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(71) Applicant: **VRIJE UNIVERSITEIT BRUSSEL**
1050 Brussel (BE)

(72) Inventors:
- **Diltoer, Marc Wim**
  1910 Kampenhout (BE)
- **Jacobs, Valéry Ann**
  1050 Brussel (BE)
- **Van Gaever, Romy**
  3001 Heverlee (BE)

(74) Representative: **Brantsandpatents bvba**
Pauline Van Pottelsberghelaan 24
9051 Ghent (BE)

(54) IMPROVED SYSTEM AND METHOD FOR VENTILATION AND ILLUMINATION OF AN OPERATING ROOM

(57) The invention concerns an improved system and method for ventilating and illuminating an operating area. The system comprises an air pressure chamber and a lighting system, the lighting system providing one or more directed light beams of which the origin and direction can be controllably altered with respect to the air pressure chamber. The chamber comprises a transparent wall with a set of perforations for creating a substantially laminar air flow on the outside of the air pressure chamber. It further provides a use of a transparent plate for illuminating and creating a laminar air flow in an operating area, the transparent plate comprising a set of perforations through which a substantially laminar air flow is provided towards the operating area, said plate having a minimal transmittance of 30% for directed light beams with an angle of incidence on said plate below 45°.

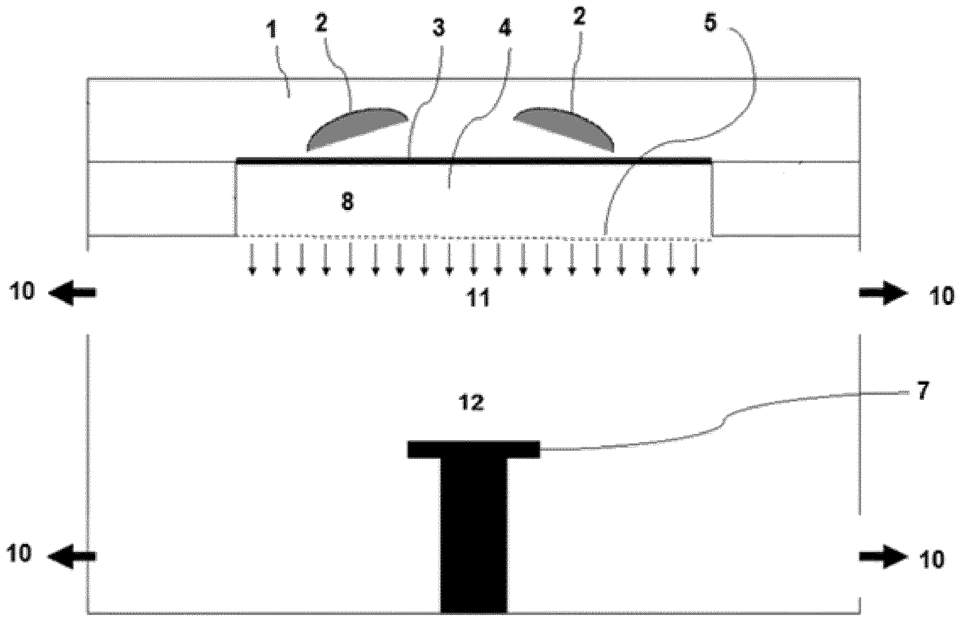

FIG. 1B

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an improved system and method for ventilating and illuminating an operating area in an operating room.

BACKGROUND

[0002] In order for a medical specialist and his/her team to be able to perform a surgical intervention, intensive illumination of an operation area and particularly a patient's inside is generally necessary. To this end, many operating rooms (OR's) are provided with lamps mounted on a distal end of movable supporting arms. These arms may be controlled manually in order to direct light in a desired direction and provide the proper illumination needed during the surgery. This conventional way of illuminating an OR however has several disadvantages. For example, each of the lamps has to be manually manipulated to illuminate a particular area of an OR. If an operation requires various areas of a human body or various areas of an OR to be illuminated (apart from a patient e.g. also an instrument cart or table), this may be hard to achieve using these conventional means. Also, the areas of an OR that need to be illuminated may change during an operation, the various lamps may thus repeatedly have to be manipulated manually, which can be cumbersome. Furthermore, the presence of a supporting arm and a lamp may disturb the downwards unidirectional low-turbulent flow (ULF), such as a laminar air flow (LAF) established by a ULF or LAF ceiling; even more so if a plurality of lamps is provided in order to be able to illuminate different parts of an OR. Adding to this interference, there is also thermal interference from the heat the lamps create, which can also drastically change the air flow pattern.

[0003] ULF ceilings may be provided in (parts) of operating rooms to establish a ULF, e.g. a substantially laminar vertical air flow from the ceiling to an operating area. This air flow is provided to keep an operating area (and in particular the surgical wound of the patient) and an instrument table free from germs, bacteria, pathogens etc. and avoid that the medical specialist and his/her support personnel contaminate the operating area. Additionally a ULF also helps in protecting the OR, the medical personal and the patient himself from (self)contamination by the patient's germs, bacteria, etc. The presence of the supporting arms and lamps may disturb the ULF established by a ULF or LAF ceiling and thus may lead to a higher risk of infections occurring after an operation.

[0004] WO 2007/036581 discloses a lighting system comprising an array of light-emitting elements, in which the light-emitting elements can be individually controlled or in groups. This solves the problem of simultaneously illuminating different areas of an OR. However, the array of light-emitting elements is suspended from a ceiling and can significantly disturb the laminar air flow of an LAF ceiling.

[0005] WO 01/69130 discloses a ceiling comprising a plurality of prefabricated lighting module elements. Said lighting module elements comprise a gyroscopic suspension system in order to rotate a light bulb (or LED elements) around two axes. The gyroscopic suspension system however occupies a large space and requires a cumbersome installation. Moreover, if such a lamp is mounted in an LAF ceiling, the space occupied by the lamp cannot be used for passing air into the OR.

[0006] WO 2012/013749 discloses a laminar air flow plenum comprising one or more light-emitting elements, capable of rotating along two perpendicular axes. The light-emitting elements are integrated in the lower horizontal wall of the plenum and have been reduced in surface so as not to disturb the LAF pattern at patient height. However, this might still produce turbulences that can cause contamination of the operating area. Furthermore, this configuration will either not be able to illuminate every zone according to surgical luminaires standards, such as the current European Standard IEC 60601-2-41, as the light-emitting elements are stationary, or need a high amount of light-emitting elements in order to be able to illuminate every zone. The latter will lead to a higher consumption of energy and will create more turbulences as there are more light-emitting elements in the lower horizontal wall.

[0007] FR 2032919 discloses a mobile illumination and ventilation system, where the lamps are integrated with the ventilation system and the system can be moved and rotated as it held by an arm that does not interfere with the ventilation. It requires the surgeon or other surgical staff to manually adjust the light and is limited in size for practical reasons, and therefore in ventilating and lighting range. Furthermore, by adjusting the system, turbulences can be created that can cause contamination of the patient, as the ventilation follows the direction of the lighting. In a further embodiment, an extra element is added that can direct the air flow separately from the lighting. However, changing the direction of the lighting while keeping the direction of the air flow constant is impractical in this configuration. In addition, a steady, laminar flow will not be achieved in this embodiment.

[0008] Furthermore, evolutions in healthcare regulations have grown stricter over the years and specific operation room requirements are expected to become more strictly regulated in the future. Whereas a very liberal regulation is still applied in many countries for now, this bound to change in the future. Due to the massive impact of surgical site infections (SSI), setting higher legally required regulations is a logical evolution, and a near inevitable evolution from a medical perspective.

[0009] It is clear that there is need of a system that will satisfy both ventilation and illumination demands, especially on the level of the patient and surgical staff.

[0010] The aim of the present invention is to provide a solution to overcome at least part of the above mentioned disadvantages. The invention is disclosed in the claims.

SUMMARY

[0011] In a first aspect, the present invention provides a system for ventilating and illuminating an operating area, whereby said system comprises at least one static air pressure chamber positioned above said operating area in an operating room, and a lighting system. The static air pressure chamber comprises at least one inlet for air and a transparent lower wall, whereby said transparent lower wall comprises a set of perforations for allowing air to flow from the air pressure chamber to the operating room, the set of perforations being arranged such that a ULF, preferably a LAF, can be provided in the operating area. The lighting system is positioned above the transparent lower wall, and is arranged to provide one or more directed light beams to the operating area through the transparent lower wall. The lighting system comprises one or more light-emitting elements for producing said light beams. The system as a whole is characterized in that the light-emitting elements are mounted movably relative to the air pressure chamber such that the direction and the point of origin of the light beams can be controllably altered. Hereby the light beam's origin and direction can be altered without substantially modifying the ULF.

[0012] In a preferred embodiment, the light-emitting elements are LED lamps. LEDs typically produce a small amount of heat compared to other light sources. In an alternatively preferred embodiment, other light-emitting elements that produce relatively little heat with respect to their light output, are used.

[0013] In a further embodiment, the invention provides a system described above, whereby the static air pressure chamber comprises a transparent upper wall, and whereby the lighting system comprises a static lighting chamber above the transparent upper wall of the static air pressure chamber, and whereby the light-emitting elements of the lighting system are moveably mounted to the lighting chamber and arranged to provide one or more directed light beams to the operating area through the transparent upper wall and the transparent lower wall of the air pressure chamber. Preferably, the transparent upper wall is liquid impermeable. Preferably, the inlets for air are located in a side walls or upper wall of the air pressure chamber.

[0014] In an alternative embodiment, the invention provides a system as described above, whereby the lighting system is located inside the air pressure chamber. In a preferred embodiment, at least one inlet for air is located in a side wall of the air pressure chamber. Preferably all inlets are in a side wall of the air pressure chamber.

[0015] In a preferred embodiment, at least one inlet for air is provided with a filter system for filtering air that moves from outside of the air pressure chamber to the inside of said air pressure chamber. In a further preferred embodiment, all inlets for air are provided with a filter system. In the most preferred embodiment, said filter systems comprise at least one high-efficiency particulate arrestance (HEPA) filter.

[0016] In a preferred embodiment, the system comprises a device for remotely controlling the direction and the point of origin of the light beams. This allows members of the surgical team to adjust lighting without manually handling the lighting system which could allow pollutants to reach the operating area by transference from the lighting system to the members of the surgical team. Remotely executing these adjustments is also more practical, as the adjustment can comprise an automatic focusing step for the light beams.

[0017] In a further preferred embodiment, the device for remotely controlling the direction and the point of origin of the light beams does not comprise the sterility of the operating area. In an embodiment, the device is in a remote location with respect to the operating area. In an alternative embodiment, the device is sterile. Preferably, the device has a touchless interface.

[0018] In a preferred embodiment, the set of perforations of the transparent lower wall is arranged to provide a ULF, preferably a LAF, at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m from said transparent lower wall, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, when a pressure difference is present between the two sides of the transparent lower wall, and whereby said transparent lower wall has a minimal transmittance of 30% for light beams with an angle of incidence on said transparent lower wall below 45°. Preferably, said minimal transmittance is 45%. More preferably, said minimal transmittance is 60%. Most preferably, it is even higher than 60°. By demanding a high transmittance, the number and/or strength of the light-emitting elements can be reduced, saving energy, room and making the system cheaper and more efficient, as the fewer light-emitting elements there are, the simpler it will be to alter the direction and the point of origin of the one or more directed light beams.

