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(54) **BUILDING VENTILATOR**

GEBÄUDEVENTILATOR

VENTILATEUR POUR BÂTIMENT

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Description

[0001] The present invention relates to a ventilator for a building, and in particular although not exclusively, to a passive and passive assisted ventilation stack.

[0002] Most modern buildings require a ventilator system to provide a supply of fresh air to the building interior. Also, ventilation systems provide a means of regulating the internal temperature of a building where occupants, equipment and solar heat contribute to the internal temperature of the building and if unregulated would lead to overheating.

[0003] Legislation in most jurisdictions establish minimum fresh air requirements for the interior of buildings depending upon intended usage and occupancy levels.

[0004] Typically, most commercial large buildings utilise electricity driven air conditioning systems that both circulate air within the building and provide internal air temperature control.

[0005] In response to climate change, attributed largely to the amount of greenhouse gas emissions globally, national and international legislation has imposed emission limitations in an attempt to combat global warming. Accordingly, certain jurisdictions such as the United Kingdom have introduced regulations on the energy performance of buildings. All buildings in the United Kingdom will eventually have an energy rating including an annual carbon emission rating.

[0006] This increased awareness of the carbon footprint of buildings, has led to the re-examination of the energy performance and suitability of all working systems associated with the building that consume energy. Air conditioning is one of the greatest energy consumers in buildings, and therefore provides potential to make a dramatic impact on the building's overall energy rating. Therefore a ventilation system that requires no energy input is an attractive option for modern construction.

[0007] There are two main categories for ventilation strategies, namely mechanical and natural. Mechanical ventilation is the most commonly used form as it offers on demand and controllable delivery rates. Examples of mechanical ventilation include convention air conditioning that utilises refrigeration and a fan to drive airflow circulation around the system and the interior of the building.

[0008] Natural ventilation relies on the external wind conditions to deliver the required fresh air supply. A natural ventilation stack device sits at the top of the building or room and acts as both an inlet and extract. As warm air rises and exits the room via the stack, a negative pressure is created in the room which acts to draw-in an external fresh air supply. The flow of air through the device is further assisted by the windward and leeward pressures exerted on it by the external wind speed. The rate at which the flow is delivered to the receiving room is controlled by mechanical dampers and a static ceiling diffuser.

[0009] Natural ventilation systems may be further cat-

egorised into two groups, namely passive and active. A passive stack applies no mechanical force to induce the flow through the device. An active stack utilises a mechanical force to create or direct the flow through the system. The active stack ensures the required air supply rates will be achieved. However, this stack does not offer the level of energy consumption savings of the passive system.

[0010] GB 2432207 discloses an active stack ventilation arrangement that utilises a fan positioned at the bottom of the ventilator to draw air into the building interior.

[0011] Whilst advantageous over conventional air conditioning systems the inventors have identified a number of disadvantages with existing natural ventilation assemblies of the kind identified above.

[0012] Accordingly, the present invention provides a natural ventilator configured to supply fresh air into the interior of a building and importantly to allow stale air to exit the building interior without requiring mechanical or electrically driven components.

[0013] A hybrid device which offers the mechanical assistance of an active stack without compromising the energy consumption level of a passive stack is provided and is referred to as a passive-assisted stack. This hybrid device utilises a fan positioned within the natural ventilator, the fan being operable only when required to assist the flow of air between the building exterior and interior via the ventilator.

[0014] According to the present invention there is provided a building ventilator comprising: a frame mountable at an opening in a roof of a building, the frame defining a duct to convey air between an exterior and an interior of the building; a plurality of vent blades mountable at an external facing region of the frame such that the blades are mounted at the exterior of the building and are stacked above one another to form a louver, each blade having a leading edge to be external facing relative to the duct and a trailing edge to be internal facing relative to the duct; wherein the distance in the vertical direction between adjacent blades at the their respective leading edge regions is in the range 25 to 35 mm; a fan operative to assist the airflow current in a downward direction through the duct and into the interior of the building; the ventilator characterised in that: the fan is mounted at an upper region of the ventilator in the vertical direction.

[0015] Preferably, the vertical distance between adjacent blades is 27 to 33 mm. More preferably, the vertical distance between adjacent blades is 30 mm.

[0016] The inventors have discovered that by altering the angle of inclination of the individual blades of the louver, the velocity and pressure performance and importantly the rate of air flow into and out of the building interior is improved and optimised with regard to the circulation of clean air from the building's exterior to its interior.

[0017] Preferably, the angle of inclination is within the range 34 to 36° and optimally is 35°.

[0018] Optionally, the ventilator comprises internal walls extending in the longitudinal direction between the

external and internal facing ends of the frame to partition the air flow duct and to guide air flow through the ventilator.

[0019] The ventilator frame and louver may comprise any shape and configuration to suit the requirements of the building. For example, the cross sectional profile, in the horizontal plane, of the frame and louver sections of the ventilator may define a circle, oval, square or rectangle. Preferably, the frame is cuboid in particular rectangular or square cuboid comprising four walls being open at a top and adjacent bottom face. The frame is arranged in the ventilator with the top face being external facing and the bottom face being interior facing.

[0020] Preferably, the ventilator blades are joined at each end to adjacent blades, in the same plane, to define the edges of a rectangle and/or square. This quad blade structure may be formed as a modular arrangement or as a unitary blade arrangement in which the four blades are inclined upwardly towards a central plane within the square or rectangle. The quad blade arrangement may be mounted at the exterior facing top face of the cuboidal frame above its four walls to define a louver having four sides comprising a plurality of blades arranged on top of one another extending over each face.

[0021] Optionally, the ventilator may comprise a cover member to sit above the uppermost blade and block the exterior facing end of the duct defined by the upper region of the louver.

[0022] Optionally, each blade may comprise a flange positioned at the leading and trailing edge and projecting transverse to the blade. With the blades aligned in position to be inclined at an angle 32 to 38° relative to a horizontal plane, each flange may extend substantially vertically.

[0023] Preferably, the ventilator comprises a stack of four to six blades arranged on top of one another, the blades comprising a single blade or quadrant of blades having four sides in the same plane. Preferably, the ventilator comprises four blades and in particular four quadrant blade sets. As will be appreciated, the ventilator may comprise any number of vent blades to suit the requirements of the building with regard to fresh air delivery rates and wind noise.

[0024] Optionally, the ventilator may comprise a fan mounted within the louver region of the device defined by the stack of blades substantially between a lowermost blade and an uppermost blade in the vertical direction.

[0025] Preferably, the fan is mounted within the louver region of the device towards the blade positioned furthest from the external facing end of the frame in the vertical direction. More preferably, the fan is mounted within the louver region of the device substantially in the same horizontal plane as the blade positioned furthest from the external facing end of the frame in the vertical direction. The fan may be mounted centrally within the louver region of the device in the horizontal plane.

[0026] According to a specific implementation, the ventilator is devoid of internal partition walls within the duct

extending in the vertical direction between the external and internal facing ends.

[0027] Preferably, the ventilator comprises control means to provide manual and/or automatic control of the fan. The ventilator may also comprise an electric motor configured to drive the fan with the control means coupled to the electric motor. Optionally, the control means may be coupled to a suitable wind gauge and is operative in response to the wind speed detected by the wind gauge.

[0028] A specific implementation of the present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a building comprising a ventilator according to a specific implementation of the present invention;

Figure 2 is a more detailed illustration of the ventilator of the present invention as detailed in Figure 1;

Figure 3 is a cross sectional side elevation view of the ventilator of Figure 2;

Figure 4a is a side elevation view a vent blade that defines the louver of Figure 3;

Figure 4b is a perspective view of the vent blade of Figure 4a;

Figure 4c is a cross sectional side elevation view of two adjacent vent blades positioned on top of one another in the vertical direction defining a portion of the louver of Figure 3;

Figure 5 is a side perspective view of the ventilator of Figure 3;

Figure 6 illustrates a perspective view of the ventilator of Figure 3 further comprising a fan assembly located within the louver section of the ventilator of Figure 5;

Figure 7 illustrates the different regions and directions of pressure and velocity measurement through the ventilator of Figure 3;

Figure 8 is a graph of pressure versus blade angle at various regions of the ventilator of Figure 7;

Figure 9 is a graph of velocity versus blade angle at various regions of the ventilator of Figure 7;

Figure 10 is a graph of pressure versus velocity in the vertical direction through the centre of the ventilator of Figure 3;

Figure 11 is a graph illustrating the overall performance of blade angle on the air flow rate through the ventilator of Figure 7;

Figure 12 illustrates the affect on the air flow path through the ventilator of Figure 3 by a fan positioned at an upper region of the ventilator;

Figure 13 illustrates the affect on the air flow path through the ventilator of Figure 3 by a fan positioned at a middle region of the ventilator;

Figure 14 illustrates the affect on the air flow path through the ventilator of Figure 3 by a fan positioned at a bottom region of the ventilator;

Figure 15 illustrates the fresh air delivery rates provided by the ventilator with the fan at the top, middle

and bottom positions as illustrated in Figures 12 to 14.

Figure 16 is a graph of velocity/pressure against a distance of separation of the vent blades for the ventilator of Figure 3.

Figure 17a is a graph of the internal velocity of air delivered into the building with a louver blade separation distance of 60 mm from practical experimental investigations;

Figure 17b is a graph of the internal velocity of air delivered into the building with a louver blade separation distance of 30 mm from practical experimental investigations;

Figure 17c is a graph of the internal velocity of air delivered into the building with a louver blade separation distance of 20 mm from practical experimental investigations.

[0029] A natural ventilator provided by the inventors is optimised to supply fresh air into the interior of a building whilst minimising energy consumption. The present invention provides both a passive and a passive-active system configured to maintain airflow rates into the building interior in the event of reduced wind speed at the exterior of the building.

[0030] Figure 1 illustrates a building 100 comprising roof 101 separating an exterior region 103 from the building interior 104. A ventilator 102 is positioned at an opening 105 formed in the roof 101.

[0031] Figure 2 illustrates ventilator 102 comprising a louver region 201 comprising a plurality of vent blades 202 stacked on top of one another in the vertical direction. The vent blades are positioned on top of and extend from a frame 200 mounted in the opening 105 formed within roof 101. A cover 204 is positioned at an uppermost region of ventilator 102 to cover the internal duct formed within the ventilator 102 defined by louver blades 202 and ventilator frame 200. According to the specific implementation, frame 200 comprises four substantially planar panels 203 connected together at adjacent edges to form a hollow cuboid.

