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(54) **Title:** EXTRACTOR UNIT

(57) **Abstract:** Described herein is an extractor unit comprising: at least one fan for creating: an extraction airflow, and an air curtain airflow, an extractor duct for the extraction airflow for extracting waste gases from a region, a hood coupled to the duct for receiving the air curtain airflow from the fan and expelling an air curtain to envelop the region, and an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct.

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Extractor unit

Field of the invention

The present invention relates to extractor units for containing and/or extracting waste gases from the cooking region, such as a cooktop or similar.

Background to the invention

Cook tops which are used for heating and cooking food and saucepans, fry pans and the like produced waste gases in the form of steam and other gases laden with food particles and smells.

To keep the kitchen clean and to prevent smells from emanating through the kitchen, extractor units are typically used. They use a fan to create an airflow to suck the waste gases (cooking effluent) into a duct an expel them through an exhaust to ambient air.

However, such extractor units are only partially effective. Not all waste gases are captured by the extractor unit. Some waste gases can still escape from the cooktop

Summary of invention

it is an object of the invention to provide an extractor unit that provides an air curtain to improve containment and/or extraction of waste gases from a cooktop or other region producing waste gases.

In one aspect the present invention may be said to comprise an extractor unit comprising: at least one fan for creating: an extraction airflow, and an air curtain airflow, an extractor duct for the extraction airflow for extracting waste gases from a region, a hood coupled to the duct for receiving the air curtain airflow from the fan and expelling an air curtain to envelop the region, and an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct.

Optionally the hood comprises a plenum with an inlet opening for receiving air curtain airflow from the air curtain fan and an outlet for expelling the air curtain to the region.

Optionally the outlet comprises a slot around at least part of the perimeter of the plenum and lips around the slot for directing the air curtain.

Optionally the hood has a plenum and slotted outlet at least partially around the perimeter of the hood for expelling the air curtain, and a deflector on proximate the slotted outlet to direct the air curtain.

Optionally the deflector and/or slot extend at least partially to the back of the hood.

Optionally there are at least two fans, a first exhaust fan for creating the extraction airflow and a second air curtain fan for creating the air curtain airflow.

Optionally the exhaust fan and the air curtain fan are disposed in the extractor duct housing.

Optionally the plenum with an inlet opening receives air curtain airflow from the air curtain fan and an outlet for expelling the air curtain to the region.

Optionally, the inlet comprises an aerofoil cross-section to form one at least one circulating current with the extraction airflow, air curtain airflow and/or waste gases.

Optionally the inlet is U-shaped with three aerofoil inlet sections positioned around the region.

Optionally the region as a cooking region of a cooktop.

Optionally the hood comprises a deflector to guide flow (from convection and/or turbulent airflows) downwards.

Optionally the convection current mixes air from the air curtain, extraction airflow and the waste gases.

Optionally the inlet comprises a filter formed of alternating and overlapping elongated extrusions with curved cross sections.

Optionally there is a single fan for creating an extraction airflow and an air curtain airflow, wherein extraction airflow through the fan is filtered and recirculated into the air curtain flow.

Optionally the deflector and/or slot extend at least partially to the back of the hood. Optionally, the deflector can extend all the way (that is, completely) around the hood.

Optionally the deflector is positioned around the hood, or within the hood.

Optionally the plenum comprises two chambers, optionally separated by a baffle that is optionally movable.

Optionally the plenum comprises a baffle that goes at least partially across or through the plenum, and optionally goes entirely through the plenum.

Optionally the extractor unit further comprises secondary baffles that extend from the baffle.

Optionally the extractor unit further comprises a controller for operating the fan to control the air velocity and flow rate of air curtain exiting the slotted outlet.

Optionally the controller controls the air velocity and the flow rate of the air curtain to be within a certain range and/or the ratio between them to be in a certain range.

Optionally the controller operates the fan to control the extraction airflow.

Optionally the extractor unit further comprises one or more sensors or other means positioned at a suitable location to determine the existence, magnitude and/or direction of cross-flow, wherein the extractor unit is configured so that the air curtain exit velocity/flow rate through different parts of the air curtain slot are controlled to create airflows to counteract/compensate for the cross-flow.

Optionally the extractor is configured, through structure and/or control of operation, to:

- provide a flow rate of the air curtain to a desired ratio of the flow rate of extraction airflow to improve performance, and/or
- provide an air velocity of the air curtain to between a desired range to improve performance, and/or
- provide the air velocity of the air curtain as a desired percentage of the extraction rate to improve performance, and/or

- provide an exit velocity of the air curtain across the slot to reduce the variability of the exit velocity across the slot.

Optionally

- the flow rate of the air curtain is between about 6-12% and preferably 9% of that of the flow rate of extraction airflow, and/or
- the air velocity of the air curtain measured at 57mm is between about 1.1m/s and 2m/s, and/or
- the air velocity of the air curtain measured at 57mm as a percentage of the extraction rate is between about 12% to 17% of the extraction flow rate, or between about 10% to 20%, or between about 5% to 25%.