[0019] In a second aspect, the present invention provides, but is not limited to, a system for ventilating and illuminating a spatial region, comprising an air pressure chamber and a lighting system. Said air pressure chamber comprises two oppositely located transparent walls and at least one air inlet optionally comprising a filter system, whereby a first transparent wall comprises a set of perforations for allowing air to flow from inside the chamber to an exterior side of said first transparent wall of the air pressure chamber, the set of perforations being arranged such that a ULF, preferably a LAF, can be provided at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, from said first transparent wall. The lighting system is suitable for, and preferably arranged for, providing one or more directed light beams through the two oppositely placed transparent walls of the air pressure chamber, whereby said lighting system comprises a lighting chamber and one or more light-emitting elements. The system as a whole is characterized in that the light-emitting elements are mounted movably relative to the lighting chamber such that the direction and the point of origin of the light beams with respect to the lighting chamber can be controllably altered, hereby not changing the ULF.

[0020] In an alternative embodiment, the system comprises an air pressure chamber. Said air pressure chamber comprises a transparent wall, a lighting system and at least one air inlet optionally comprising a filter system. Said transparent wall comprises a set of perforations for allowing air to flow from inside the air pressure chamber to an exterior side, the set of perforations being arranged such that a ULF, preferably a LAF, can be provided at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, from said first transparent wall. The lighting system is suitable for, and preferably arranged for, providing one or more directed light beams through the transparent wall, and comprises one or more light-emitting elements, located inside the air pressure chamber. The system as a whole is characterized in that said light-emitting elements are adapted to be mounted movably relative to the transparent wall such that the direction and the point of origin of the light beams with respect to the transparent wall can be controllably altered.

[0021] In a third aspect, the present invention provides, but is not limited to, a method for illuminating and creating a ULF, preferably a LAF, in an operating area, comprising following steps: a) creating an air flow through perforations of a transparent wall by an air pressure difference between a first side of the transparent wall and a second side of the transparent wall, thereby providing a ULF, preferably a substantially LAF on the second side of the transparent wall and in the operating area. Preferably the ULF is provided at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, from said transparent wall; b) illuminating the operating area by one or more directed light beams, whereby said light beams originate from the first side of the transparent wall and pass through the transparent wall; c) and controllably moving and/or rotating the origin and direction of the light beams without substantially modifying the ULF.

[0022] In an embodiment, the method as described above uses a system as described above.

[0023] In a fourth aspect, the present invention provides the use of a transparent plate for transmitting directed light beams to an operating area and for creating a ULF, preferably a LAF, in said operating area. Said transparent plate comprises a set of perforations through which air flows towards the operating area, said air flow being a ULF, preferably a LAF at the operating area, which is preferably located at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, from said transparent plate, whereby said transparent plate has a minimal transmittance of 30% for directed light beams with an angle of incidence on said plate below 45°. Preferably, the transparent plate has a minimal transmittance of 45% with an angle of incidence on said plate below 45°. More preferably, the minimal transmittance 60% with an angle of incidence on said plate below 45°. Most preferably, the minimal transmittance with an angle of incidence on said plate below 45° is even higher than 60°.

DESCRIPTION OF THE FIGURES

[0024]

FIG. 1A shows a cross section along the long axis of the operating table of an operating theatre with the installed system whereby there is a separate lighting chamber.

FIG. 1B shows a cross section along the short axis of the operating table of an operating theatre with the installed system whereby there is a separate lighting chamber.

FIG. 2A shows a cross section along the long axis of the operating table of an operating theatre with the installed system whereby the lighting system is located inside the air pressure chamber.

FIG. 2B shows a cross section along the short axis of the operating table of an operating theatre with the installed system whereby the lighting system is located inside the air pressure chamber.

FIG. 3 shows from a top view a transparent plate comprising a set of perforations for providing a ULF, preferably a LAF, on the bottom right, a side view of said plate on the top right and an enhanced view of the perforations on the left.

FIG. 4 shows from a top view a configuration of the light-emitting elements of the lighting systems.

FIG. 5 shows a luminous intensity distribution of a light-emitting element with focusing optics.

FIG. 6A and **6B** respectively show a setup of an operating room with a commercial diffuser and surgical luminaire, and a setup of an operating room with a transparent perforated plate for ventilating an operating area as described in this document.

FIG. 7 shows from a top view a commercial diffuser (left) as used in FIG. 6A and the transparent perforated plate (right) as used in FIG. 6B.

FIG. 8A and **FIG. 8B** the velocity (solid line) and turbulence intensity (dotted line) of the air flow in the setup of FIG. 6A. FIG. 8A shows this for the air flow parallel to longitudinal axis of the outlet of FIG. 6A, FIG. 8B shows this for the air flow perpendicular to the sidewall in which the outlet is included.

FIG. 9A and **FIG. 9B** show the velocity (solid line) and turbulence intensity (dotted line) of the air flow in the setup of FIG. 6B, parallel to the outlet of FIG. 6B. FIG. 9A shows this for the air flow parallel to the longitudinal axis of the outlet of FIG. 6B,

FIG. 9B shows this for the air flow perpendicular to the sidewall in which the outlet is included.

FIG. 10 shows transmittance versus surface factor for a variety of transparent perforated plates, obtained through ray-trace simulations.

FIG. 11 shows numerical simulations of the mass fraction of particles in a setup using the transparent plate of the invention (left figure), using a commercial diffuser (center figure) and using a commercial diffuser with a deployed luminaire (right figure), whereby a particle source is included in the bottom left corner of each figure.

DETAILED DESCRIPTION OF THE INVENTION

[0025] The term "ULF" as used herein refers to a unidirectional low-turbulence flow, characterized by having few cross currents or vortices which would disturb the flow pattern. The ULF is used so that an area is kept sterile from its environment through a stable flow in one direction, thereby not allowing environmental contaminants to reach the area. This is achieved by reducing turbulence to a minimum, as this could allow particles to move from the environment to the sterile area. Preferably the ULF is a laminar air flow (LAF). The ULFs used herein are preferably delivered with a high airflow velocity, of at least 0.13 m/s and preferably at least 0.23 m/s.

[0026] The term "laminar flow" or "laminar air flow" or "LAF" as used herein refers to a unidirectional laminar displacement of air, and is in such a stricter form of a ULF. A laminar air flow has no cross currents and vortices. The laminar air flows used herein are preferably delivered with a high airflow velocity, of at least 0.13 m/s and preferably at least 0.23 m/s.

[0027] The term "operating area" as used herein is synonym to "sterile area" or "protected area" and refers to a spatial region comprising at least the wounds of a patient, the sterile coverings around the wounds, the instrument table and instruments thereon and the front side of surgical staff members when they are around the operating table. Preferably, the operating area is larger than this and comprises all surgical staff members which come into contact with the patient.

[0028] The term "transmittance" as used herein refers to the visible transmittance, being the fraction of incident light that passes through a sample, said light being in the visible spectrum.

[0029] The term "transparent lower wall" as used herein refers to the lower wall of the air pressure chamber, which is at least partially transparent and/or may comprise several parts which form said transparent lower wall upon assembly. The latter may be for practical reasons such as facilitation of installation and transport. The lower wall needs to be at least partially transparent for light beams to be able to pass through the lower wall. However, this does not exclude non-transparent parts being comprised in the transparent lower wall.

[0030] The term "transparent upper wall" as used herein refers to the upper wall of the air pressure chamber, which is at least partially transparent and/or may comprise several parts which form said transparent upper wall upon assembly, for the same reasons as mentioned for the transparent lower wall. Again, this does not exclude non-transparent parts being comprised in the transparent upper wall.

[0031] In a first aspect, the present invention provides, but is not limited to, a system for ventilating and illuminating an operating area as described in the summary. The air pressure chamber can be configured as a plenum in an operating room, as is often the case now with ventilation systems, or even in the ceiling of the operating room. Typically, the lower transparent wall of the air pressure chamber has an area of about 8-9 m^2, however this can be adapted. Predominant shapes are square or octagonal (about 3m x 3m) or rectangular (about 3.2m x 2.8m). Again, other shapes and dimensions can be used, depending on the specific needs. Preferably a lighting system is employed that can provide shadow-free light by combining several light beams from different positions and under different angles. Through this configuration, even when a member of the surgical staff, or an instrument is blocking a light beam, at least one other light beam will be able to illuminate the desired area. In a preferred embodiment, the light-emitting elements of the lighting system are LED lamps. These lamps are more energy-efficient and have a longer lifespan than standard lamps. Furthermore, they produce direct light beams instead of light beams in all directions. The energy-efficiency is especially important as LED lamps do not produce as much heat as standard lamps. This heat can create thermal discomfort to members of the surgical staff, which the use of LED lamps will reduce.

[0032] A great advantage of the system according to the invention is the combination of a stationary ventilation system, creating a stable, high-quality ULF or even LAF, while the lighting system can be moved and rotated according to need, separately from the ventilation, thus allowing a wide spectrum of illumination angles and positioning. The configuration of this system overcomes other problems in the prior art by placing the lighting system above the transparent lower wall. This transparent lower wall is perforated so as to provide a ULF, preferably a LAF, in a desired zone below the air pressure chamber. The lighting system no longer interferes with the air flow pattern when light is needed from directly above the operating area. In prior art systems, the lighting systems could be moved and would be placed between the operating area and the filter designed to provide a ULF, preferably a LAF. The lighting system interferes with the air flow in this configuration and can create turbulences in the operating area which allow for contamination of the operating area and patients therein by pathogens, such as bacteria or fungi, carried by air born particles. Furthermore, by placing the lighting system here, a surgical team member in the operating theatre can experience thermal discomfort from the lighting system, whereas the present invention places the lighting system at a greater distance from the operating area, thereby reducing possible thermal discomfort. Other prior art systems place light-emitting elements in the lower wall of the air pressure chamber. While this allows light from directly above the operating area, it reduces the area on the lower wall available to create a LAF pattern and does not allow the lighting system to be moved relative to the ventilation system.

[0033] In a first embodiment, the system comprises at least two separate chambers, at least one for ventilation of the operating area, and at least one other for the illumination of the operating area. These chambers can be installed in an operating room, but can be adapted for use in other environments where a specific ULF or LAF pattern and illumination are desired, such as clean rooms and others. This embodiment of course incorporates the advantages mentioned above. Furthermore, by having separate chambers for ventilation and lighting, the air pressure chamber and the lighting chamber, the construction and operation of the system is simplified. Preferably, the transparent upper wall of the air pressure chamber separating the air pressure chamber from the lighting chamber is liquid impermeable and will shield the air pressure chamber from unwanted pollution. In mechanical systems as can be used for controllably altering the direction and the point of origin of the light beams, pollution can come from leaks of hydraulic fluid, erosion or oxidation of components and others, thus creating dirt. By having a liquid impermeable upper wall, the lighting chamber cannot contaminate the air pressure chamber below it. Furthermore, this configuration where the air pressure chamber is generally devoid of elements on the inside will be able to create a stable ULF, preferably LAF, pattern beneath the lower transparent wall more easily. Preferably, at least one inlet for air is located in a side wall of the air pressure chamber. The size and the amount of the inlets for air is dependent on the necessary volume and pressure of incoming air. More preferably all of the inlets for air are located in the side walls of the air pressure chamber. In this configuration, the air supplied to the air pressure chamber does not pass through the lighting chamber, where the temperature of the supplied air might change due to the heat emitted by the lighting system, or can be contaminated by pollutants in the lighting chamber. Furthermore, by placing the inlets for air in the side walls, they do not reduce the available surface for the light beams to pass through, thereby allowing a greater functional range of the light beams, both in direction as in point of origin. In a preferred embodiment, an air supply system provides conditioned air to the air pressure chamber through the inlet for air. Preferably, the temperature, humidity and/or other characteristics of said conditioned air can be adjusted according to required specifications. Generally, the temperature of the ULF or LAF is a few degrees lower than the ambient temperature in the operating theatre, promoting a non-turbulent down flow of air. This embodiment is shown in FIG. 1A and FIG. 1B.