[0032] Referring to figure 3, an upper open face 305 of frame 200 is external facing relative to building interior 104. The adjacent open bottom face 304 is positioned facing the building interior 104 with frame panels 203 extending through opening 105. The louver blades 202 extend from the external facing open end 305 of frame 200 positioned external 103 to the building interior 104. Accordingly, frame 200 and louver blades 202 define an internal air flow passageway extending vertically through the ventilator comprising internal louver duct 300 positioned directly above duct 302 defined by frame 200.

[0033] Optionally, one or a plurality of internal partition walls 301 may be positioned within the frame duct 302 and/or louver duct 300 to guide the airflow through the ventilator and into the building interior 104.

[0034] Referring to figures 4a to 4c, each louver blade 202 comprises an inclined, substantially planar region

400 extending between an uppermost flange 401 and a lowermost flange 402, each flange 401, 402 extending over the upper and lower edges of the inclined blade region 400 respectively, when the blade is aligned substantially in the horizontal plane as illustrated in figures 3 and 4A. Each flange 401, 402 is allied substantially vertically when blade 202 is aligned horizontally with each flange 401, 402 extending transverse to the inclined blade region 400. Uppermost flange 401 comprises an uppermost edge 410 and a lowermost edge 411 in contact with the uppermost edge of the inclined blade region 400. The lowermost flange 402 comprises a lowermost edge 409 and an uppermost edge 412 in contact with a lowermost edge of the inclined blade region 400.

[0035] Each blade 202 comprises four inclined blade regions 403, 406, 407, 408 as illustrated in figure 4b. Each blade region is bordered by upper and lower flanges 401, 402 as illustrated in figure 4a. Each of the four blade regions 403, 406, 407, 408 and the associated flanges 401, 402 are connected at their respective ends to form a square or rectangular quadrant, with each side represented by each of the four inclined blade regions.

[0036] Referring to figures 4a and 4c, each inclined blade region 400 is inclined, relative to a horizontal plane 417 by an angle θ . According to the specific implementation, θ is in the region of 30 to 40°, 32 to 38° and 34 to 36° and optimally substantially 35°.

[0037] As illustrated in figure 3, each louver blade 202 is arranged on top of one another in a vertical direction above frame 200 to form the louver. In this orientation, each blade 200 is separated from a neighbouring blade, in a vertical direction by distance d. Distance d is defined as the distance between the lowermost edge 409 of flange 402 of an upper blade A and the upper edge 412 of flange 402 of a neighbouring lower blade B. Distance d corresponds to the available space, in the vertical direction through which air may flow from exterior 103 into the louver interior 300. Where each blade 202 is devoid of upper and lower flanges 401, 402 respectively, distance d corresponds to the distance between the lowermost surfaces 413 of an upper blade to the uppermost surface 414 of a lower blade.

[0038] Referring to figure 4c, each blade 202 comprises a leading edge 416 being external facing and a trailing edge 415 arranged internally to define louver duct 300. According to the quadrant blade arrangement of 4b, each blade comprises four leading edges and four trailing edges.

[0039] Alternatively, where each blade 202 is devoid of upper and lower flanges 401, 402, respectively, distance d corresponds to the distance between the leading edges of each blade A and B.

[0040] Referring to figure 5, louver 201 comprises an uppermost blade 500 positioned furthest from frame 200 in the vertical direction. A lowermost blade 501 sits directly on top of the uppermost open face 305 of frame 200. The present invention is configured to utilise any number of louver blades positioned intermediate 502 be-

tween upper blade 500 and lower blade 501. Ventilator 102 comprises four blades and in particular four blade quadrants illustrated in figure 4b stacked on top of one another directly above frame 200.

[0041] The present invention also relates to a hybrid natural and mechanical ventilator referred to a passive-assisted natural ventilator. The hybrid ventilator utilises a low energy fan driven by a low voltage battery (not shown). The battery may be charged by a solar panel (not shown) positioned at/or on top of cover 204. Alternatively the fan or battery may be coupled to a mains supply. Figure 6 illustrates a passive-assisted ventilator arrangement comprising a fan 600 having fan blades 605, the fan and blades being mounted internally within ventilator 102. Through experimental investigation, the inventors have determined that fresh air delivery rates through ventilator 102 into building interior 104 are optimised with fan 600 positioned at an uppermost region the ventilator and in particular at or towards the uppermost fan blade 500 at region 601 in a vertical direction through ventilator 102. Fan 600 is positioned substantially centrally within a blade quadrant of figure 4b in the horizontal plane.

[0042] Frame 200 may be divided into three regions in the vertical direction, an uppermost region 602 positioned directly below lowermost fan blade 501; a lowermost region 604 and an intermediate region 603 positioned between upper and lower regions 602, 604 respectively, in the vertical direction. According to the present invention, control dampers (not shown) may be housed within lowermost frame region 604 to provide control of the airflow velocity and direction through the ventilator and into the building interior 104.

[0043] The inventors undertook a numerical investigation using computational fluid dynamics to determined air pressure and current velocity and in particular fresh air delivery rates through the ventilator. Figure 7 illustrates the various regions through the ventilator for which statistical airflow behaviour was investigated. In order to obtain a clear pattern of the pressure and velocity profiles within the ventilator, six regions were investigated with regions 700 to 704 representing pressure and velocity in the horizontal plane at various regions spaced apart in a vertical direction through the ventilator. The pressure and velocity was also determined in the vertical plane 705 extending through the louver duct 300 and frame duct 302 referring to figure 3. Plane 700 is positioned at the top of the vent in close proximity to the uppermost fan blade 500. Plane 701 is positioned at the top of the frame in close proximity to its uppermost open face 305. Plane 701 is positioned at the top of a vertex build up in the ventilator referred to as the trailing edge stall with plane 702 positioned at the bottom of this vertex. Planes 703 and 704 are positioned at the either side of the dampener region 604 in a vertical direction with plane 704 positioned in close proximity to the bottom open face 304 of frame 200. The results of the pressure and velocity investigation, illustrated in figures 8 to 11, correspond to the var-

ious regions through the ventilator in which data was analysed as detailed in figure 7.

[0044] The present invention is designed to provide optimum 'comfort levels' within building interior 104. This is achieved via an investigation into the variation of air velocity, pressure and density through various regions of the ventilator in response to variation of the angle θ , distance d and position of fan 600 in a vertical direction through ventilator 102. Figures 8 to 11 detail the effects of blade angle variation; figures 12 to 15 illustrate the effect of fan position within the ventilator and figure 16 illustrates the effects of louver spacing.

Louver Blade Angle

[0045] The effect of varying the blade angle on the pressure and velocity through the ventilator was determined to achieve the optimum blade angle for maximum comfort levels and in particular fresh air delivery rates into the building interior 104.

[0046] Referring to figure 8, air pressure data 800 was obtained at region 703; air pressure data 801 was obtained at region 704; air pressure data 802 corresponds to the pressure drop across the dampener region 604; air pressure data 803 corresponds to pressures at region 700.

[0047] Referring to figure 9, air velocity data 900 was obtained at region 703; air velocity data 901 was obtained at region 704; air velocity data 902 corresponds to the 'comfort level' representing the average airflow movement velocity within room interior 104; air velocity data 903 was obtained at region 700.

[0048] Referring to figure 10 data 1000 correspond to the air pressure verses blade angle in the vertical plane 705 with data 1001 corresponding to the air velocity in the vertical plane 705. Figure 11 illustrates the overall performance of the ventilator with data 1001 corresponding to the 'comfort level' and data 1000 and 1001 corresponding to that of figures 8 and 9.

[0049] The purpose of investigation was to establish maximum air movement within a controlled volume which represents a small classroom. Utilising eight different computational fluid dynamics (CFD) models, the angle of the blades was increased by 5° each model, for a range of $10^\circ - 45^\circ$. The external wind velocity was set at 4.5 m/s, as this is the UK average wind speed.

[0050] Previous work has shown the critical role of damping on occupants' comfort levels. Accordingly data was obtained at planes 703 and 704 placed either side of the damping unit. In order for the dampers to operate effectively the pressure drop across them must be at a minimum, thus enable the unit to control accurately the rate of flow. Figure 8 show the two trends of data 800 and data 801 are at their closest over a range of $28^\circ - 37^\circ$.

[0051] Referring to figure 9, in order for the dampers to work effectively, it is desirable for the velocity drop across data 900 and data 901 to be at a minimum. This range is as expected, due to pressure and velocity being

proportional, across the same values of 28° - 37°.

[0052] Figure 10 illustrates the average velocity and pressure across the vent against the attack angle of the blade. As the pressure inside the ventilator decreases the velocity will increase, as effectively any flow restriction is reduced. From figure 10 it is evident that at the points of intersection, the flow and pressure is at the optimum for the ventilator's performance. The two points of intersection of data 1000 and 1001 are 28° and 35° respectively.

[0053] However the purpose of optimising the ventilator performance ultimately is to provide optimum comfort levels inside the occupancy area. Therefore in order to assess this performance, the comfort level within the area must be shown in tandem with the ventilator's pressure and velocity profiles.

[0054] Figure 11 illustrates the scaled comfort level, pressure and velocity against the blade angle. The comfort level is scaled by a factor of ten in order for it to fit the velocity and pressure profiles for comparison, this does not affect the results in any way. The plots show clearly that at the second point of intersection, 35°, the comfort level within the occupied area is at its peak.

[0055] Therefore the overall performance of the ventilator peaks at the 35° angle. Comparison of the data at 35° with the benchmarked 45° blade angle shows a 45% increase in occupants' comfort level, and a 42% reduce in the trailing edge stall pressure produced. It is clear that reduction in trailing edge stall is proportional to the increase in occupant's comfort level.

[0056] From the results it is evident that by altering the blade angle, the velocity and pressure performance is improved to desirable levels to achieve optimum occupant comfort levels.

[0057] This investigation confirms that a blade angle of 35° provides optimum performance at the given parameters.

[0058] The investigation also established that the reduction in trailing edge stall is proportional to the increased velocity distribution within the occupied space. This connection is established as the removal of such restrictive pressure allows a free flow through the ventilator, and is pivotal to the operation of the control mechanism, namely the damper unit.