In another aspect the present invention may be said to comprise a method of controlling an extractor unit that:

- provides a flow rate of the air curtain to a desired ratio of the flow rate of extraction airflow to improve performance, and/or
- provides an air velocity of the air curtain to between a desired range to improve performance, and/or
- provides the air velocity of the air curtain as a desired percentage of the extraction rate to improve performance, and/or
- provides an exit velocity of the air curtain across the slot to reduce the variability of the exit velocity across the slot.

In another aspect the present invention may be said to comprise an extractor unit comprising: at least one fan for creating: an extraction airflow, and an extractor duct for the extraction airflow for extracting waste gases from a region, a hood coupled to the duct with a deflector, and an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct.

Optionally the deflector is positioned around the hood, or within the hood.

Optionally the depth (recess) of the deflector is between about 10mm and about 50mm, and preferably between about 20mm and about 40mm.

Optionally the angle of the deflector relative to the hood is between about 5 and about 20 degrees, and preferably between about 10 and about 15 degrees.

Optionally the deflector is positioned and/or extends at least along three sides, and preferably along four sides of the hood.

Optionally the deflector shape is recessed in the hood and optionally positioned as far as possible to the edge of the hood to enlarge the effective envelope of the hood.

In another aspect the present invention may be said to comprise an extractor unit for reducing cross flow comprising: at least one fan for creating: an extraction airflow, and an extractor duct for the extraction airflow for extracting waste gases from a region, a hood coupled to the duct, an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct, and one or more sensors or other means positioned at a suitable location to determine the existence, magnitude and/or direction of cross-flow, wherein the extractor unit is configured so that the air curtain exit velocity/flow rate through different parts of the air curtain slot are controlled to create airflows to counteract/compensate for the cross-flow.

In another aspect the present invention may be said to comprise an extractor unit for reducing cross flow comprising: at least one fan for creating: an extraction airflow, and air curtain airflow, an extractor duct for the extraction airflow for extracting waste gases from a region, a hood coupled to the duct, an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct, wherein the extractor unit is configured to control the extraction airflow and/or air curtain airflow to maintain balance in air flow or at least reduce imbalance in air flow.

Optionally the imbalance in air flow is cross-flow due to environmental and/or operational factors, and to maintain balance in air flow or at least reduce imbalance in air flow comprises eliminating cross-flow or at least reducing cross-flow.

Optionally the extractor unit is configured to determine, and/or configured with information of, the existence, magnitude, and/or direction of cross-flow.

Optionally to eliminate cross-flow or at least reduce cross-flow the extractor unit is configured so that the air curtain exit velocity/flow rate through different parts of an air curtain outlet are controlled to create airflows to counteract/compensate for the cross-flow.

Optionally the extractor unit further comprises one or more sensors or other means positioned at a suitable location to and/or a controller determine the existence, magnitude and/or direction of cross-flow.

Optionally the one or more sensors or other means are one or more of:

- flow sensor
- camera
- cooktop sensor to sense operation of the cook top
- movement sensor
- smoke sensor
- IR sensor

Optionally the extractor unit further comprises a controller configured with information of the existence, magnitude and/or direction of cross-flow.

Optionally the extraction unit further comprises a user interface to enter the information; optionally where the information could be one or more of: existence, magnitude and/or direction of cross-flow, and/or information from which existence, magnitude and/or direction of cross-flow can be determined.

Optionally balance or imbalance of air flow is static or dynamic, and determination and/or information of the balance or imbalance of airflow is:

- generated once, e.g. during calibration
- dynamically throughout operation of the extractor unit.

In another aspect the present invention may be said to comprise an extractor unit comprising: at least one fan for creating: an extraction airflow, and an air curtain airflow, an extractor duct for the extraction airflow for extracting waste gases from a region, a hood coupled to the duct for receiving the air curtain airflow from the fan and expelling an air curtain to envelop the region, and an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct wherein the hood has a plenum and slotted outlet at least partially around the perimeter of the hood for expelling the air curtain, and a deflector on proximate the slotted outlet to direct the air curtain.

In another aspect the present invention may be said to comprise an extractor unit comprising: at least one fan for creating: an extraction airflow, and an extractor duct for the extraction airflow for extracting waste gases from a region, a hood coupled to the duct with a deflector, and an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct.

It is intended that reference to a range of numbers disclosed herein (for example, 1 to 10) also incorporates reference to all rational numbers within that range (for example, 1, 1.1, 2, 3, 3.9, 4, 5, 6, 6.5, 7, 8, 9 and 10) and also any range of rational numbers within that range (for example, 2 to 8, 1.5 to 5.5 and 3.1 to 4.7).

The term "comprising" as used in this specification means "consisting at least in part of". Related terms such as "comprise" and "comprised" are to be interpreted in the same manner.

This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

Brief description of the drawings

Embodiments will be described, of which:

Figure 1 shows in generic form a cooktop and range hood as described.
Figures 2A and 2B show various views of the range hood of a first embodiment, including internal components and circulating currents.
Figure 3A shows a perspective view of the assembled range hood with an air curtain.
Figure 3B shows various perspective views of the assembled range hood.
Figure 4 shows how various combinations of flow rates of air curtains and extraction airflows can contain and/or extract steam and an enveloped region.