[0034] In an alternative second embodiment, the lighting system is located inside the air pressure chamber. This embodiment incorporates the advantages of the general system. By placing the lighting system in the air pressure chamber, the system is reduced in height and can be installed in existing operating theatres without needing drastic modifications to the operating theatre. In a further preferred embodiment, at least one inlet for air is located in a wall of the air pressure chamber above the lighting system. This is preferable as the air will flow past the lighting system to the transparent lower wall, and can be used to cool down the lighting system, which is beneficial to the lifespan and functioning of the lighting system. LED lamps for instance deteriorate when exposed to elevated temperatures. The size and the amount of the inlets for air is dependent on the necessary volume and pressure of incoming air. This embodiment is show in FIG. 2A and FIG. 2B.

[0035] In a further preferred embodiment for both the first and the second embodiment, at least one inlet for air, and preferably all inlets for air, comprises a filter system for purifying the air that moves from outside to inside of the air pressure chamber. Preferably this filter system comprises a HEPA filter, or more preferably even an ULPA (Ultra-Low Particulate Air) filter. It is further preferable that the specification of the HEPA filter according to the European norm is at least H13, preferably higher. HEPA filters are composed of a mat of randomly arranged fibres, typically fiberglass with diameters between 0.5 and 2.0 micron, and are employed to remove submicron (and of course larger) size particles from the air by trapping the particles on or to a fibre through a combination of interception, impaction and diffusion, whereby the predominance of a factor is dependent on the size of the particles. HEPA filters are designed to arrest very fine particles, but they do not filter out gasses or odour molecules. In order to expand the filtration range to such particles, other filters such as activated carbon filters, can be used in combination with a HEPA filter. Preferably, the filter system comprises at least 3 stages, more preferably 4 stages. Most preferably, the HEPA filter is the final filter in the filter system before the air reaches the air pressure chamber.

[0036] In a further preferred embodiment for both the first and the second embodiment, the system comprises a device for remotely controlling the direction and the point of origin of the light beams. This allows for the light beams to be configured according to the specific needs of an operation. Furthermore, should obstructions to the light beams be present in the operating theatre, the light beams can be easily adjusted to still illuminate the operating area by adjusting the point of origin and/or direction of the light beams. This is often the case due to surgical staff members blocking light beams. The advantages of a device for remotely controlling this are many. It is a more practical way of controlling the lighting system as a surgeon, or other surgical team members can adjust the configuration while in place in the operating area. Furthermore, by using a device for remote control, there is no need for physical contact with the lighting system, which can be contaminated with pollutants. The device for remotely controlling the lighting system can for instance comprise a touchscreen interface, a mouse, a pointing pen or other instruments to communicate adjustments to the lighting system. These instruments mentioned above can be operated by a surgical staff member not coming into direct or indirect contact with a patient during an operation, in which case the instruments do not need to be sterile. The instruments can also be operated by surgical staff members coming into direct or indirect contact with a patient during an operation. In this case, the instruments need to be sterile, which can be accomplished for instance through the use of a touchless interface device or by placing a sterile cover on a touch screen.

[0037] In a possible embodiment, the device for remotely controlling the direction and point of origin of the light beams is a touchless interface device. This further improves the sterility of surgical cast members, as they are not required to even touch the interface to adjust the light beams. Systems as these have been described, for instance in US 8,166,421 and also in *'IDEAL: Innovative DEsign of an Automated surgical Luminaire'.*

[0038] In a further preferred embodiment for both the first and the second embodiment, the set of perforations of the transparent lower wall is arranged to provide a ULF, preferably a LAF, at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m from said transparent lower wall, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and 2.0 m, and any value there between, from said transparent lower wall when a pressure difference is present between the two sides of the transparent lower wall, and whereby said transparent lower wall has a minimal transmittance of 30%, preferably 45%, more preferably 60% and most preferably higher than 60%, for light beams with an angle of incidence on said transparent lower wall below 45°.

[0039] In a second aspect, the invention provides a system for ventilating and illuminating a spatial region. In a first embodiment of this aspect, the system comprises an air pressure chamber and a lighting system, as described in the summary. By allowing the light-emitting elements to be moved and/or rotated relative to the lighting chamber, preferably independent from each other, the system is adapted to provide a stable ULF, preferably a LAF, in the spatial region without said ULF or LAF being obstructed by the lighting system that is illuminating said spatial region. By separating the lighting system from the air pressure chamber, the installation of such a system is made easier. Another advantage is that a ULF or LAF is more efficiently achieved, first of all, as said, by removing the lighting system from the flow path of the ULF or LAF, as this is a problem with systems in the prior art. Secondly, by having a substantially empty air pressure chamber, the air flow created therein will be more stable and will further ensure a stable ULF, preferably a

LAF, in the spatial region. Furthermore, the separation also reduces the contamination danger of the air inside the air pressure chamber, as the lighting system does not come into direct contact with the air flow. In a further preferred embodiment, the second transparent wall is liquid impermeable. In a further preferred embodiment, at least one inlet for air is located in another wall of the air pressure chamber than the two oppositely located transparent walls. More preferably, said at least one inlet for air is provided with a filter system for filtering air that moves from outside of the air pressure chamber to the inside of said air pressure chamber. Most preferably, said filter system comprises at least one HEPA filter. In a further preferred embodiment, the system comprises a device for remotely controlling the direction and point of origin of the light beams. More preferably, said device is a touchless interface device. In a further preferred embodiment, the set of perforations of the transparent lower wall is arranged to provide a ULF, preferably a LAF, at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m from said transparent lower wall, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, from said transparent lower wall when a pressure difference is present between the two sides of the transparent lower wall, and whereby said transparent lower wall has a minimal transmittance of 30%, preferably 45%, more preferably 60% and most preferably higher than 60%, for light beams with an angle of incidence on said transparent lower wall below 45°.

[0040] In a second embodiment of the second aspect, the invention provides a system for ventilating and illuminating a spatial region, comprising an air pressure chamber, as described in the summary. The light-emitting elements can be moved and/or rotated relative to the transparent wall of the air pressure chamber, thus providing a stable ULF, preferably LAF, in the spatial region without said ULF or LAF being obstructed by the lighting system that is illuminating said spatial region. The system is restricted in dimensions, which enables installation in space-restricted environments and also requires very little modification to the existing infrastructures in these environments. Furthermore, it can be installed easily as it is encased in a single air pressure chamber. In a further preferred embodiment, at least one inlet is provided with a filter system for filtering air that moves from outside of the air pressure chamber to the inside of said air pressure chamber. Preferably, said filter system comprises at least one HEPA filter. In a further preferred embodiment, the system comprises a device, preferably a touch less touch interface device, for remotely controlling the direction and the point of origin of the light beams. In a further preferred embodiment, the set of perforations of the transparent lower wall is arranged to provide a ULF, preferably a LAF, at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m from said transparent lower wall, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, from said transparent lower wall when a pressure difference is present between the two sides of the transparent lower wall, and whereby said transparent lower wall has a minimal transmittance of 30%, preferably 45%, more preferably 60% and most preferably higher than 60%, for light beams with an angle of incidence on said transparent lower wall below 45°.

[0041] The system described above allows for the light-emitting elements to be moved and/or rotated relative to the transparent wall, preferably independent from each other. It is adapted to provide a stable ULF, preferably a LAF, in the spatial region without said ULF or LAF being obstructed by the lighting system that is illuminating said spatial region. Furthermore, as the lighting system is located in the air pressure chamber, the air flow passing through the air pressure chamber can be used to cool the light-emitting elements of the light system, as these can considerably heat up when operational. As said before, both lifespan and functioning of the light-emitting elements can suffer from exposure to elevated temperatures, so it is beneficial to keep these elements well ventilated.

[0042] In a third aspect, the invention provides a method for illuminating and creating a ULF, preferably a LAF, in an operating area, comprising the following steps:

a. creating an air flow through perforations of a transparent wall by an air pressure difference between a first side of the transparent wall and a second side of the transparent wall, thereby providing a ULF, preferably a LAF, on the second side of the transparent wall and in the operating area. Preferably the ULF is provided at a distance comprised between 0.1 m and 4 m from said transparent wall. If the space where a ULF is provided is larger, that is also fine;
b. illuminating the operating area by one or more directed light beams, whereby said light beams originate from the first side of the transparent wall and pass through the transparent wall;
c. and controllably moving and/or rotating the origin and direction of the light beams without substantially modifying the ULF.

[0043] A possible way to create an air flow through the perforations of the transparent wall, is by inducing a pressure difference between the two sides of the transparent wall, the velocity of the air flow can be adjusted by changing the pressure difference. In a preferred embodiment, the air supplied to the air pressure chamber is filtered. More preferably, it has been filtered by a HEPA or even a ULPA filter. Furthermore, the temperature of the supplied air is regulated and can be adjusted.

[0044] By making the light beams originate from the first side of the transparent wall, the presence of light-emitting elements for creating the light beams does not interfere with the ULF or LAF, thereby disturbing the air flow pattern and causing turbulences, as is the case in many systems in the prior art. Furthermore, the method described above allows the light beams to be adjusted both in point of origin as in direction, independently from the ULF or LAF. By keeping a stable ULF or LAF, turbulences are avoided and the desired operating area is constantly kept sterile under the desired conditions. The moving and/or rotating of the light beams can be handled directly or remotely. Remote operation of the lighting is preferable as it is more practical, and can be executed efficiently and meticulously by an appropriate automated system, an example of this is described in *'IDEAL: Innovative DEsign of an Automated surgical Luminaire'.* Furthermore, the device for remotely controlling the light beams is a touchless interface device. This is even more preferable as, by obviating physical contact to the device during medical procedures, it ensures sterility, which is of the utmost importance during surgery and other medical procedures.

[0045] In a preferred embodiment, the method as described above uses any system as described in this document. The configuration of the systems described in this document has many advantages over the prior art systems, as has been described above, and will allow for a stable ULF, preferably a LAF, at the operating area, while the lighting system can be controlled to adjust point of origin and/or direction of the light beams, without said lighting system interfering with the ULF or LAF. This method will be further described using a system according to the first and second embodiment of the first aspect of the invention in the examples.

[0046] In a fourth and final aspect, the invention provides a use for a transparent plate for transmitting directed light beams to an operating area and for creating a ULF, preferably an LAF, in said operating area, whereby said transparent plate comprises a set of perforations through which air flows towards the operating area, said flow being a ULF, preferably a LAF, at the operating area, which is preferably located at a distance comprised between three times the average diameter of the perforations in the lower wall and at least 4 m from said transparent lower wall, preferably between 0.1 m and 4 m, such as between 0.3 m and 3 m or between 0.5 m and 2 m, e.g. at 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m, 1.0 m, 1.1 m, 1.2 m, 1.3 m, 1.4 m, 1.5 m, 1.6 m, 1.7 m, 1.8 m, 1.9 m and/or 2.0 m, and any value there between, from said plate, whereby said plate has a minimal transmittance of 30%, preferably of 45%, more preferably of 60% and most preferably higher than 60%, for directed light beams with an angle of incidence on said plate below 45°. The plate according to this invention allows a lighting system to be used so as not to disturb a ULF, preferably a LAF, created by the plate in a spatial region at one side of the plate, while still being able to illuminate said spatial region from the opposite side of the plate. Such a plate is shown in FIG. 3. This holds a significant advantage over the methods in the prior art, where woven sheets of fabric are used as a diffuser for creating a ULF or LAF, as the transparent plate with perforations allows light to pass through it and illuminate an operating area. The perforations allow a ULF to be provided that surpasses current systems used in operating rooms, which do not account for position of lighting systems and ignore thermal discomfort issues. The use of the plate as described herein solves the problem by combining sufficient illumination and sufficient ventilation. The ULF is created due to all of the individual perforations of the plate experiencing an equal pressure difference between the two sides of the transparent plate. The air flow generated through the individual holes due to this pressure difference will therefore be equal in velocity, flow rate and direction. As the perforations are placed in a pattern with little distance between the perforations, the air flows, equal in velocity, flow rate and direction, from each individual perforation, will create a stable, low-turbulence air flow pattern within a distance of three times the diameter of the perforations. This way, a general unidirectional air flow is created that is low-turbulent.

