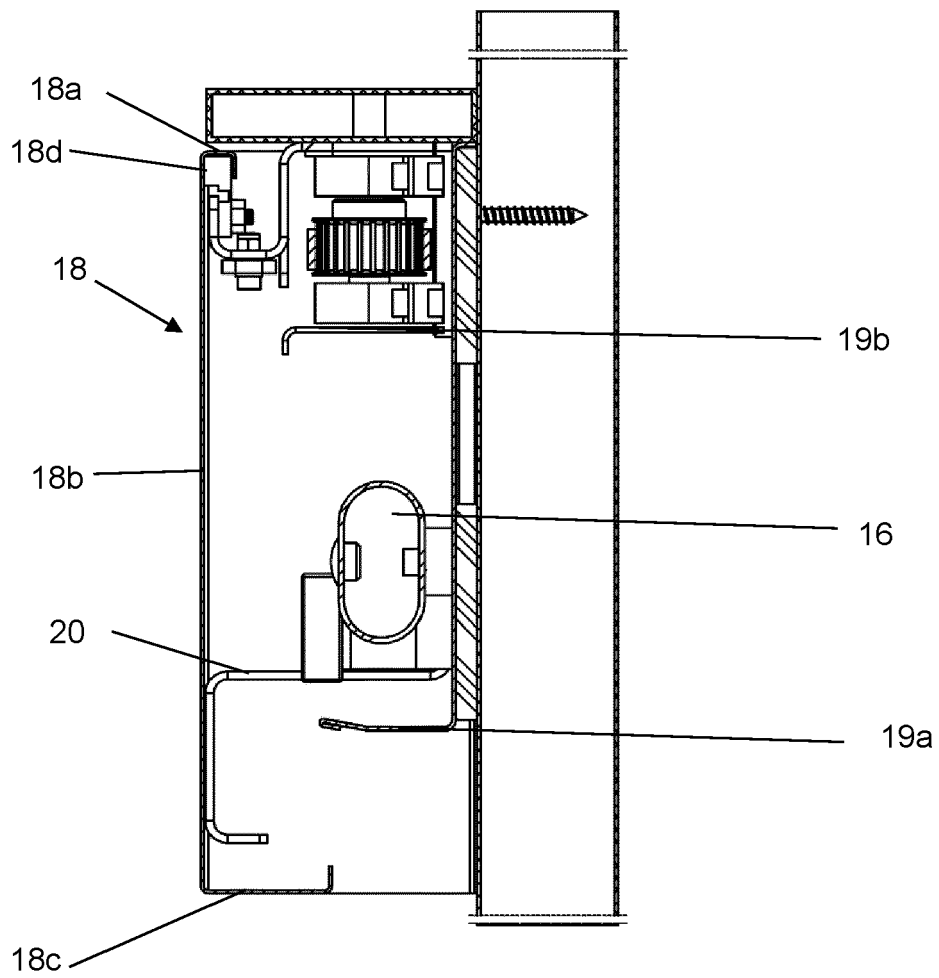


Figure 4

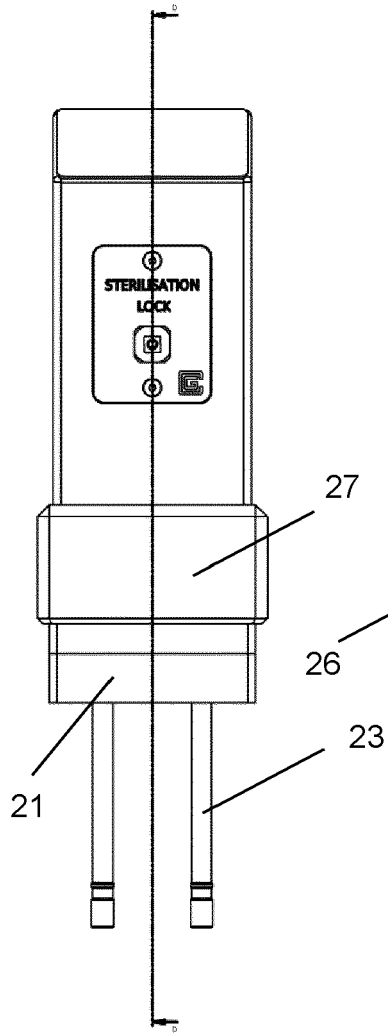


Figure 5a

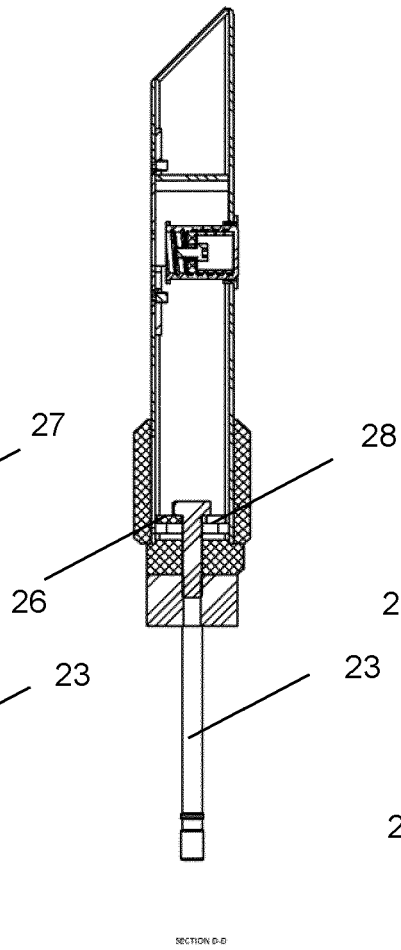


Figure 5b

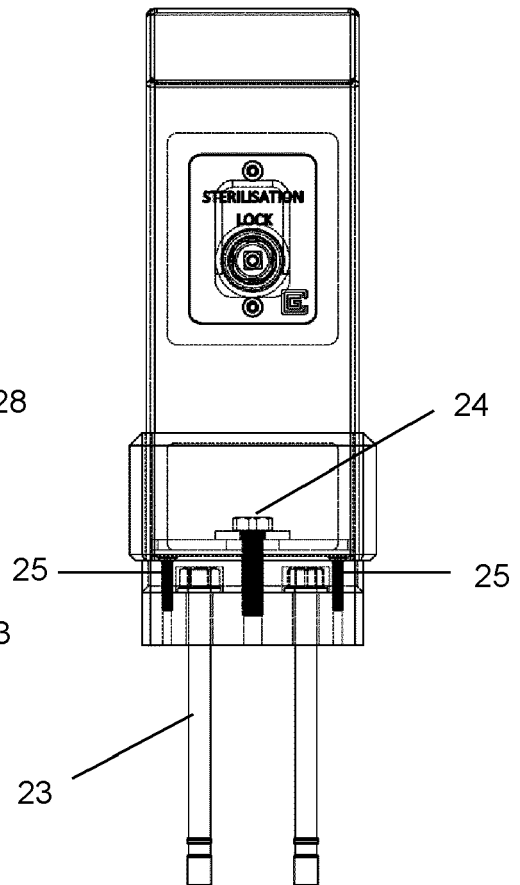


Figure 5c