Ventilator Fan Position

[0059] The location of fan 600 within ventilator 102 was examined. It has been found that even at low pressure, the air supply rate through the ventilator is excessive which would cause control dampers located within region 604 to work harder in order to dampen the airstream into the building interior 104. The effects of increasing the use of the control dampeners increases the energy consumption of ventilator 102 which is undesirable.

[0060] Figure 12 illustrates the ventilator 102 with fan 600 positioned, in accordance with claim 1, at an upper region of the ventilator in close proximity to uppermost

fan blades 500. Fan 600 is operative to assist the airflow current in a downward direction 1200 through the internal duct of the ventilator 300, 302. The airflow stream 1201 continues out of the bottom face 304 and into building interior 104 and then circulates 1202 through interior 104 and exits this interior 1203 as the airflow current circulates between exterior 103 and interior 104. Importantly, due to the creation of the airflow profile within the ventilator 100 by fan 600 positioned at uppermost louver blade 500, stale air 1203 from interior 104 is capable of exiting the ventilator via flow path 1205 between louver blades 202.

[0061] Figure 13 illustrates the ventilator of figure 12 with fan 600 positioned, according to a non-claimed embodiment, at a more central region corresponding to region 602 illustrated in figure 6. In this arrangement, fan 600 creates a strong airflow stream 1300 and 1301 in a substantially vertically direction into interior 104. Stale air 1302 re-enters the ventilator via open face 304. However, this stale air 1302 is then directed 1303 into the airflow suction path created by fan 600 to be reintroduced into interior 104 via airflow path 1300. This diversion of the airflow path 1303 is caused by the airflow currents created within the louver region due to this mid fan position.

[0062] Figures 14 illustrates a similar arrangement to figures 12 and 13 albeit with fan 600 positioned, according to a non-claimed embodiment, at a lowermost part of ventilator 102 corresponding to region 604 of figure 6. In this position, a strong airflow current is created 1400, 1401 in a vertical direction within interior 104. Stale air 1402 then re-enters the ventilator via open face 304 and is redirected at 1405 into the suction airflow path created by fan 600. As with the arrangement of figure 13, stale air 1303, 1405 is prevented from escaping from the ventilator 1205 (referring to figure 12) due to the turbulence created within the louver region 201 by the relative fan position.

[0063] The fan position also has an affect upon the airflow at environment 103 into louver duct 300. Referring to figure 12, with fan 600 at an uppermost position, clean air is capable of flowing into the ventilator 1204 over the entire height of the blade stack. In contrast, and referring to figures 13 and 14, the fresh air supply 1304, 1403 into the ventilator is perturbed by the eddy currents created within ventilated duct 300. With fan 600 positioned at its lowest most orientation of figure 14, the fresh air supply is prevented from entering the ventilator 1404 due to the turbulence within louver duct 300. In the orientations of figures 13 and 14, there is no clear area through which the exhaust air may exit the ventilator and according it is re-circulated within interior 104 by the effective fan pressure.

[0064] Figure 15 illustrates the total fresh air delivery rates supplied by ventilator 102 for the three fan positions of figures 12, 13 and 14. Data 1500, 1501 and 1502 correspond to fan 600 positioned at the top (figure 12), middle (figure 13) and bottom (figure 14), of ventilator 102, respectively.

[0065] The British Standard (BS) minimum fresh air delivery rates are specified as 0.8 L/sec per m² and 5 L/sec per occupant. The occupancy level for this investigation was 20 occupants which is the recommended level for a small classroom. According to the present investigation, when the external wind velocity is 1 m/s ventilator 102 does not meet the criteria for the amount of fresh air per occupants and therefore the passive ventilator 102 requires assistance.

[0066] A total of 18 CFD models were created covering a pressure range of 20 - 120 Pa, in three different locations. The results show that in each of the three locations of figures 12 to 14, a fan pressure of 20 Pa assists the external wind velocity (1 m/s) to achieve the BS criterion.

[0067] The fan in the top position of figure 12 creates the smallest increase in fresh air supply from 4.5 to 18.5 L/sec per occupant at a fan pressure of 20 Pa. The flow visualisation of these results (figure 15) shows that the fan draws in fresh air whilst allowing the receiving room's exhaust air to exit via two channels 1205 either side of the fan.

[0068] The fan in the middle and bottom positions of figures 13 and 14, respectively, shows very similar results in terms of fresh air supply rate. Both give considerable improvements of 111 and 11.5 L/sec respectively. The flow visualisation of these results show that for the middle fan position (figure 13) the fresh air (external) is restricted in one quadrant, and the exhaust air (room internal) has no natural path 1303 to exit ventilator 102. Figure 14 illustrates that at the bottom fan position, the restriction is in both quadrants 1405 and again there is no return path for the exhaust air.

[0069] The flow delivery rate results of figure 15 for the middle and bottom fan position show that although the rate at which the air is delivered into the room has increased, little fresh air is drawn into the room. Instead, the air is being re-circulated by the fan in these two positions and therefore the ventilator does not meet the fresh air delivery rate requirements.

[0070] From the results, it was clear that a low voltage fan would need to produce a minimum pressure of 20 Pa to achieve the BS required minimum ventilation rates. The fan should be located in the top position to ensure fresh air is drawn in at low external wind speeds (1 m/s) and delivered to the receiving room without restricting the exhaust air flow path.

Louver Blade Separation Distance

[0071] By changing the external distance of separation between the closest regions of adjacent louver blades 202 (distance d) illustrated in figures 4c and 5, the rate at which fresh air is delivered into the building interior is affected. The undesirable affects of increasing the louver blade spacing are twofold:

- i breakthrough noise from external sources enters the ventilator 102 and hence the building interior 104;

and

- ii rain ingress, wind may be driven into the ventilator duct 300 and into building interior 104.

[0072] The objective therefore is to optimise louver spacing to give the lowest possible distance to reduce breakthrough noise and rain ingress whilst acceptable fresh air delivery rates are provided through the ventilator. Figure 16 illustrates experimental results with data 1600 corresponding to the velocity of air through the ventilator, data 1602 corresponds to the pressure of air through the ventilator and data 1601 corresponds to the 'comfort level' being the air movement rate within the building interior 104.

[0073] As illustrated in figure 16, a maximum 'comfort level' is observed for a louver spacing (d) of 30 mm. Importantly, reducing the louver spacing has therefore been found to match the observed air movement rate within interior 104 in addition to reducing breakthrough noise and the likelihood of rain ingress into ventilator 102.

[0074] Referring to figures 17a to 17c, a practical experimental investigation was undertaken to determine the effects of varying the distance between louver blades 202 (distance d) illustrated in figures 4c and 5. The three louver spacings investigated were 20 mm, 30 mm and 60 mm. The three experimental arrangements were achieved using spacer bars (not shown) at four corners of the wind vent of the type illustrated in figure 2. Reducing the distance between louver blades 202 was found to have an undesirable effect of reducing the overall height of the louver section. Accordingly, internal blanking (not shown) was used at the upper region of the louver to alleviate additional airflow which would otherwise obscure the results for comparative purposes.

[0075] The wind speed at six regions across the louver stack was monitored and the regions denominated as sample points 2, 4, 5, 6, 8 and 10. The wind speed was monitored over five days for each louver blade spacing. The average observed external wind velocities for each of the experiments was 5 m/s for the 60 mm spacing; 7 m/s for the 30 mm spacing and 7 m/s for the 20 mm with the averaged internal velocity results illustrated respectively in figures 17a, 17b and 17c.

[0076] Notwithstanding an increase in the external wind velocity (for the 30 mm and the 20 mm spacings) the results confirm that there is no significant drop in internal wind velocity by effectively halving the louver blade spacing from 60 mm to 30 mm. This investigation supports the computational fluid dynamics model illustrated in figure 16. In particular, through the experimental investigation and fluid modelling, the inventors have identified that an approximate louver blade spacing of around 30 mm is optimum with regard to sufficient internal air flow velocity whilst significantly reducing breakthrough noise and rain ingress.

Claims

1. A building ventilator (102) comprising:

a frame (200) mountable at an opening (105) in a roof (101) of a building (100), the frame (200) defining a duct (300) to convey air between an exterior (103) and an interior (104) of the building (100);

a plurality of vent blades (202) mountable at an external facing region of the frame (200) such that the blades (202) are mounted at the exterior (103) of the building (100) and are stacked above one another to form a louver (201), each blade (202) having a leading edge (416) to be external facing relative to the duct (300) and a trailing edge (415) to be internal facing relative to the duct (300);

wherein the distance in the vertical direction between adjacent blades (202) at the their respective leading edge regions is in the range 25 to 35 mm;

a fan (600) operative to assist the airflow current in a downward direction through the duct (300) and into the interior (104) of the building (100); the ventilator **characterised in that:**

the fan (600) is mounted at an upper region of the ventilator in the vertical direction.

2. The ventilator as claimed in claim 1 wherein the distance between adjacent blades (202) is in the range 27 to 33 mm.

3. The ventilator as claimed in claim 1 or 2 wherein the distance between adjacent blades (202) is 30 mm.

4. The ventilator as claimed in any preceding claim comprising internal walls mounted within the frame (200), the internal walls configured to partition the duct (300) in the longitudinal direction between the interior (104) and exterior (103) of the building (100).

5. The ventilator as claimed in any preceding claim wherein the frame (200) comprises walls extending between an open top face (305) and an open bottom face (304), the top face (305) arranged to be facing the exterior (103) of the building (100) and the bottom face (304) arranged to be facing the interior (104) of the building (100).

6. The ventilator as claimed in claim 5 wherein the blades (202) are mounted on the top face (305) and extend externally of the building (100) away from each of the walls of the frame (200).

7. The ventilator as claimed in any preceding claim wherein the blades (202) are stacked vertically

above one another and the frame (200).

8. The ventilator as claimed in any preceding claim wherein each blade comprises a flange (401, 402) extending from the leading (416) and trailing (415) edge, each flange (401, 402) orientated transverse to the plane of the blade (202).

9. The ventilator as claimed in any preceding claim wherein the blades (202) are mounted above one another to form a louver (201), the louver (201) comprising between four to six blades (202).

10. The ventilator as claimed in claim 1 wherein the duct (300) is devoid of internal partitions extending in the vertical direction between the exterior (305) and interior facing ends (304).