EXAMPLE 1:

[0047] FIG. 1A and FIG. 1B describe the invention according to the first embodiment of the first aspect, but can however be expanded to the first embodiment of the second aspect. A false ceiling or plenum is installed in the operating theatre that houses an air pressure chamber 4 and a lighting chamber 1 above said air pressure chamber 4. The air pressure chamber 4 comprises a lower transparent wall 5, an upper transparent wall 3 and two inlets for air with a HEPA filter 6 therein. In the lighting chamber 1, a lighting system 2 is housed comprising light-emitting elements that can be moved and rotated with respect to the operating area comprising the operating table 7 and other elements mentioned earlier in this document. The lighting system 2 is adapted to emit directed light beams through the upper transparent wall 3 and through the lower transparent wall 5 towards the operating area 12. A conditioned air supply 9 is filtered by the HEPA filters 6 by inducing a pressure difference between the two sides of the HEPA filter 6, thus creating an air flow through the HEPA filters 6 and providing, preferably ultraclean, filtered air 8. Said conditioned air supply 9 can be prefiltered and can be controlled in flow rate and air temperature. A further pressure difference between the inside of the air pressure chamber 4 and the operating theatre creates an air flow from the air pressure chamber 4 to the operating area 12. The set of perforations in the lower transparent wall 5 causes a ULF, preferably a LAF, 11 in the operating area 12. The operating theatre comprises air outlets 10 for venting air from the operating theatre.

EXAMPLE 2:

[0048] FIG. 2A and FIG. 2B describe the invention according to the second embodiment of the first aspect, but can however be expanded to the second embodiment of the second aspect. A false ceiling or plenum is installed in the operating theatre that houses an air pressure chamber 4. The air pressure chamber 4 comprises a lower transparent wall 5 and inlets for air with HEPA filters 6 therein. In the air pressure chamber 4, a lighting system 2 is housed comprising light-emitting elements that can be moved and rotated with respect to the operating area 12 comprising the operating table 7 and other elements mentioned earlier in this document. The lighting system 2 is adapted to emit directed light beams through the lower transparent wall 5 towards the operating area 12. A conditioned air supply 9 is filtered by the HEPA filters 6 by inducing a pressure difference between the two sides of the HEPA filter 6, thus creating an air flow through the HEPA filters 6 and providing, preferably ultraclean, filtered air 8. Said filtered air 8 can be used to cool the lighting system. Said conditioned air supply 9 can be prefiltered and can be controlled in flow rate and air temperature. A further pressure difference between the inside of the air pressure chamber 4 and the operating theatre creates an air flow from the air pressure chamber 4 to the operating area 12. The set of perforations in the lower transparent wall 5 causes a ULF, preferably a LAF, 11 in the operating area 12. The operating theatre comprises air outlets 10 for venting air from the operating theatre.

EXAMPLE 3:

[0049] FIG. 3 describes a part of a transparent plate with a set of perforations for transmitting directed light beams to an operating area and for creating an ULF, preferably a LAF, in said operating area. The entire plate has a length and breadth of about 3000 mm and a thickness of about 9.50 mm. It comprises a set of circular perforations through the plate, each with a diameter of about 5.00 mm, arranged in a grid of 198 rows and 198 columns, with a distance between the centers of neighboring perforations of about 15.00 mm, whereby the centers of the peripheral perforations are at a distance of about 20.00 mm from the closest edge of the plate. All this is clearly shown in FIG. 3. The ULF is created due to the individual perforations experiencing the same pressure difference between the two sides of the transparent plate. The air flow generated through the individual holes due to this pressure difference will therefore be equal in velocity, flow rate and direction. As the perforations are placed in a pattern with little distance between the perforations, the air flows, equal in velocity, flow rate and direction, from each individual perforation, will create a seemingly consolidated air flow pattern, comparable to constructive interference in waves within a distance of three times the diameter of the perforations. This way, a general unidirectional air flow is created that is low-turbulent. As can be seen in simulations shown in FIG. 11, the improved system of the invention (left figure in FIG. 11) effectively creates a sterile core zone (central in each separate figure) whereby the created air flow successfully keeps particles from entering the core zone from the surrounding regions. Moreover, simulations show the improved system of the invention performs at least up to par with a commercial diffuser (center figure in FIG. 11), and clearly performs better than a commercial diffuser with a luminaire (right figure in FIG. 11), the last setup being the setup used in an operating room.

EXAMPLE 4:

[0050] FIG. 4 describes the configuration of a lighting system as described above. It comprises two hundred and fourteen light-emitting diodes (LEDs) 12, which are arranged in concentric regular polygons in a single plane around a center, whereby a LED is placed at each vertex of each regular polygon, according to the following specifications, as can be seen in detail in FIG. 4. Hereby are the LEDs tilted to an inclination so that every LED is focused on a point, about 2.3 m below the center of the plane wherein the polygons lie. The angle between the direction of the light beams emitted by the LEDs and the surface normal on the plane wherein the polygons lie, is added between parentheses after every polygon. Two LEDs are placed on opposite sides of the center at a distance of about 2.5 cm, this can also be construed as a digon (0.622756°) with a circumradius of about 2.5 cm. Around this lies an octagon (1.867679°) with a circumradius of about 7.5 cm, followed by a second octagon (3.110841°), a hexadecagon (4.351078°), an icositetragon (5.587244°), a triacontagon (6.818215°), a hexatriacontagon (8.042894°), a pentatetracontagon (9.260222°) and a second pentatetracontagon (10.46917°), whereby the circumradius increases with about 5 cm between every next polygon. Every LED has a luminous flux of about 60 lumen. The lighting system further comprises focusing optics, resulting in an intensity distribution with a Full Width at Half Maximum of 7° for each LED with focusing optics, as can be seen in FIG. 5. The lighting system according to the configuration as described above, has been tested with a transparent plate with perforations described in Example 3 and a second transparent plate without perforations, which were placed parallel to the plane wherein the polygons lie and were centered according to the center of the lighting system as described above. The test concluded that the lighting system in combination with the two transparent plates mentioned in this example, complies with the current European Standard IEC 60601-2-41.

EXAMPLE 5:

[0051] In this example, the theoretical and simulated results of the transmittance of a perforated plate are discussed for a flat perforated plate. In reality, the perforations of a perforated plate are applied by drilling, which causes loss of transparency at the inner rim of the perforations, due to an increased surface roughness. Through ray-trace simulations, an estimation can be made of the loss of general transparency for the perforated plate as a hole. First of all, 'M' is defined as the mesh size, i.e. the distance between the centers of two adjacent perforations, 'D' is the thickness of the perforated plate, 'd' is the diameter of the perforations, and 'θ_i' is the angle of incidence of a light beam on the perforated plate. Based on these definitions, a surface can be further defined to indicate the amount of perforated surface that is encountered by a beam of light. This factor takes the thickness of the plate and the inclination of an incident light beam into account. Clearly, when a light beam is emitted parallel to the surface normal of a perforated plate, it will not interact with the sidewalls of the perforations. When a light beam is incident from a different angle, the sine of the angle of incidence of the light beam determines the chance of an interaction with the sidewalls of the perforations. A surface factor 'S' can be defined by the following formula:

$$S = \frac{\pi D d}{M} sin(\theta_i)$$

[0052] The surface factor is expected to be strongly correlated to the transmittance of the perforated plate, as can be seen in FIG. 10 and the following table, wherein the results of ray-trace simulations of transmittance versus surface factor are shown for varying mesh sizes (M=10, 15 and 30 mm), perforation diameters (d=2.5, 3.5 and 5.0 mm), thickness of the perforated plate (D=1.5 and 5.0 mm) and angles of incidence (θ_i=0°, 22.5° and 45°). The transmittance in these simulations was defined as the ratio between the illuminance on a virtual detector with the perforated plate to the illuminance without the perforated plate. The porosity 'P', is the ratio of the surface of the perforations with respect to the total surface of the plate, for perforations arranged in square lattices.

D	M	d	Porosity	SurfaceFactor			Received illuminance			Transmission		
				0°	22,5°	45°	0°	22,5°	45°	0°	22,5°	45°
	[mm]	[mm]	[ ]	[mm]	[mm]	[mm]	[lx]	[lx]	[lx]			
1,5	10	2,5	0,049	0	0,45	0,83	22794	21841	21094	90,4%	87,5%	83,2%
1,5	10	3,5	0,096	0	0,63	1,16	22935	21771	20729	90,9%	87,2%	81,8%
1,5	10	5	0,196	0	0,90	1,66	23219	21683	20227	92,1%	96,9%	79,8%.
1,5	15	2,5	0,023	0	0,30	0,55	22751	22155	21750	00,2%	88,8%,	85,8%
1,5	15	5	0,094	0	0,60	1,11	22938	22026	21298	91,0%	88,2%	84,0%
1,5	30	5	0,024	0	0,30	0,55	22717	22349	22078	90,1%	89,5%	87,1%
5	10	2,5	0,049	0	1,50	2,77	22945	20691	19608	91,0%	82,9%	77,3%
5	10	3,5	0,096	0	2,10	3,88	23065	20063	17992	91,5%	80,4%	71,0%
5	10	5	0,196	0	3,00	5,55	23272	19089	14983	92,3%	76,5%	59,1%
5	15	2,5	0,023	0	1,00	1,85	22875	21690	20954	90,7%	86,9%	82,6%
5	15	5	0,094	0	2,00	3,70	23031	20915	18664	91.3%	83,8%	73.6%
5	30	5	0,024	0	1,00	1,85	22834	22332	21498	90,5%	89,5%	84,8%

[0053] A linear fit to the simulation values has been added to FIG. 10 and shows to be a decent approximation of the simulated values, furthermore giving evidence to the strong correlation of the surface factor and the transmittance of the perforated plate. If the formulas and the linear fit defined above and in FIG. 10 are applied to the perforated plate of Example 4, a surface factor S of about 7.62 is found, which leads to a theoretical transmittance of about 52.1% for light beams with an angle of incidence of 50°. This can be improved further by reducing the thickness of the plate, and/or making the perforations smaller and/or placing the perforations closer to each other, of course while balancing with the performance of such a plate in creating a ULF, preferably a LAF.

EXAMPLE 6:

[0054] In the setups as shown in FIG. 6A and 6B, consisting of a transparent box of 2 m by 2 m by 2 m, with a stainless steel floor, the box accommodates a single-sided air outlet with a height of 0.2 m, located at the bottom. The exhaust air is directly removed. A one-sided air inlet with a height of 0.35 m, located at the top of the box, supplies air in the same fashion and at the same circumstances for both setups. The supply air passes a series of screens before entering the transparent box, which filter the air and minimize horizontal and vertical directed turbulences. A wooden frame is installed in the setup in which a downflow plenum of 1 m by 1 m is centrally mounted at a height of 1.65 m. In FIG. 6A, a surgical luminaire at a height of 1.2 m is included to mimic a realistic operating situation. No such luminaire is included in FIG. 6B, as in this setup, the lighting system will be placed above the transparent perforated plate and as such, will not alter the air flow as would the luminaire of FIG. 6A. The commercial diffuser, shown on the left in FIG. 7, consists of a single-layer dense fabric with a mesh size of 38 μm, whereas the transparent perforated plate on the right in FIG. 7, has perforations with a diameter of about 5 mm, whereby the centers of neighboring perforations are 15 mm apart in a square grid, as can be seen in FIG. 7.