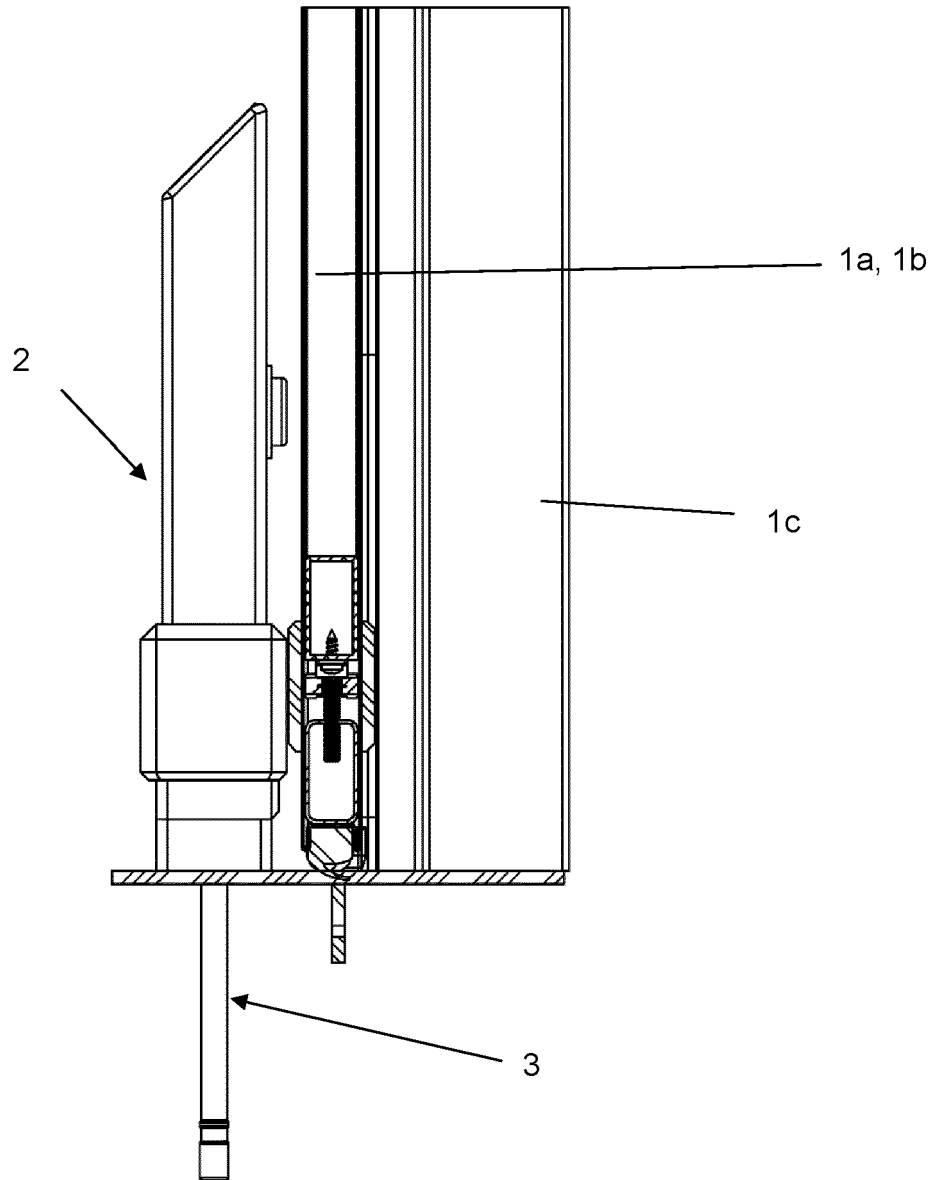


Figure 6a

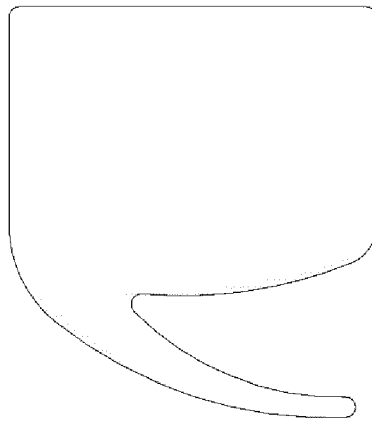


Figure 6b

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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