11. The ventilator as claimed in any preceding claim further comprising electronic control means to provide manual and/or automatic control of the fan (600).

12. The ventilator as claimed in any preceding claim wherein the fan (600) comprises an electric motor.

13. The ventilator as claimed in preceding claim wherein the fan (600) is mounted within the louver region (201) substantially in the same horizontal plane as the blade (202) positioned furthest from the external facing end (305) of the frame (200) in the vertical direction.

Patentansprüche

1. Gebäudeventilator (102), umfassend:

einen Rahmen (200), welcher an einer Öffnung (105) in einem Dach (101) eines Gebäudes (100) anbringbar ist, wobei der Rahmen (200) einen Kanal (300) definiert, um Luft zwischen einer Außenseite (103) und einem Innenraum (104) des Gebäudes (100) zu befördern;

mehrere Lüftungslamellen (202), welche an einem Außen zugewandten Bereich des Rahmens (200) derart anbringbar sind, dass die Lamellen (202) an der Außenseite (103) des Gebäudes (100) angebracht sind und übereinander gestapelt sind, um eine Lüftungsöffnung (201) auszubilden, wobei jede Lamelle (202) einen vorderen Rand (416), welcher relativ zu dem Kanal (300) nach Außen zugewandt ist, und einen hinteren Rand (415), welcher relativ zu dem Kanal (300) nach Innen zugewandt ist, aufweist;

wobei der Abstand in der vertikalen Richtung zwischen benachbarten Lamellen (202) an ihren entsprechenden vorderen Randbereichen in

dem Bereich von 25mm bis 35mm liegt;
ein Gebläse (600), welches ausgestaltet ist, den
Luftflussstrom in einer Abwärtsrichtung durch
den Kanal (300) und in den Innenraum (104)
des Gebäudes (100) zu unterstützen;
wobei der Ventilator **dadurch gekennzeichnet
ist, dass:**

das Gebläse (600) in einem oberen Bereich
des Ventilators in der vertikalen Richtung
angebracht ist.

2. Ventilator nach Anspruch 1, wobei der Abstand zwischen benachbarten Lamellen (202) in dem Bereich von 27mm bis 33mm liegt.
3. Ventilator nach Anspruch 1 oder 2, wobei der Abstand zwischen benachbarten Lamellen (202) 30mm beträgt.
4. Ventilator nach einem der vorhergehenden Ansprüche, umfassend Innenwände, welche innerhalb des Rahmens (200) angebracht sind, wobei die Innenwände ausgestaltet sind, den Kanal (300) in der Längsrichtung zwischen dem Innenraum (104) und der Außenseite (103) des Gebäudes (100) zu unterteilen.
5. Ventilator nach einem der vorhergehenden Ansprüche, wobei der Rahmen (200) Wände umfasst, welche sich zwischen einer offenen Oberseitenfläche (305) und einer offenen Unterseitenfläche (304) erstrecken, wobei die Oberseitenfläche (305) ausgestaltet ist, der Außenseite (103) des Gebäudes (100) zugewandt zu sein, und wobei die Unterseitenfläche (304) ausgestaltet ist, dem Innenraum (104) des Gebäudes (100) zugewandt zu sein.
6. Ventilator nach Anspruch 5, wobei die Lamellen (202) an der Oberseitenfläche (305) angebracht sind und sich nach Außen von dem Gebäude (100) von jeder der Wände des Rahmens (200) weg erstrecken.
7. Ventilator nach einem der vorhergehenden Ansprüche, wobei die Lamellen (202) vertikal übereinander und über dem Rahmen (200) gestapelt sind.
8. Ventilator nach einem der vorhergehenden Ansprüche, wobei jede Lamelle eine Flansch (401, 402) umfasst, welcher sich von dem vorderen (416) und hinteren (415) Rand erstreckt, wobei jeder Flansch (401, 402) quer zu der Ebene der Lamelle (202) ausgerichtet ist.
9. Ventilator nach einem der vorhergehenden Ansprüche, wobei die Lamellen (202) übereinander angebracht sind, um eine Lüftungsöffnung (201) auszu-

bilden, wobei die Lüftungsöffnung (201) zwischen vier und sechs Lamellen (202) umfasst.

10. Ventilator nach Anspruch 1, wobei der Kanal (300) frei von internen Aufteilungen ist, welche sich in der vertikalen Richtung zwischen der Außenseite (305) und dem Innenraum zugewandten Enden (304) erstrecken.
11. Ventilator nach einem der vorhergehenden Ansprüche, ferner umfassend elektronische Steuermittel, um eine manuelle und / oder automatische Steuerung des Gebläses (600) bereitzustellen.
12. Ventilator nach einem der vorhergehenden Ansprüche, wobei das Gebläse (600) einen Elektromotor umfasst.
13. Ventilator nach einem der vorhergehenden Ansprüche, wobei das Gebläse (600) innerhalb des Lüftungsöffnungsbereichs (201) im Wesentlichen in der gleichen horizontalen Ebene wie die Lamelle (202), welche am weitesten von dem nach Außen zugewandten Ende (305) des Rahmens (200) in der vertikalen Richtung angeordnet ist, angebracht ist.

Revendications

1. Ventilateur de bâtiment (102) comprenant :

un châssis (200) pouvant être monté au niveau d'une ouverture (105) sur un toit (101) d'un bâtiment (100), le châssis (200) définissant un conduit (300) pour transporter l'air entre un extérieur (103) et un intérieur (104) du bâtiment (100) ;
une pluralité d'aubes de conduit d'orifice de ventilation (202) pouvant être montées au niveau d'une région orientée vers l'extérieur du châssis (200) de sorte que les aubes (202) sont montées à l'extérieur (103) du bâtiment (100) et sont empilées les unes sur les autres afin de former un déflecteur (201), chaque aube (202) ayant un bord d'attaque (416) destiné à être orienté vers l'extérieur par rapport au conduit (300) et un bord de fuite (415) destiné à être orienté vers l'intérieur par rapport au conduit (300) ;
dans lequel la distance dans la direction verticale entre les aubes (202) adjacentes au niveau de leurs régions de bord d'attaque respectives est de l'ordre de 25 à 35 mm ;
une soufflante (600) opérationnelle pour assister le courant d'écoulement d'air dans une direction descendante à travers le conduit (300) et à l'intérieur (104) du bâtiment (100) ;
le ventilateur étant **caractérisé en ce que :**

la soufflante (600) est montée au niveau

- d'une région supérieure du ventilateur dans la direction verticale.
2. Ventilateur selon la revendication 1, dans lequel la distance entre les aubes (202) adjacentes est de l'ordre de 27 à 33 mm.
 3. Ventilateur selon la revendication 1 ou 2, dans lequel la distance entre les aubes (202) adjacentes est de 30 mm.
 4. Ventilateur selon l'une quelconque des revendications précédentes, comprenant des parois internes montées à l'intérieur du châssis (200), les parois internes étant configurées pour séparer le conduit (300) dans la direction longitudinale entre l'intérieur (104) et l'extérieur (103) du bâtiment (100).
 5. Ventilateur selon l'une quelconque des revendications précédentes, dans lequel le châssis (200) comprend des parois s'étendant entre une face supérieure ouverte (305) et une face inférieure ouverte (304), la face supérieure (305) étant agencée pour être orientée vers l'extérieur (103) du bâtiment (100) et la face inférieure (304) étant agencée pour être orientée vers l'intérieur (104) du bâtiment (100).
 6. Ventilateur selon la revendication 5, dans lequel les aubes (202) sont montées sur la face supérieure (305) et s'étendent à l'extérieur du bâtiment (100) à distance de chacune des parois du châssis (200).
 7. Ventilateur selon l'une quelconque des revendications précédentes, dans lequel les aubes (202) sont empilées verticalement les unes sur les autres et sur le châssis (200).
 8. Ventilateur selon l'une quelconque des revendications précédentes, dans lequel chaque aube comprend un rebord (401, 402) s'étendant à partir du bord d'attaque (416) et du bord de fuite (415), chaque rebord (401, 402) étant orienté transversalement par rapport au plan de l'aube (202).
 9. Ventilateur selon l'une quelconque des revendications précédentes, dans lequel les aubes (202) sont montées les unes au-dessus des autres afin de former un déflecteur (201), le déflecteur (201) comprenant entre quatre et six aubes (202).
 10. Ventilateur selon la revendication 1, dans lequel le conduit (300) est dépourvu de cloisons internes s'étendant dans la direction verticale entre les extrémités orientées vers l'extérieur (305) et l'intérieur (304).
 11. Ventilateur selon l'une quelconque des revendications précédentes, comprenant en outre des moyens de commande électronique pour fournir une commande manuelle et/ou automatique de la soufflante (600).
 12. Ventilateur selon l'une quelconque des revendications précédentes, dans lequel le ventilateur (600) comprend un moteur électrique.
 13. Ventilateur selon l'une quelconque des revendications précédentes, dans lequel le ventilateur (600) est monté à l'intérieur de la région de déflecteur (201) sensiblement dans le même plan horizontal que l'aube (202) la plus éloignée de l'extrémité orientée vers l'extérieur (305) du châssis (200) dans la direction verticale.