[0055] For both setups of FIG. 6A and 6B, air velocities and turbulence intensities were obtained at a height of 0.8 m on two horizontal cross sections with 10 cm intervals, starting at 30 cm from each wall of FIG. 6A and FIG. 6B. These cross sections are respectively parallel to the longitudinal axis of the outlet, and perpendicular to the sidewall wherein said outlet is built. To obtain the data, four hot-sphere anemometers were used at each point during 300 s with a frequency of 5 Hz. Two SensoAnemo SF3 anemometers with an accuracy of 0.02 m/s (+1%) and two Dantec Low Velocity Transducer 54R10 anemometers with an accuracy of +/- 5 % of the reading, and are able to measure the omnidirectional velocity within a range of 0.05 to 5 m/s with a sampling rate up to 8 Hz, and were calibrated in a separated calibration setup. The measurements were performed under isothermal conditions. FIG. 8A and FIG. 8B show the results of these measurements for the commercial diffuser with surgical luminaire. FIG. 9A and FIG. 9B show the results using the transparent perforated plate described above and shown on the right in FIG. 7. It is clear from FIG. 8A and FIG. 8B that the presence of the surgical luminaire in the commercial setup severely disrupts the creation of a ULF, especially in the area where it should be created, directly below the diffuser. The air flow velocity in this area is strongly reduced and furthermore, high turbulence intensities are found in the wake of the luminaire, especially in FIG. 8B, which compromise safe operating conditions even further in this setup. In the setup using a transparent perforated plate, seen in FIG. 6B, the surgical luminaire is not necessary and as such creates a high enough air flow velocity below the transparent plate, while allowing relatively low turbulence in this region. This can be seen in FIG. 9A and FIG. 9B. In the region directly below the diffuser, an average velocity of respectively 0.36 m/s and 0.25 m/s are found, and average turbulence intensities of respectively 18% and 23%, whereas for the commercial diffuser the average velocities respectively are 0.11 m/s and 0.15 m/s with average turbulence intensities of respectively 43% and 45%. This furthermore proves that the invention is an improvement on the currently known systems and methods, as the commercial diffuser not only fails to produce a sufficient air velocity in the area where a ULF should be maintained, but also creates much stronger turbulences in said area. The invention described in this document succeeds in creating and maintaining a ULF in an area, while allowing sufficient illumination of said area or parts thereof.

Claims

1. System for ventilating and illuminating an operating area, comprising:

   a. at least one static air pressure chamber positioned above said operating area in an operating room, comprising at least one inlet for air and a transparent lower wall, whereby said transparent lower wall comprises a set of perforations for allowing air to flow from the air pressure chamber to the operating room, the set of perforations being arranged such that a ULF, preferably a LAF, can be provided in the operating area;
   b. a lighting system positioned above said transparent lower wall, for providing one or more directed light beams to the operating area through the transparent lower wall, comprising one or more light-emitting elements;

   characterized in that said light-emitting elements are mounted movably relative to the air pressure chamber such that the direction and the point of origin of the light beams can be controllably altered, hereby not substantially modifying the laminar air flow.

2. System for ventilating and illuminating an operating area according to claim 1, whereby the static air pressure chamber comprises a transparent upper wall, and whereby the lighting system comprises a static lighting chamber above the transparent upper wall of the static air pressure chamber, and whereby the light-emitting elements of the lighting system are adapted to provide one or more directed light beams to the operating area through the transparent

upper wall and the transparent lower wall of the air pressure chamber.

3. System for ventilating and illuminating an operating area according to claim 1, whereby the lighting system is located inside the air pressure chamber.

4. System according to any of the claims 1 or 2, wherein the transparent upper wall is liquid impermeable.

5. System according to any of the claims 1, 2 or 4, wherein the air pressure chamber comprises at least one side wall and at least one inlet for air is located in said side wall of the air pressure chamber.

6. System according to any of the claims 1 to 5, wherein at least one inlet is provided with a filter system for filtering air that moves from outside of the air pressure chamber to the inside of said air pressure chamber.

7. System according to claim 6, wherein the filter system comprises at least one HEPA filter.

8. System according to any of the claims 1 to 7, comprising a device for remotely controlling the direction and the point of origin of the light beams.

9. System according to claims 8, the device for remotely controlling the direction and the point of origin of the light beams comprises a touchless interface device.

10. System according to any of the claims 1 to 9, whereby the set of perforations of the transparent lower wall is arranged to provide a ULF, preferably a LAF, at a distance comprised between three times the average diameter of the perforations in the transparent lower wall and at least 4 m from said transparent lower wall when a pressure difference is present between the two sides of the transparent lower wall, and whereby said transparent lower wall has a minimal transmittance of 30% for light beams with an angle of incidence on said transparent lower wall below 45°.

11. System for ventilating and illuminating a spatial region, comprising:

    a. an air pressure chamber, comprising two oppositely located transparent walls and at least one air inlet optionally comprising a filter system, whereby a first transparent wall comprises a set of perforations for allowing air to flow from inside the chamber to an exterior side of said first transparent wall of the air pressure chamber, the set of perforations being arranged such that a ULF, preferably a LAF, can be provided at a distance comprised between three times the average diameter of the perforations in the transparent lower wall and at least 4 m from said first transparent wall;
    b. a lighting system for providing one or more directed light beams through the two oppositely placed transparent walls of the air pressure chamber, whereby said lighting system comprises a lighting chamber and one or more light-emitting elements;

    characterized in that said light-emitting elements are mounted movably relative to the lighting chamber such that the direction and the point of origin of the light beams with respect to the lighting chamber can be controllably altered, hereby not substantially modifying the laminar air flow.

12. System for ventilating and illuminating a spatial region, comprising an air pressure chamber, which comprises:

    a. a transparent wall, comprising a set of perforations for allowing air to flow from inside the air pressure chamber to an exterior side, the set of perforations being arranged such that a ULF, preferably a LAF, can be provided at a distance comprised between three times the average diameter of the perforations in the transparent lower wall and at least 4 m from said transparent wall;
    b. at least one air inlet, optionally comprising a filter system;
    c. and a lighting system suitable for providing one or more directed light beams through the transparent wall, whereby said lighting system comprises one or more light-emitting elements;

    characterized in that said light-emitting elements are mounted movably relative to the transparent wall such that the direction and the point of origin of the light beams with respect to the transparent wall can be controllably altered, hereby not substantially modifying the laminar air flow.

13. A method for illuminating and creating a laminar air flow in an operating area, comprising the following steps:

a. creating an air flow through perforations of a transparent wall by an air pressure difference between a first side of the transparent wall and a second side of the transparent wall, thereby providing a laminar air flow on the second side of the transparent wall and in the operating area, preferably the laminar air flow being provided at a distance comprised between three times the average diameter of the perforations in the transparent lower wall and at least 4 m from said transparent wall;
b. illuminating the operating area by one or more directed light beams, said light beams originating from the first side of the transparent wall and passing through the transparent wall,

characterized in that the method comprises the step of c. controllably moving and/or rotating the origin and direction of the light beams without substantially modifying the laminar air flow.

14. A method for illuminating and creating a laminar air flow in an operating area according to claim 13, using a system according to any of the claims 1 to 12.

15. Use of a transparent plate for transmitting directed light beams to an operating area and for creating a substantially laminar air flow in said operating area, whereby said transparent plate comprises a set of perforations through which air flows towards the operating area, said air flow being a substantially laminar air flow at the operating area, which is preferably located at a distance comprised between three times the average diameter of the perforations in the transparent lower wall and at least 4 m from said plate, whereby said plate has a minimal transmittance of 30% for directed light beams with an angle of incidence on said plate below 45°.

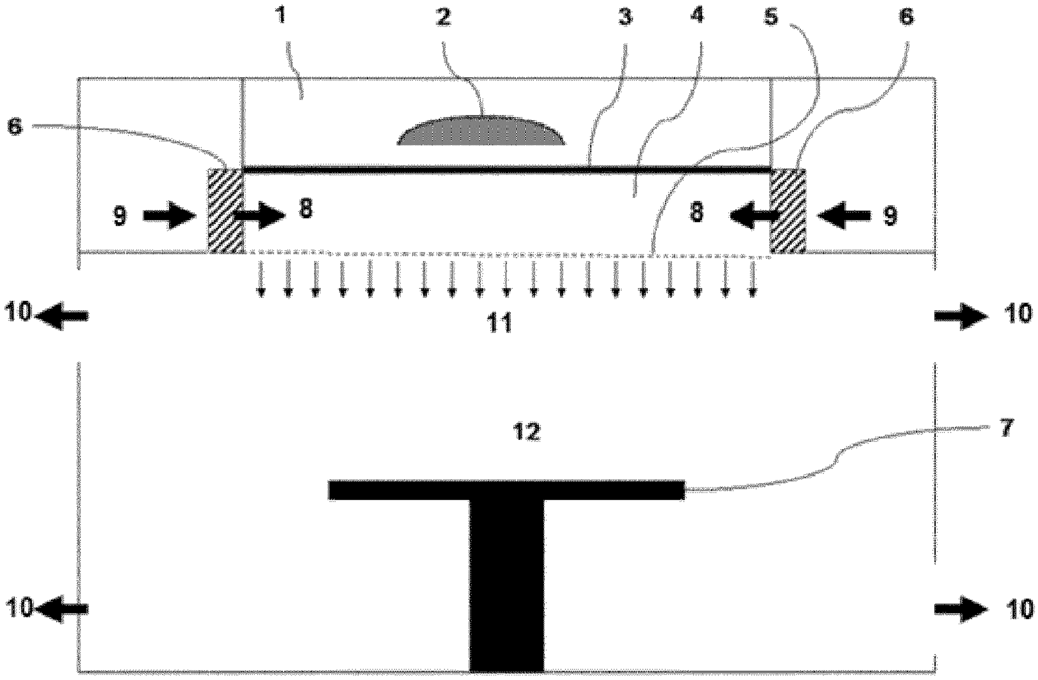

FIG. 1A

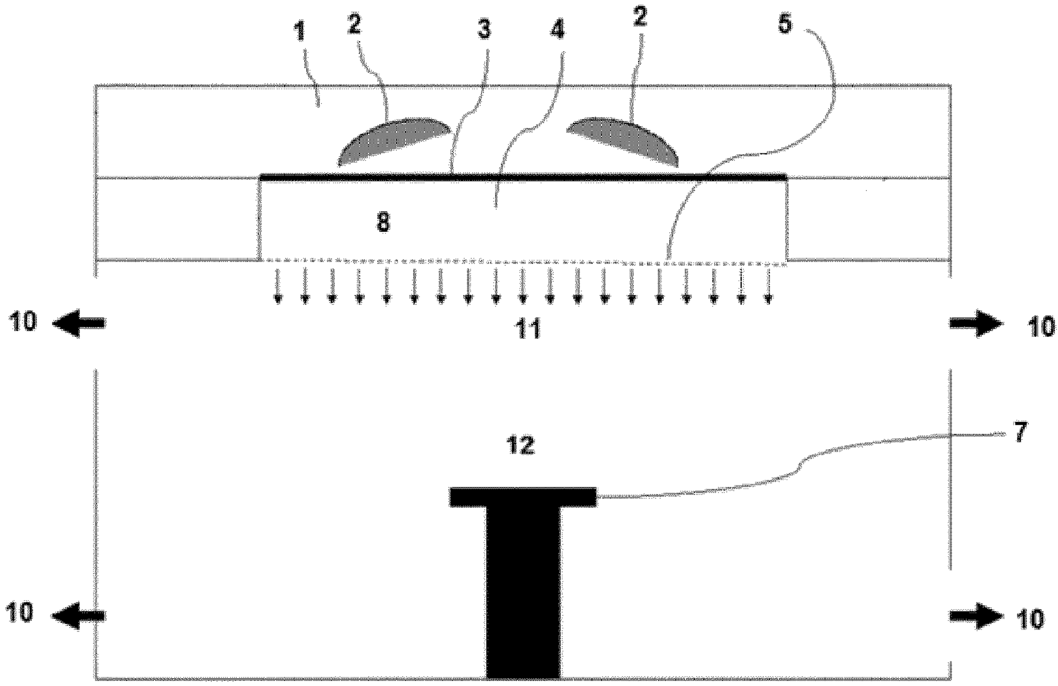

FIG. 1B

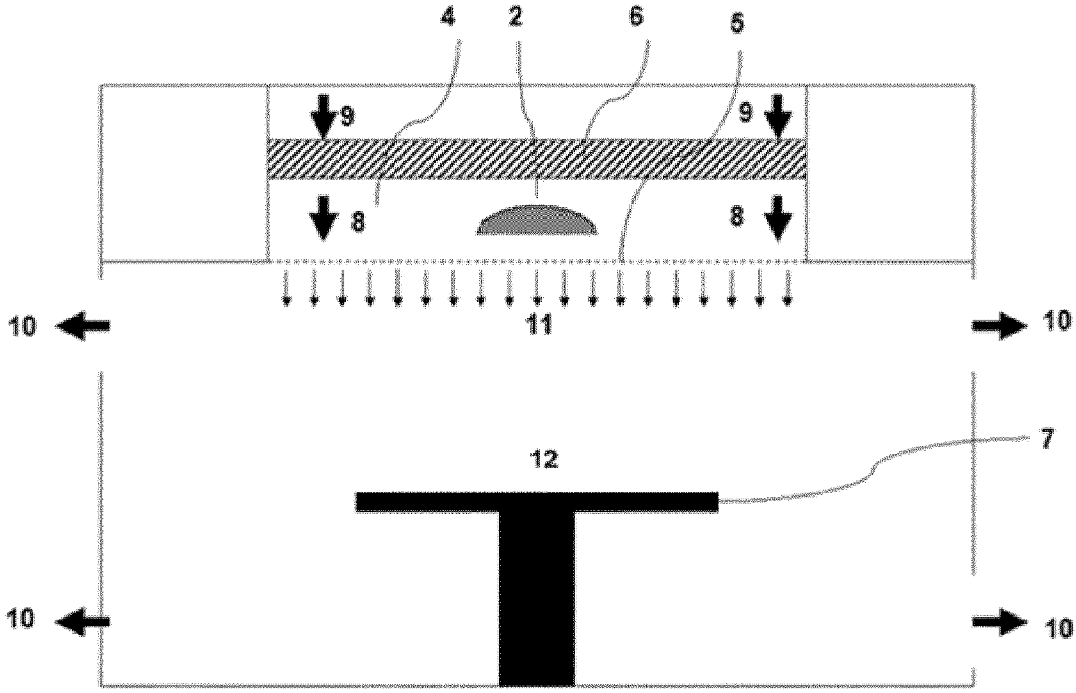

FIG. 2A

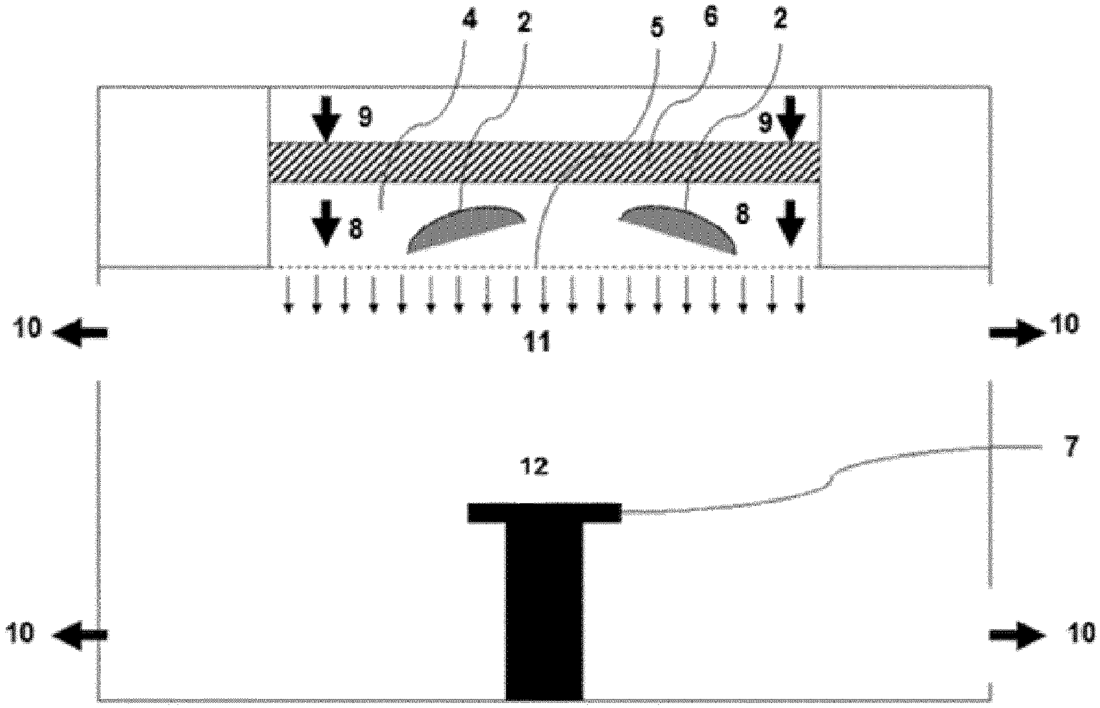

FIG. 2B

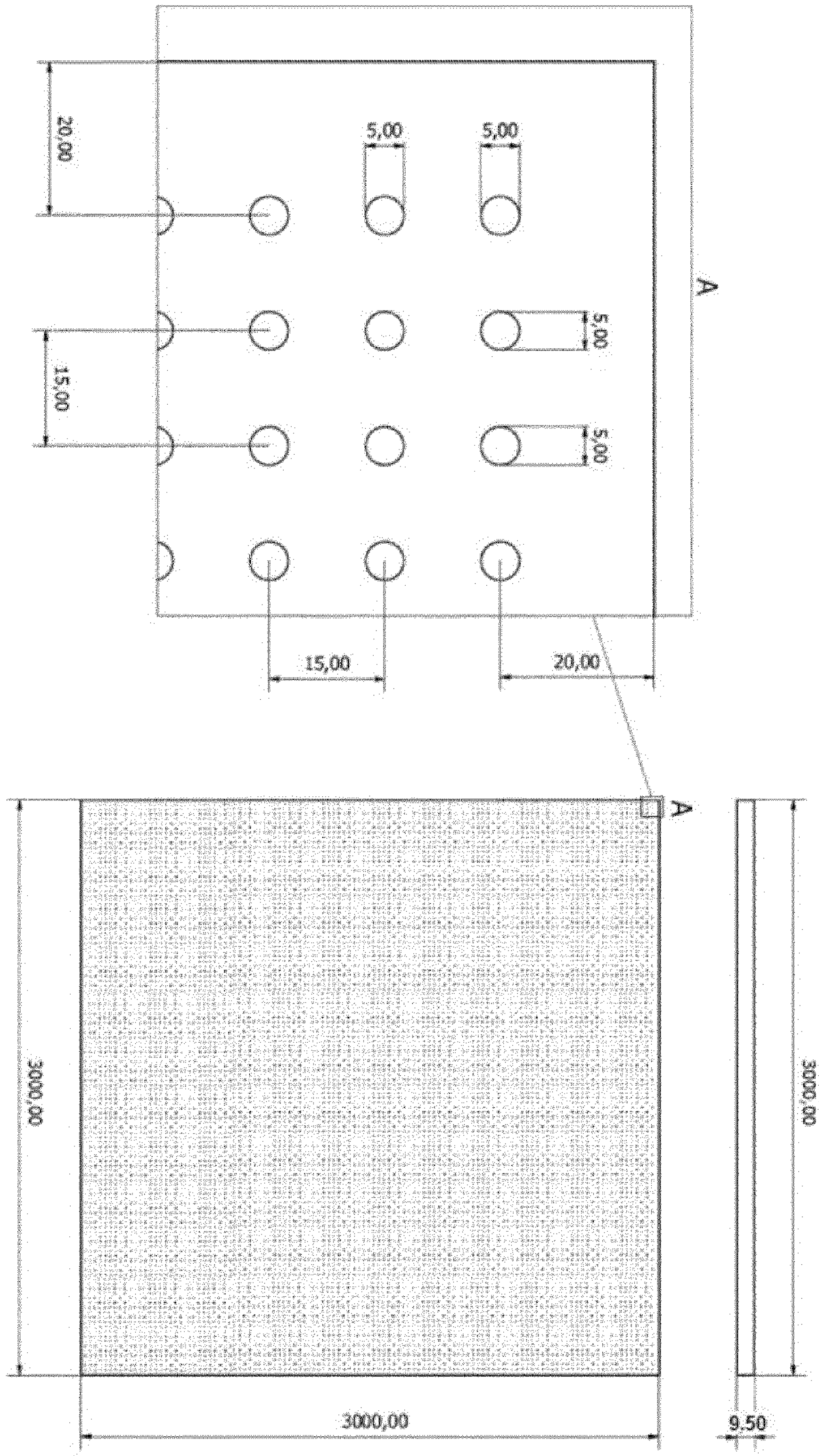
20,00
5,00
5,00
A
5,00
15,00
5,00
15,00
20,00
A
3000,00
3000,00
3000,00
9,50