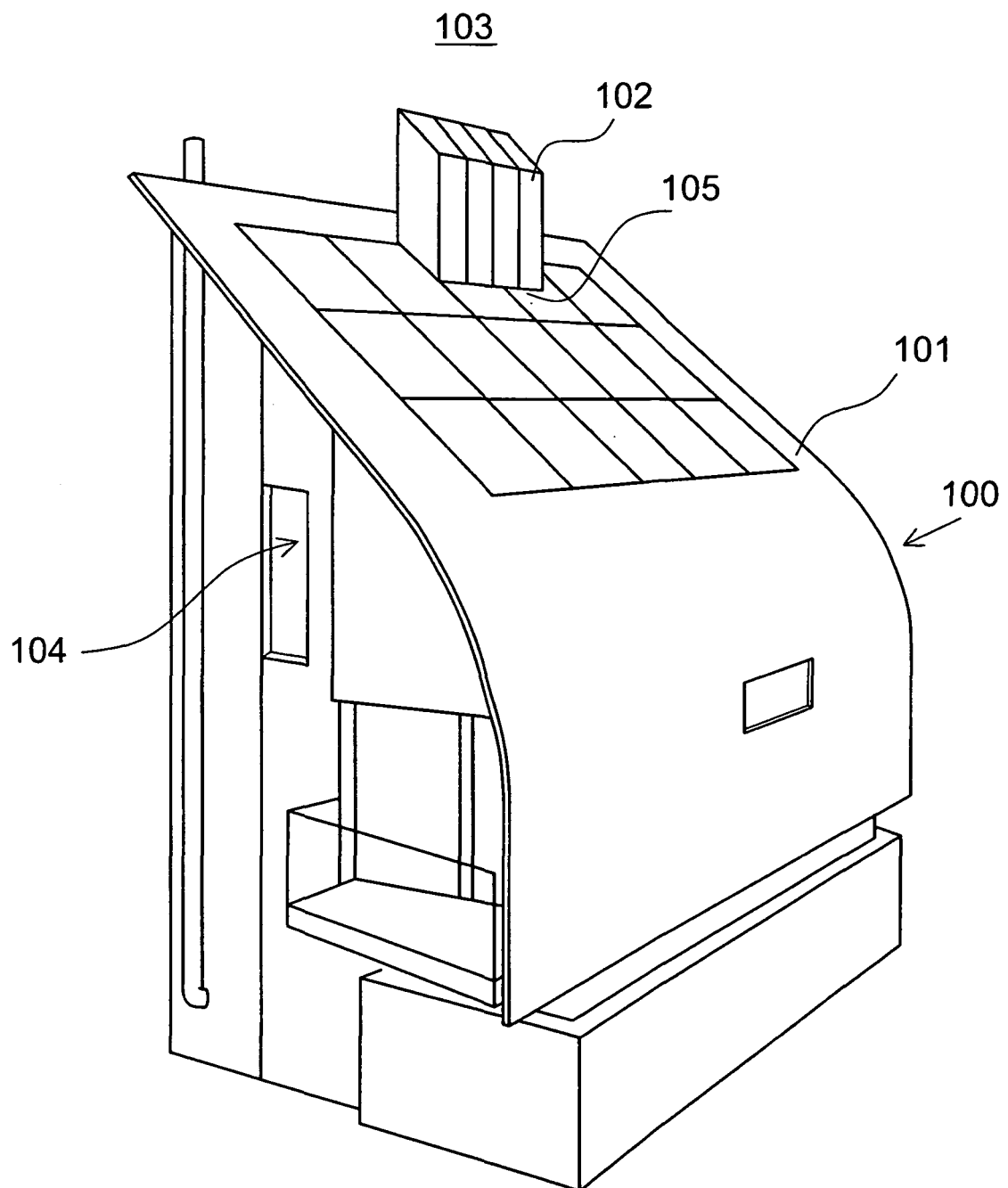


Fig. 1

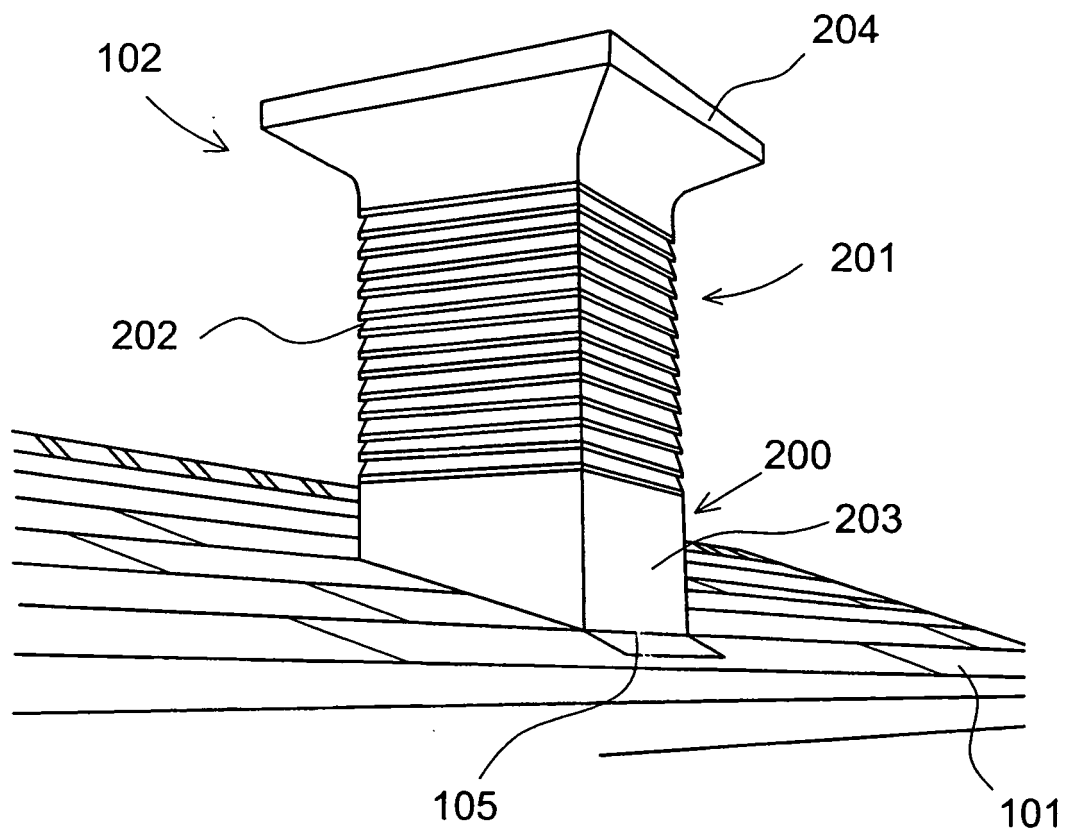


Fig. 2

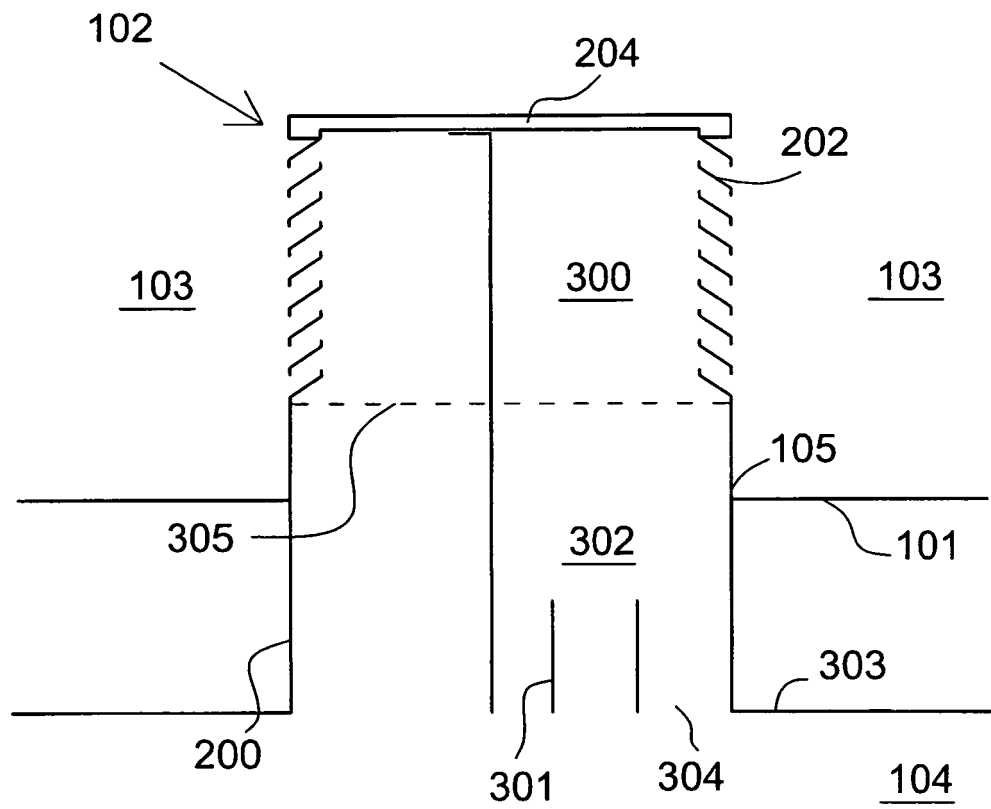


Fig. 3

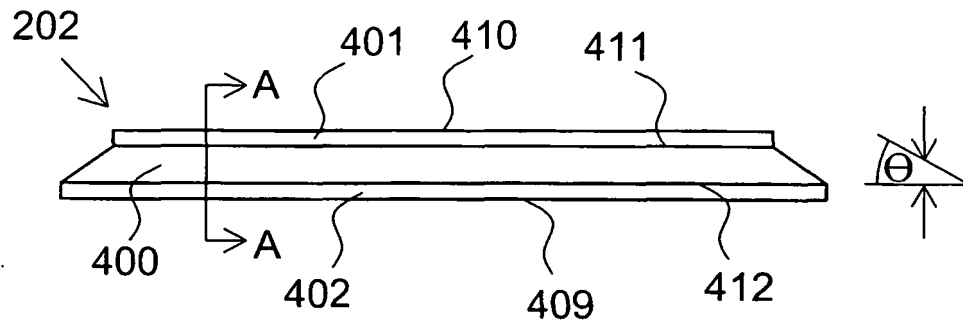


Fig. 4A

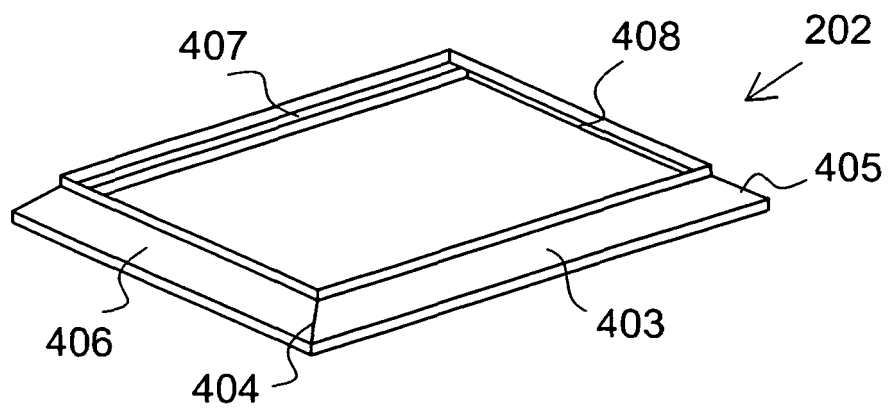