FIG. 3

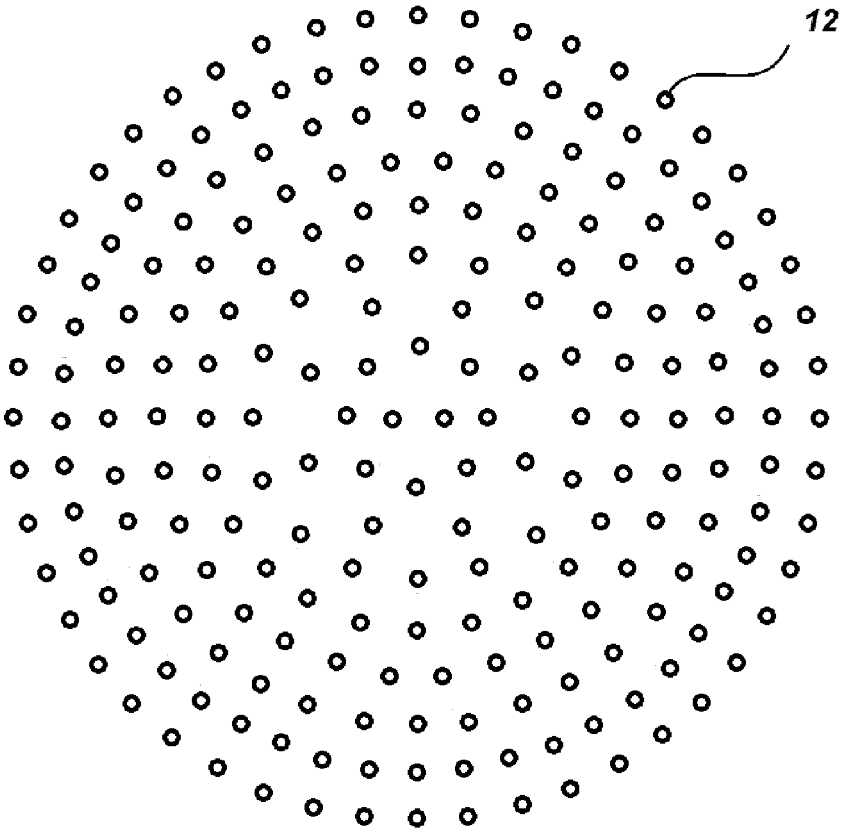

FIG. 4

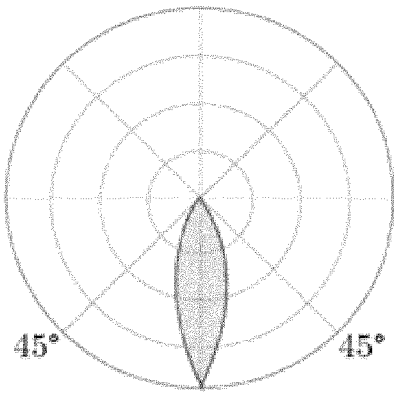

FIG. 5

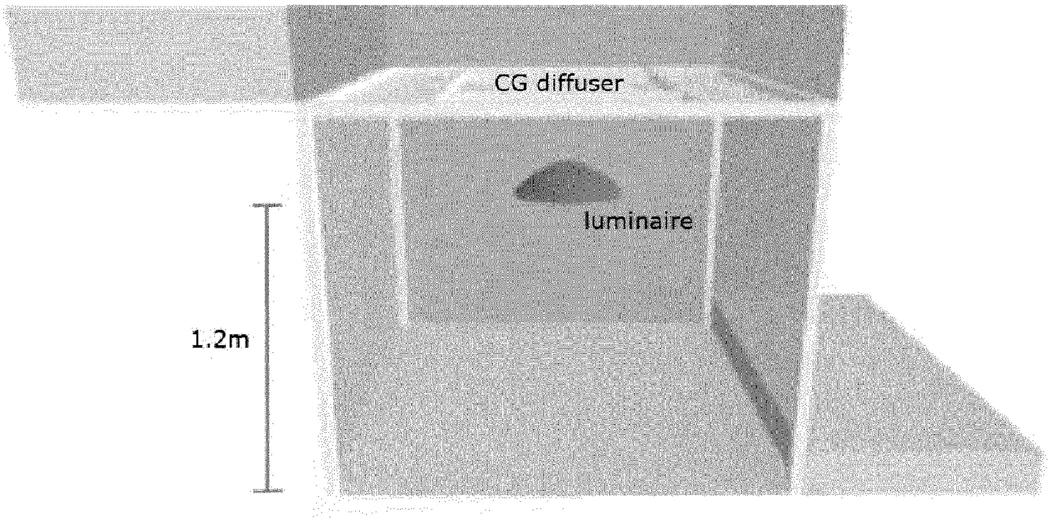
CG diffuser
luminaire
1.2m

FIG. 6A

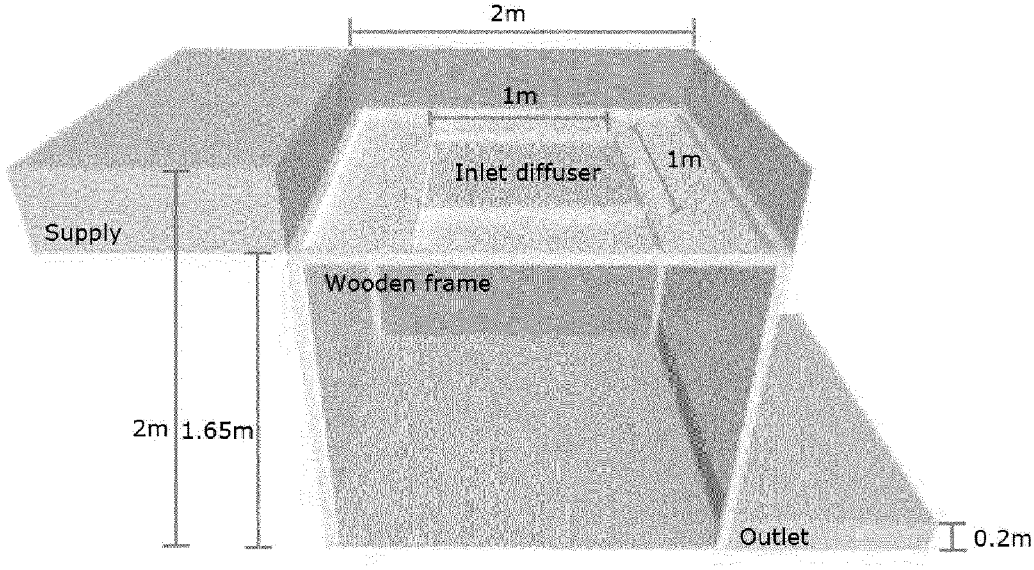
2m
1m
1m
Inlet diffuser
Supply
Wooden frame
2m
1.65m
Outlet
0.2m

FIG. 6B

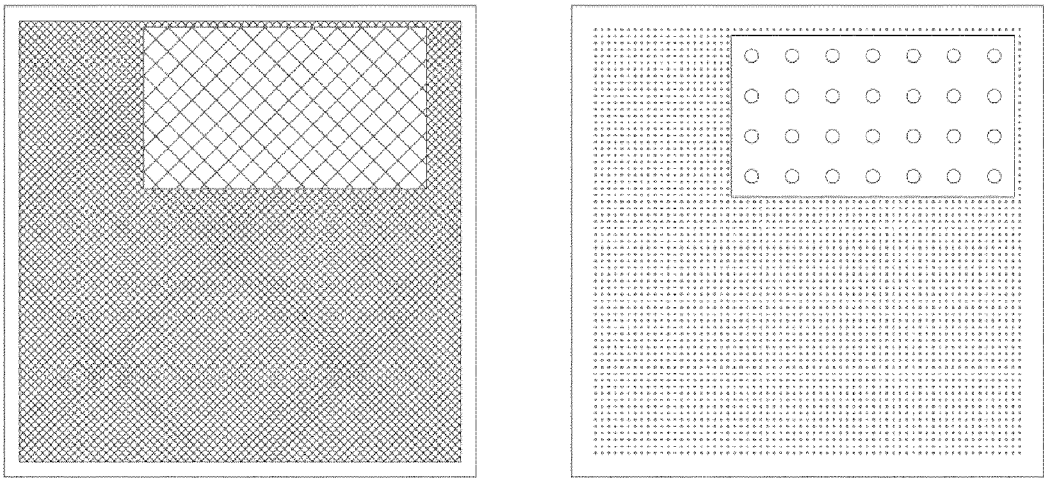

FIG. 7

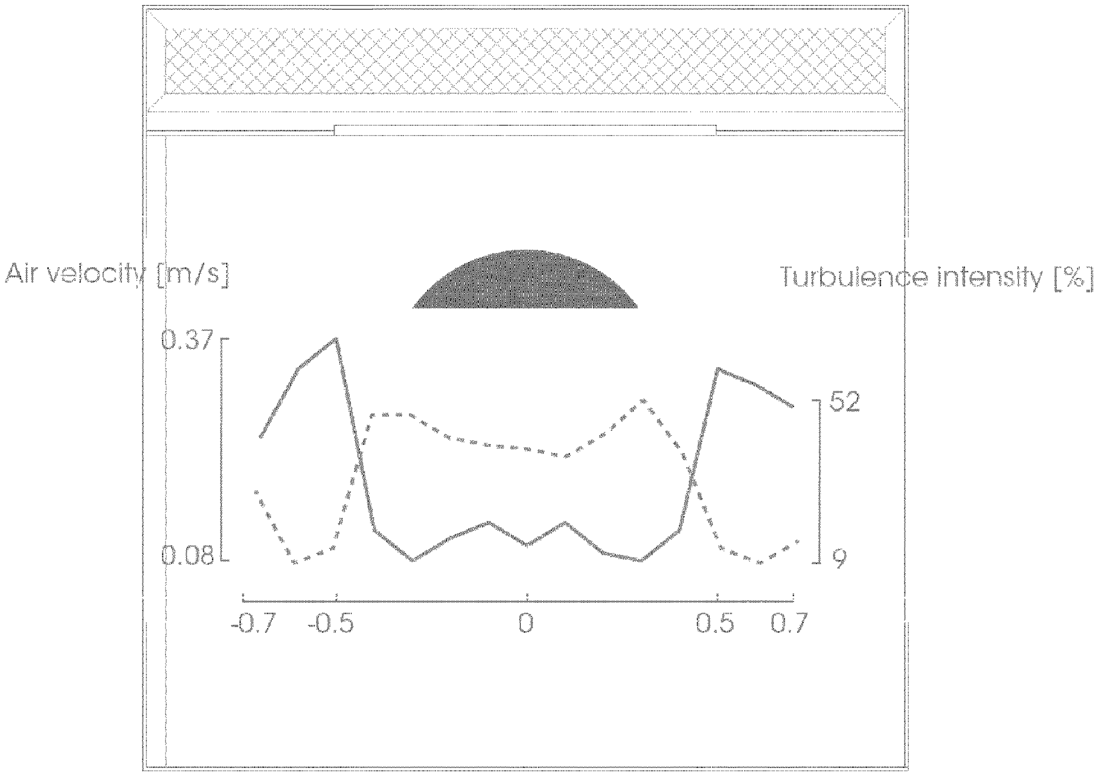
Air velocity [m/s]
Turbulence intensity [%]
0.37
0.08
52
9
-0.7
-0.5
0
0.5
0.7

FIG. 8A

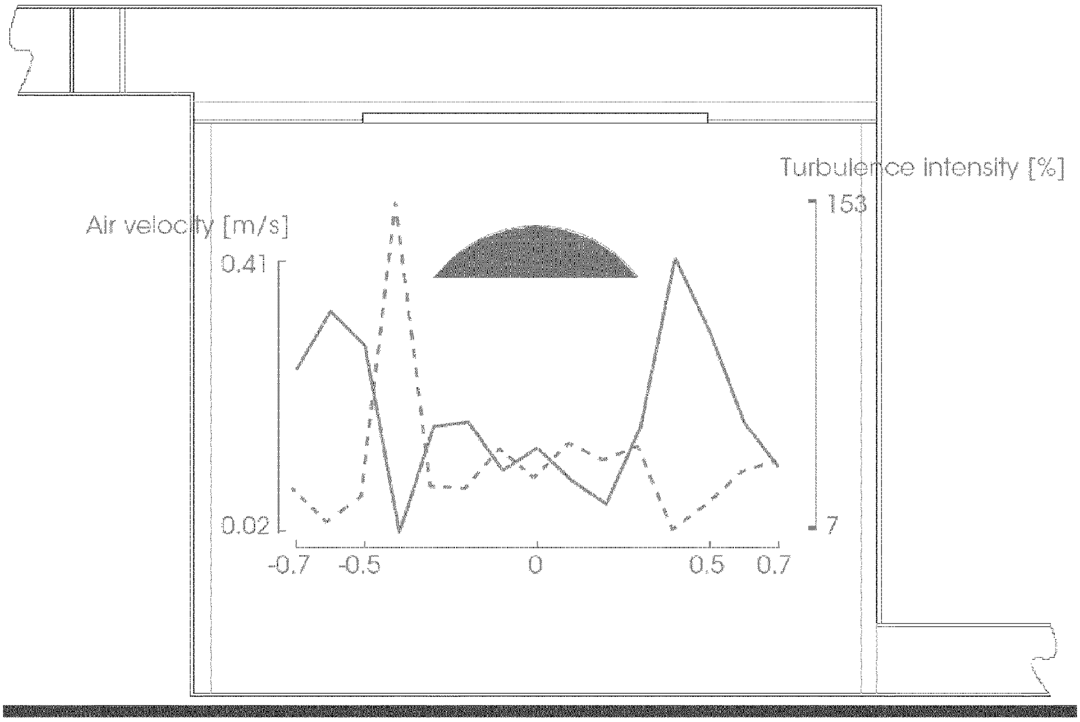
Turbulence intensity [%]
153
Air velocity [m/s]
0.41
0.02
7
-0.7
-0.5
0
0.5
0.7