Fig. 4B

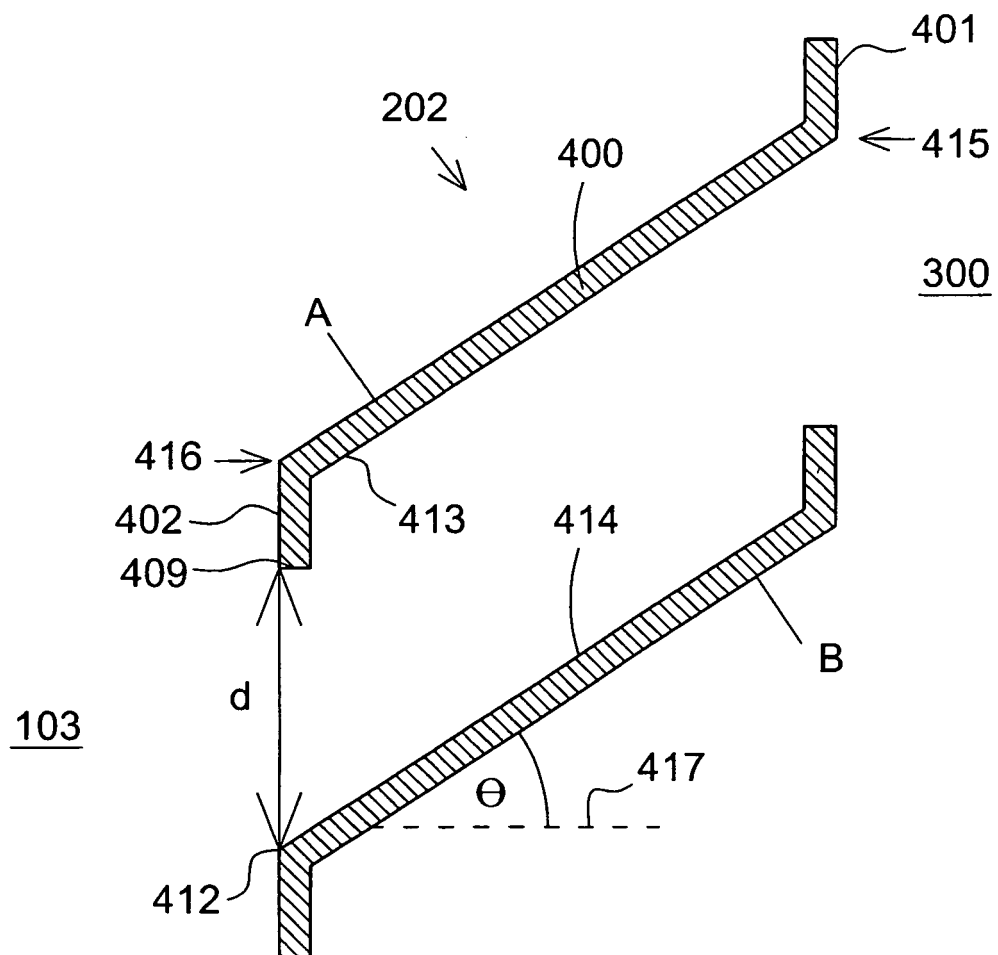


Fig. 4C

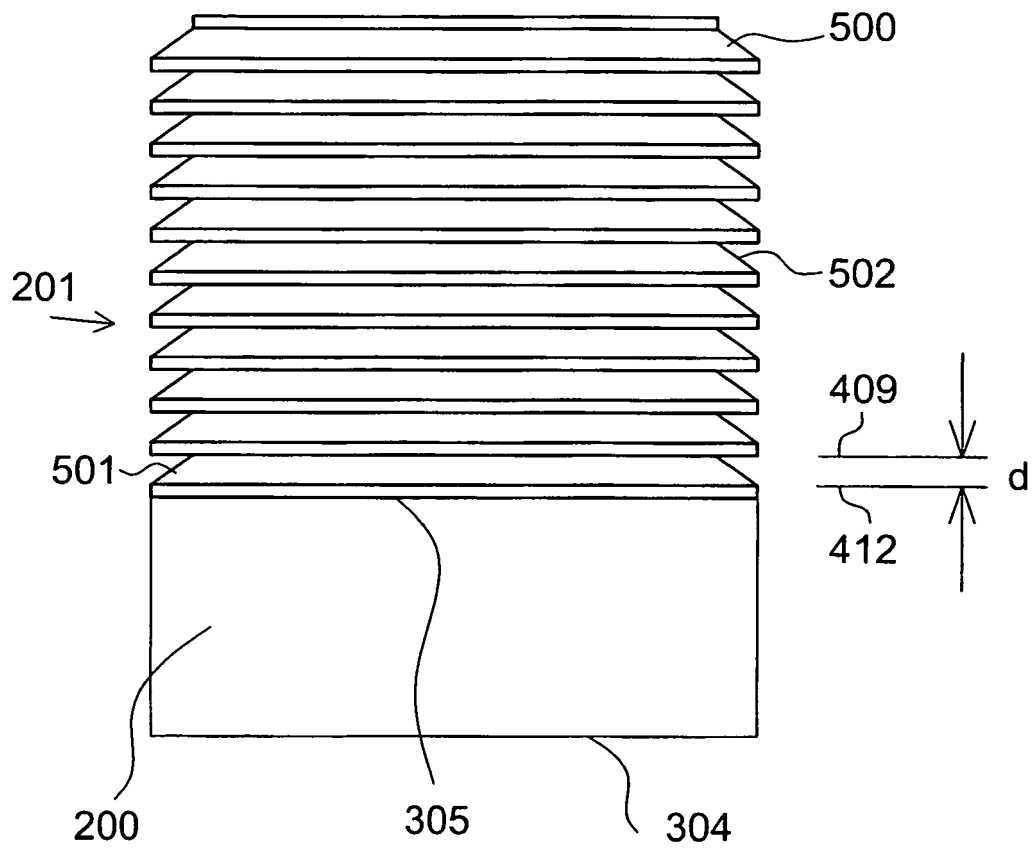


Fig. 5

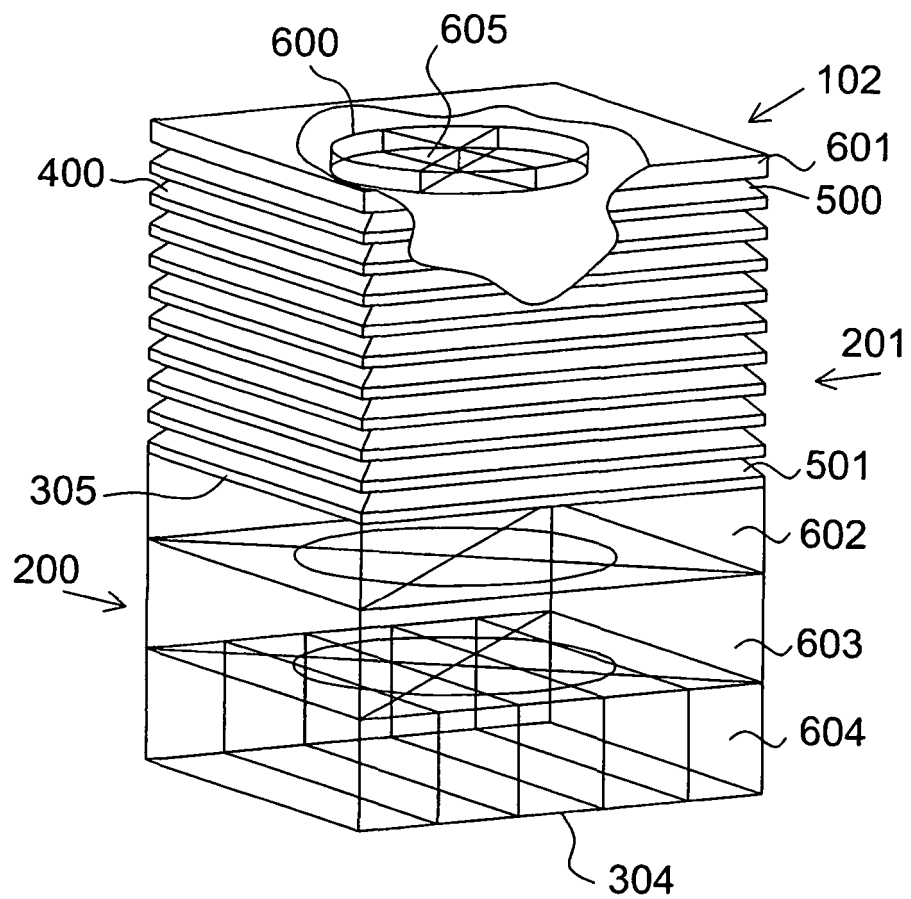


Fig. 6

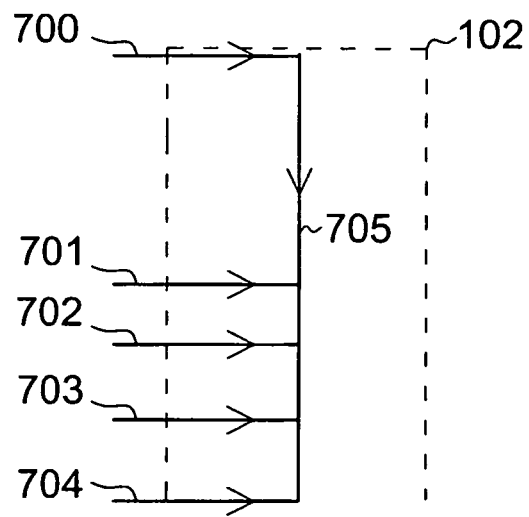


Fig. 7

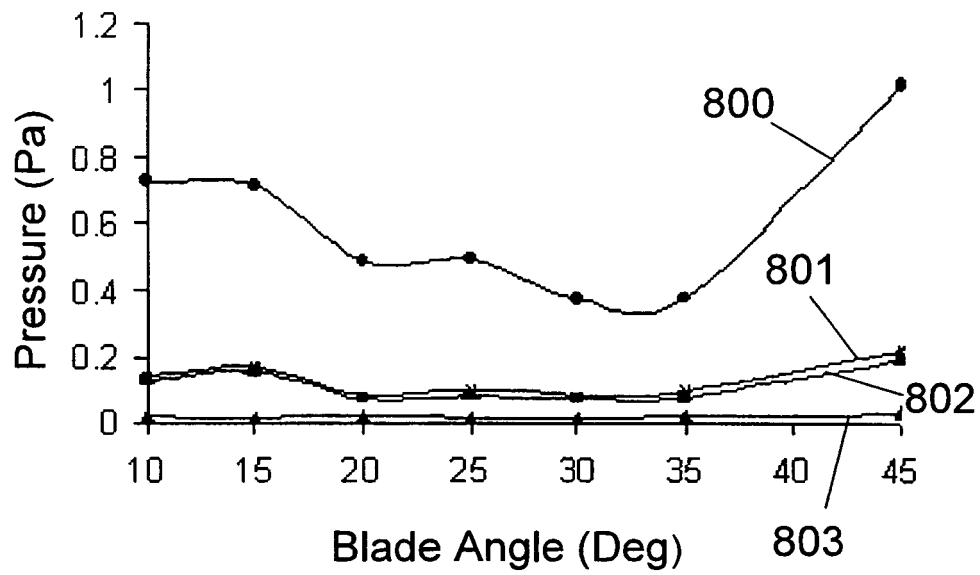


Fig. 8

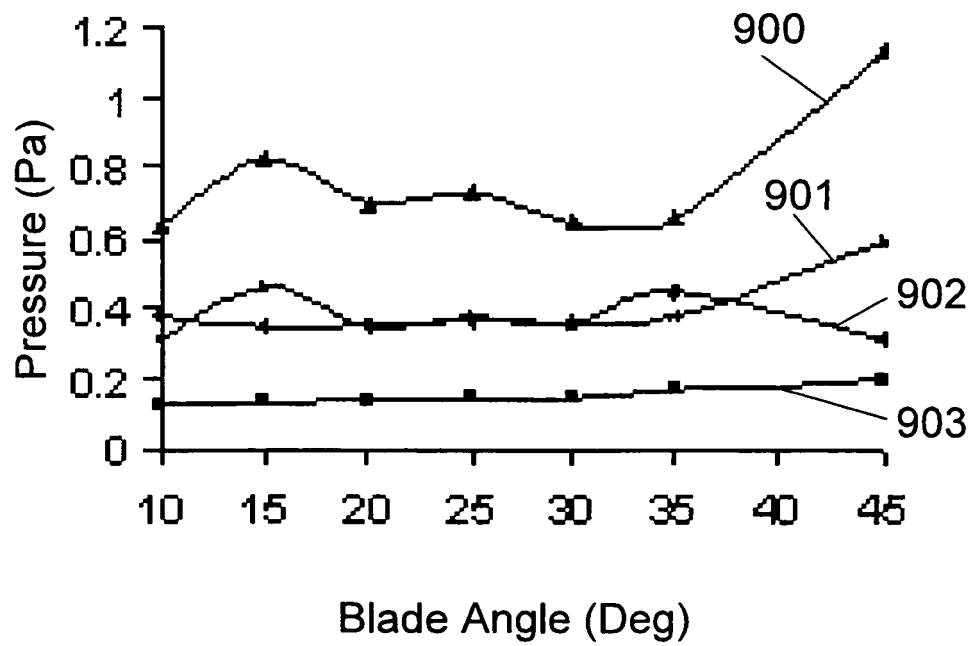


Fig. 9

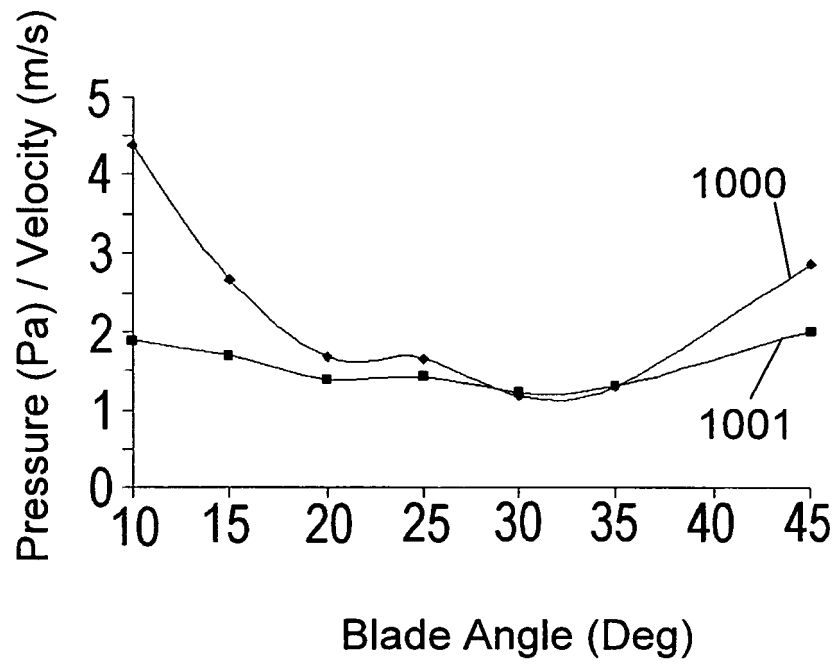


Fig. 10

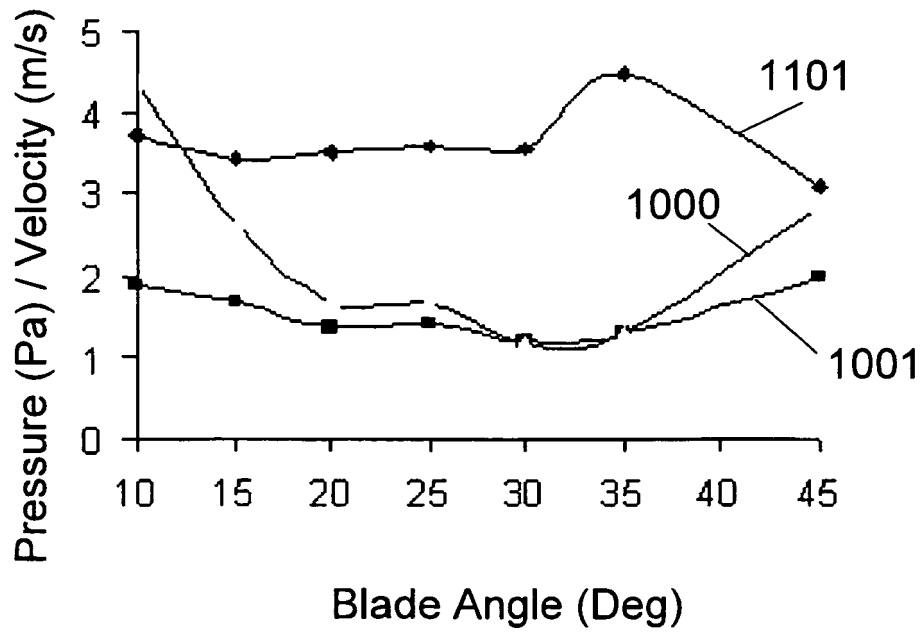
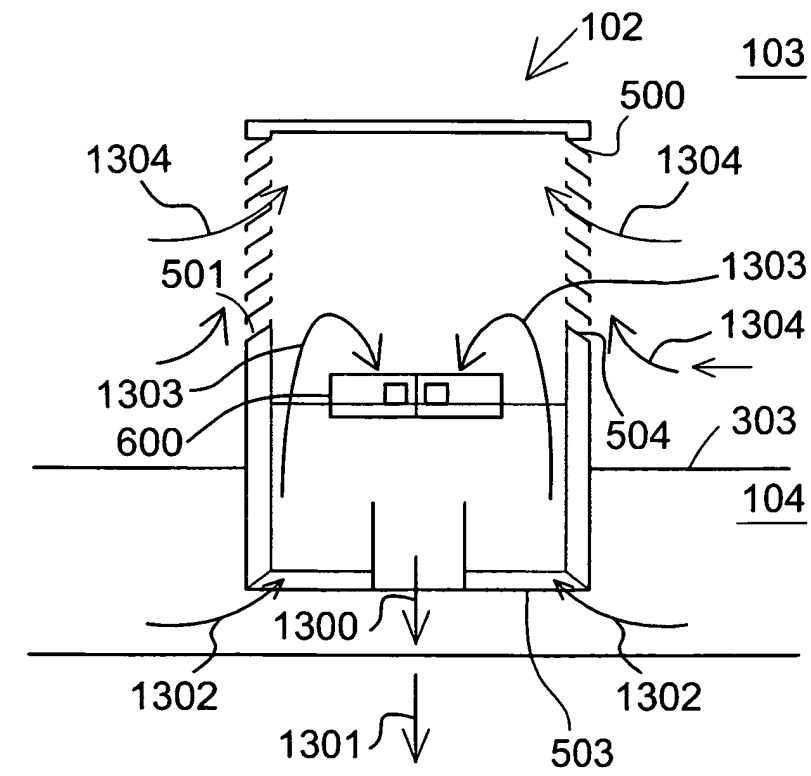
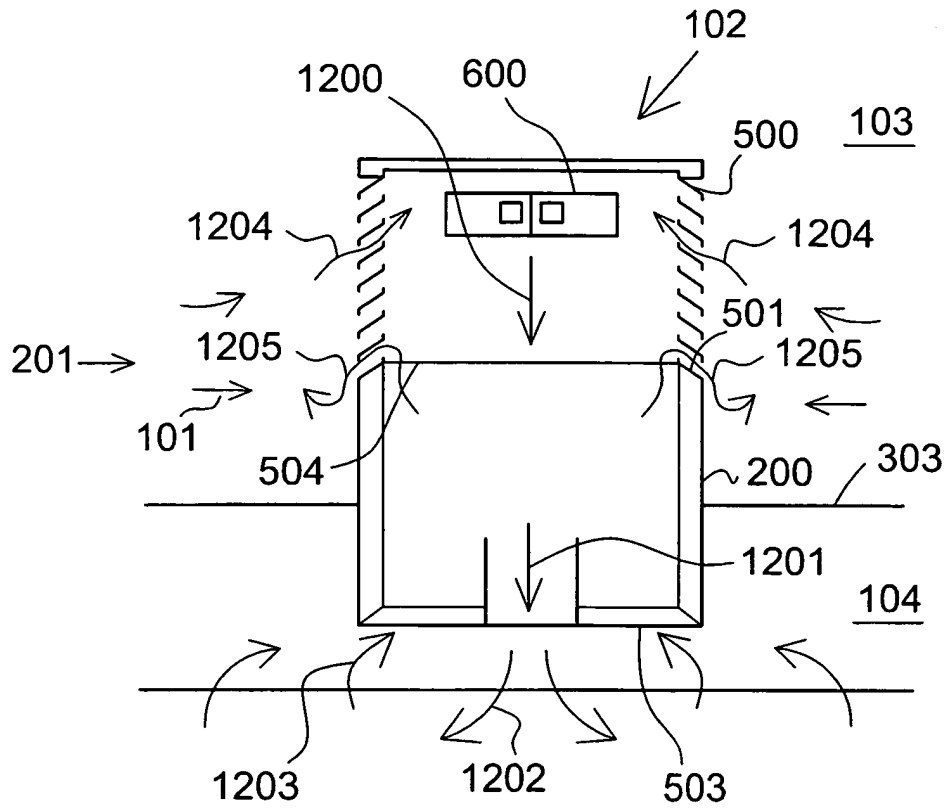