FIG. 8B

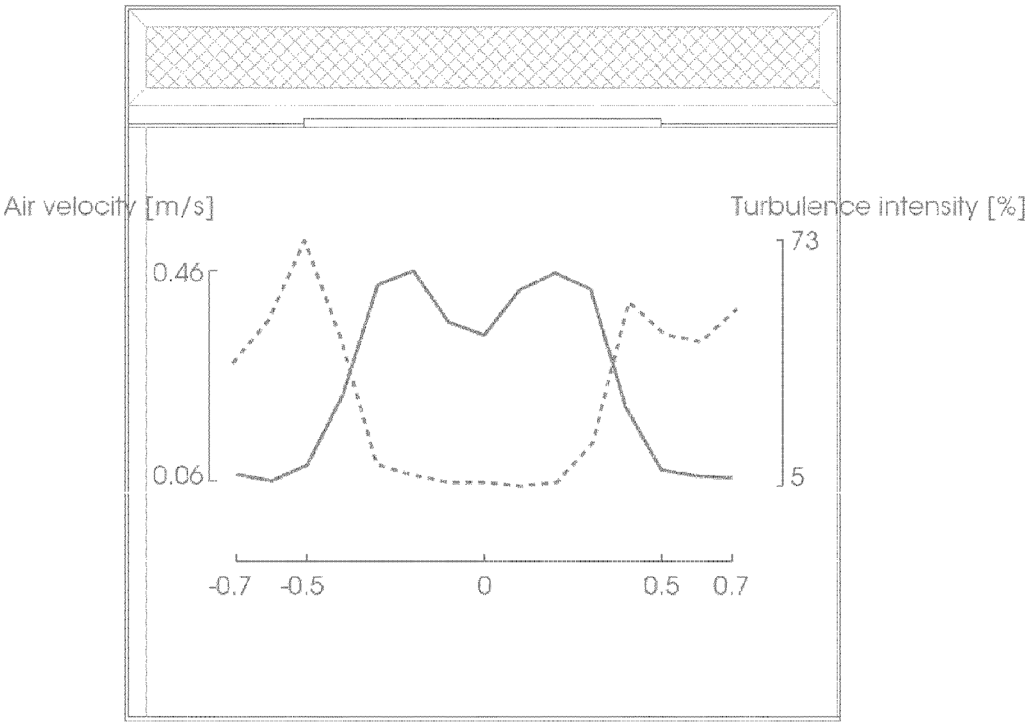
Air velocity [m/s]
Turbulence intensity [%]
73
0.46
0.06
5
-0.7
-0.5
0
0.5
0.7

FIG. 9A

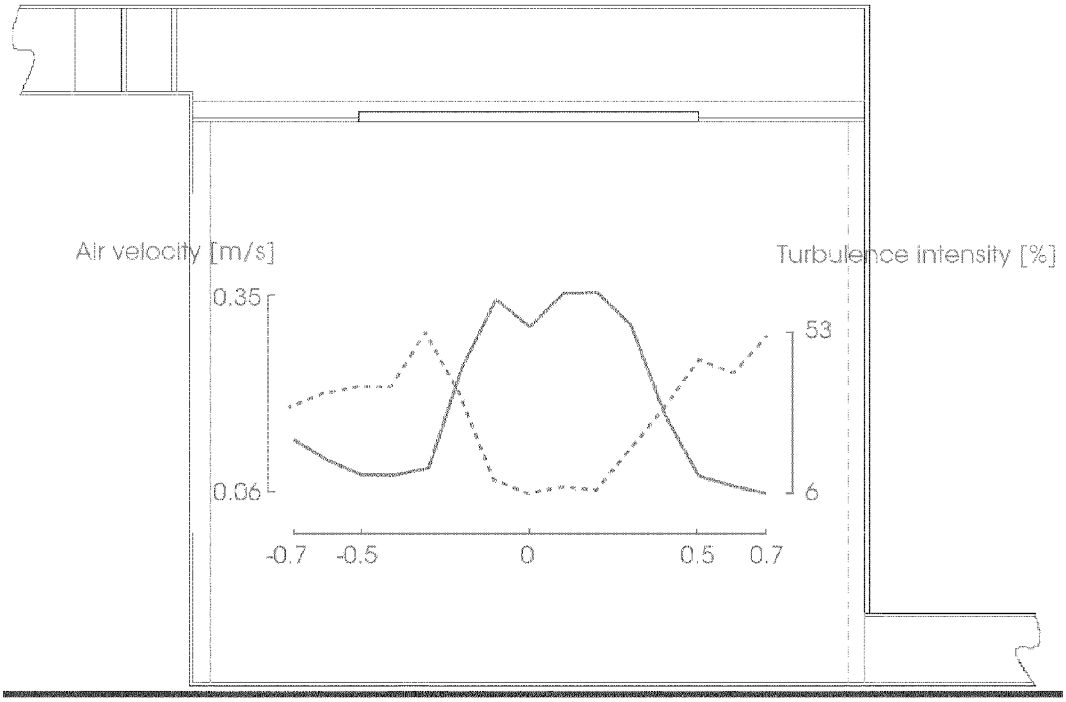
Air velocity [m/s]
Turbulence intensity [%]
0.35
0.06
53
6
-0.7
-0.5
0
0.5
0.7

FIG. 9B

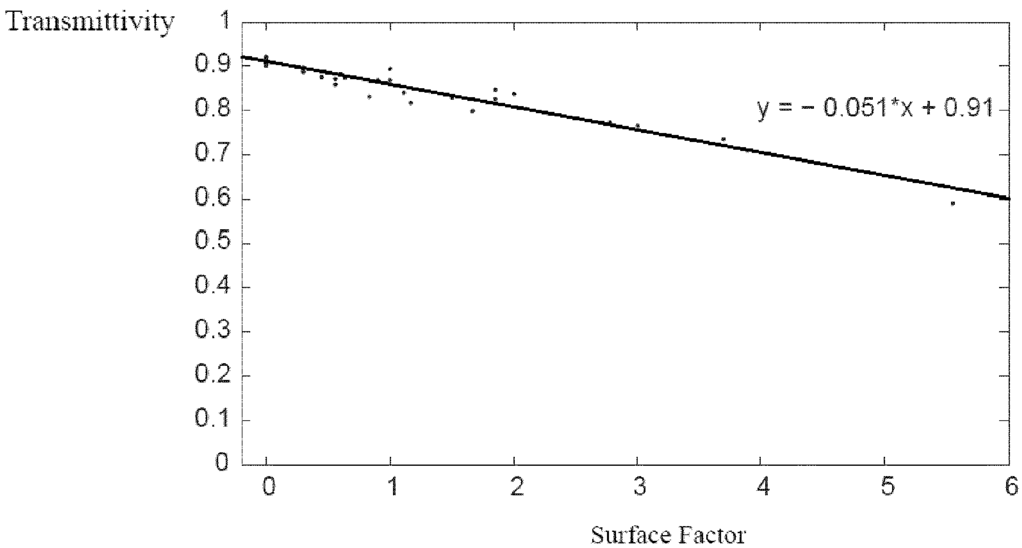
Transmittivity
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y = − 0.051*x + 0.91
0
1
2
3
4
5
6
Surface Factor

FIG. 10

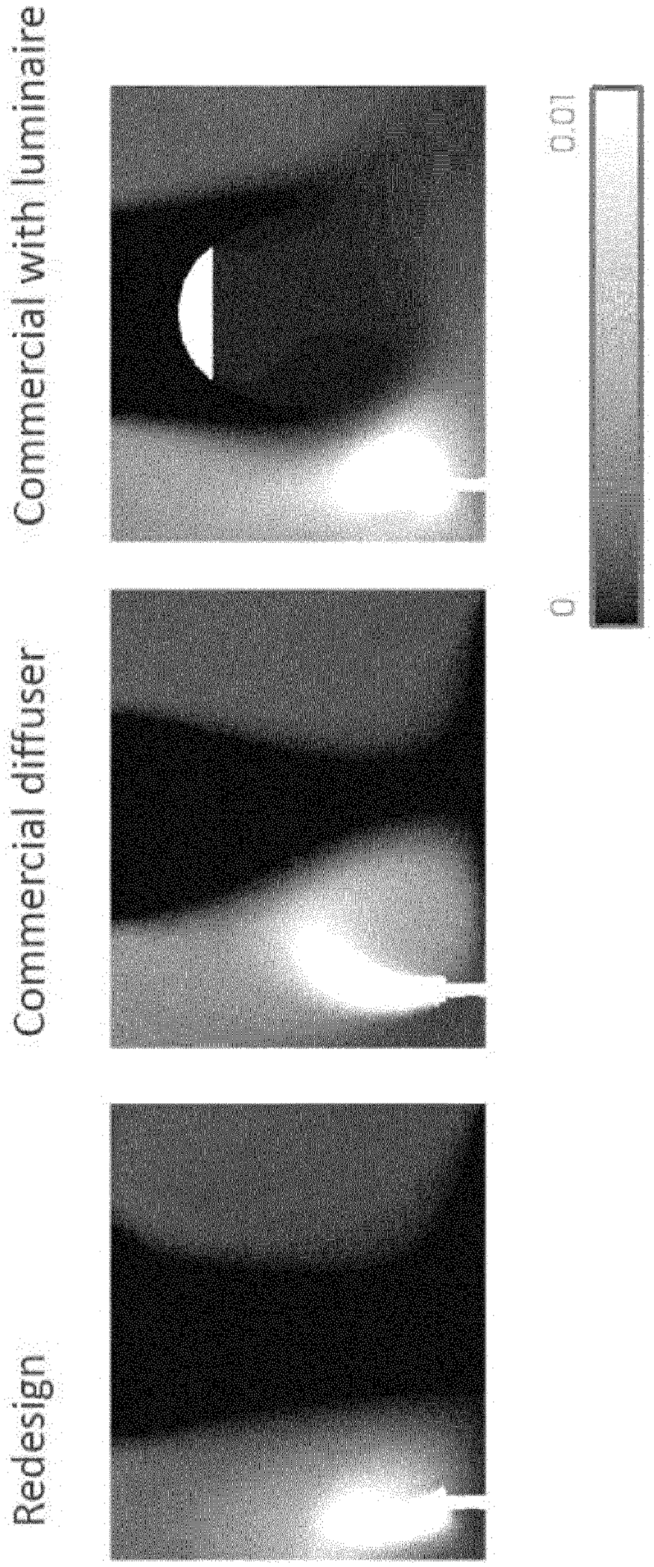
Commercial with luminaire
Commercial diffuser
Redesign
0.01
0

FIG. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 2278

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 85 07 713 U1 (DONALD HERBST) 17 July 1986 (1986-07-17) * page 5, line 21 - page 8; figures 1,2 * -----	1,12	INV. A61G13/10 F21V33/00 F24F13/078
A	EP 2 413 018 A1 (CORPORACIO SANITARIA PARC TAULI [ES]; TELSTAR TECHNOLOGIES S L [ES]; F) 1 February 2012 (2012-02-01) * paragraphs [0025], [0026], [0037] - [0039]; figure 1e * -----	1,12	
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			A61G F21V F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	1 October 2015	Birlanga Pérez, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons
& : member of the same patent family, corresponding document

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 16 2278

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01-10-2015

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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