Fig. 11



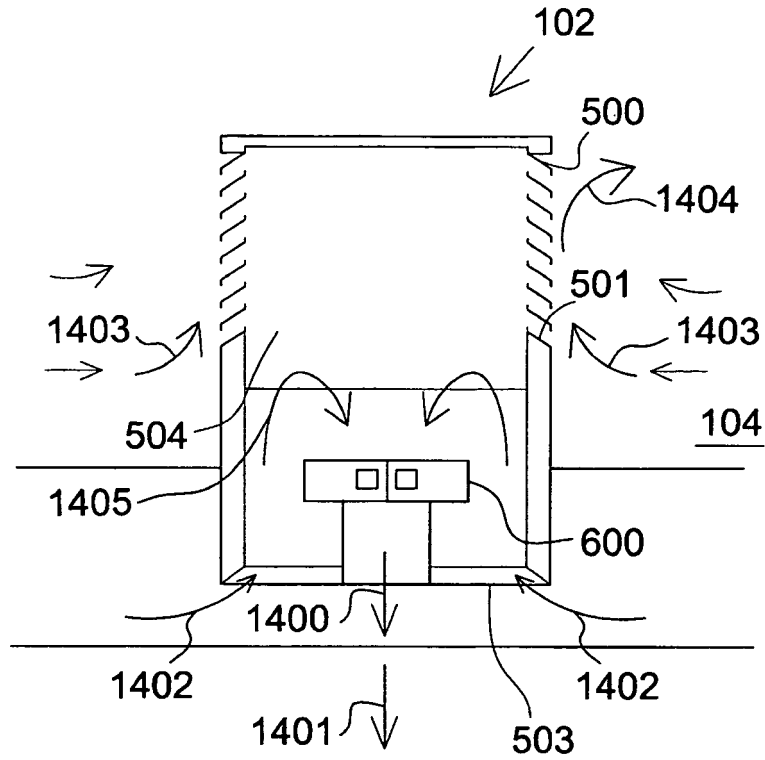


Fig. 14

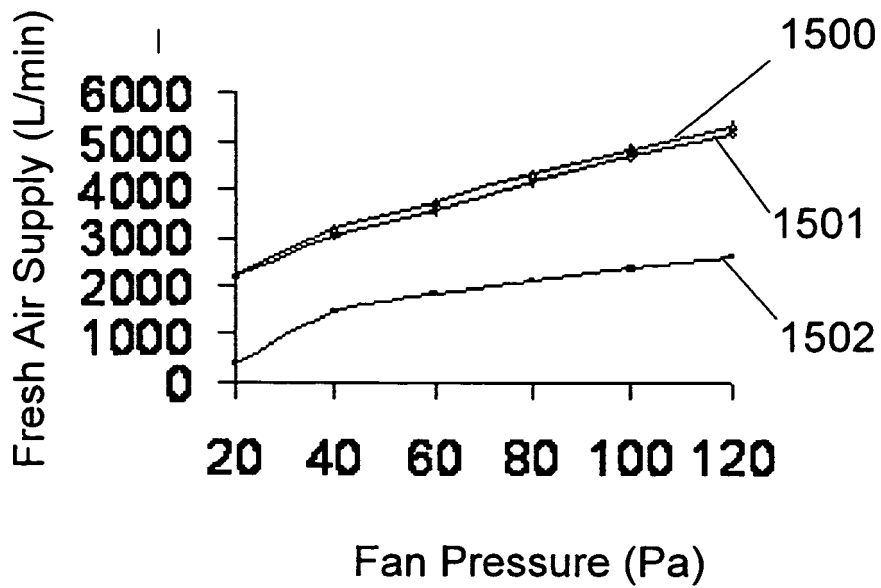


Fig. 15

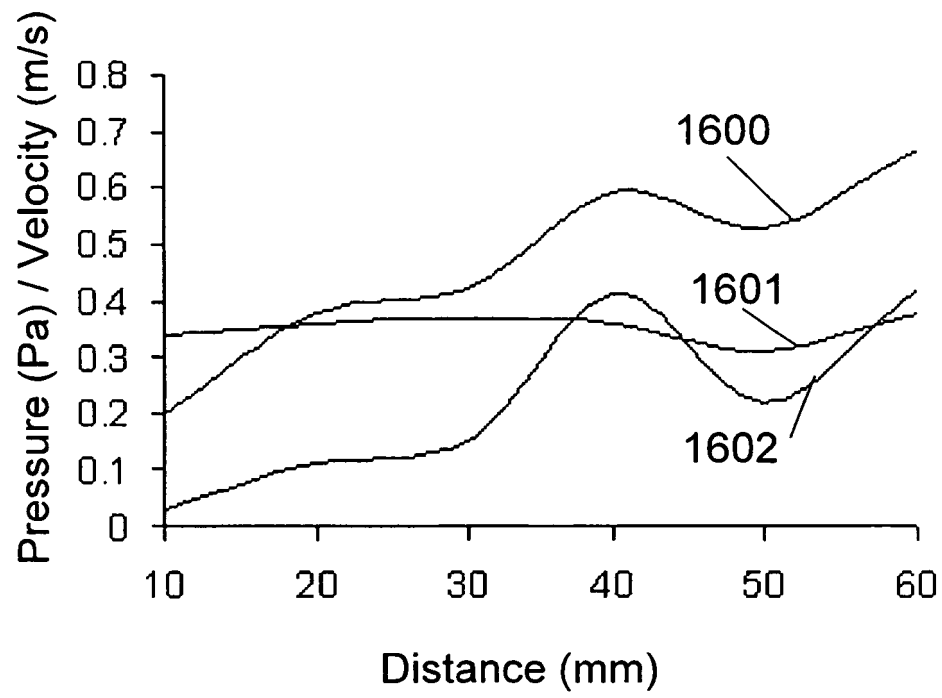


Fig. 16

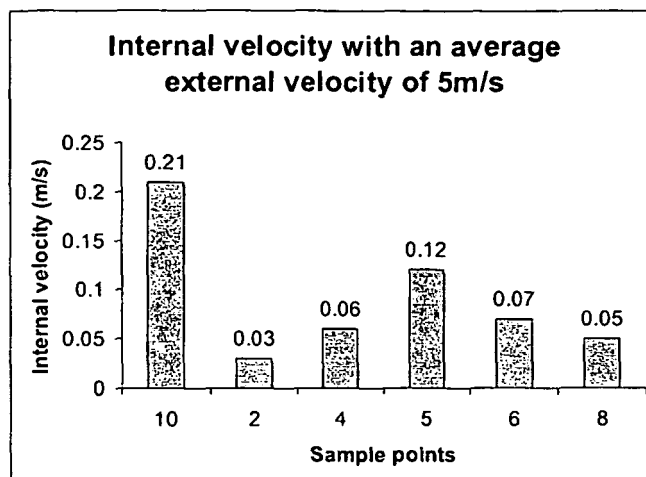


Fig. 17A

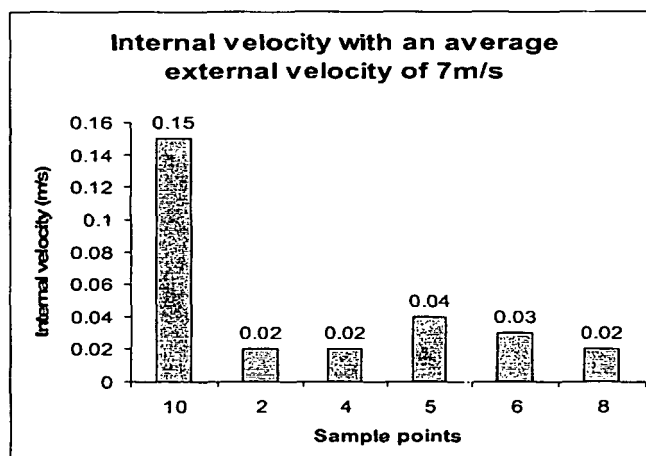


Fig. 17B

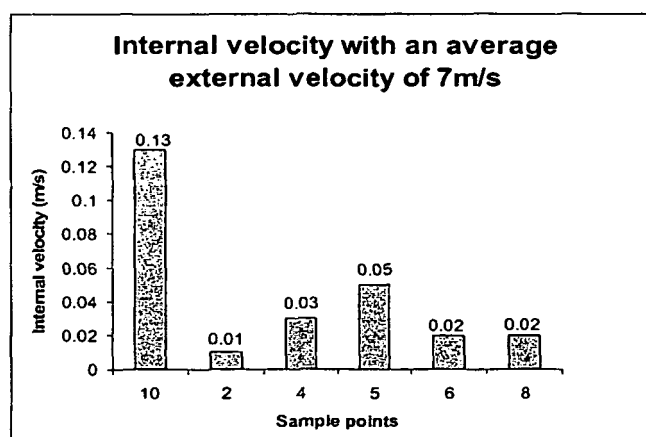


Fig. 17C

REFERENCES CITED IN THE DESCRIPTION

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