Figure 5A shows a partial cutaway of the hood showing the plenum, air curtain slot and deflector; and a second view of the air curtain fan.

Figure 5B shows a top view of the hood disassembled from the range hood.

Figure 5C shows a variation of the nozzle of the hood/plenum.

Figure 6 shows the aerofoil and filter within the aerofoil.

Figure 7 shows the air curtain fan and the exhaust fan.

Figure 8 shows a second embodiment of the range hood without the aerofoil.

Figure 9 shows the impact of the range hood on a dwelling air purifier

Figure 10 shows a lateral turbulent flow of waste gases that is not contained by a traditional air curtain, and in contrast a present embodiment with a deflector that redirects and contains turbulent flow.

Figure 11 shows an air curtain flow rate to extraction air flow flow rate ratios and their efficacy for containing particles in the enveloped region.

Figure 12 shows the containment of grease with two prior art air curtains (T and Haier) and the air curtain of the present embodiments.

Figure 13 shows containment of CO2 and CO of one prior art air curtain (T8) and an air curtain according to the present embodiments.

Figure 14 shows the exit profile velocity along the slot for various configurations of plenums.

Figure 15 shows a dual chamber arrangement with a baffle, apertures and a movable plate to control aperture opening.

Figure 16 shows experimental data indicating extraction efficacy.

Figure 17 shows an elevation view of a range hood over a cooktop, and an underside plan view of the range hood indicating lateral cross-flow.

Figure 18 shows a further embodiment comprising a plenum with an internal deflector.

Figures 19A, 19B show a first variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.

Figures 20 show a second variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.

Figures 21A, 21B shows a third variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.

Figure 22 shows various air curtain flow rates.

Figures 23A, 23B show a fourth variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.

Figures 24A, 24B show a fifth variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.

Figures 25A, 25B, 25C show a sixth variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.
Figures 26A, 26B, 26C show a seventh variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.
Figures 27A, 27B, show an eighth variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.
Figures 28A, 28B, 28C show a ninth variation of a plenum, with respective air curtain exit velocity profile and internal air flow in the plenum.

Detailed description of embodiments

Overview

Figure 1 shows in diagrammatic form the context of the present invention and one general embodiment. It is a waste gases extractor unit (often termed "extractor fan" or "rangehood", and herein will be referred to "extractor unit") for extracting waste gases 11 from a cooking region 12 over a cooktop 13. Waste gases 11 will typically be steam, often carrying particles, smells, grease, CO_2, CO, NO_x and other matter from cooking/gases, but this is not the limit of possible waste gases that may exist during use of a cooking top, nor limit the possible waste gases that the extractor unit could extract. The present embodiments described provide for improved waste gases extraction from the cooking region. This can be measured in terms of the particle count outside the cooking region, for example. Improving waste gases extraction (reducing the particle count outside the cooking region) can be achieved by a combination of providing and controlling extraction airflow to remove waste gases that result in particles that might otherwise leak out beyond the cooking region, and/or providing and controlling an air curtain flow for assisting in containing the waste gases (and therefore particles) within the cooking region so that they do not leak out until extracted by the extraction flow. Other structural aspects of the present embodiments described can also assist with improving extraction/reducing the particle count outside the cooking region. Generally improved waste gases extraction from the cooking region can be termed "extraction efficacy", which can be measured in terms of particle count outside the cooking region - the lower the particle count, the better the extraction efficacy. Improved extraction efficacy can be achieved through a range of techniques described herein, which improve the actual extraction of waste gases (and therefore reduction of particles), and/or the containment of waste gases (and therefore particles) within the cooking region.

Extractor units can take the form of T-shaped, S-shaped and L-shaped. Embodiments of the present invention are described herein with reference to a T-shaped extractor units for exemplary purposes, but they can equally be applied to other types of range hood is also. Reference only to T-shaped extractor units herein and should not be considered limiting to the extent of which the embodiments described could be applied.

In general terms, the extractor unit 10 comprises an extractor duct housing (chimney) 7 comprising an extractor duct (e.g. see embodiment Figure 2) 14 with an outlet 28 (e.g. see embodiment Figure 2) to ambient for outgoing exhaust (extraction) airflow and an inlet 25 (e.g. see embodiment Figure 2) above the cooking region for receiving airflow 15 for extracting waste gases 11 from the cooking region 12. A cooking region hood ("canopy") 16 is provided that comprises a plenum/air chamber 50 (e.g. see embodiment Figure 5A, and also in more detail in Figure 19A and various alternatives in Figures 20A to 28C) in an outer housing. The hood is coupled to and around the extractor duct 14 for providing an air curtain 17 (e.g. see Figure 3A) to the cooking region. Also provided is an (optional) aerofoiled inlet 18 for receiving waste gases 11 and for creating convection currents 19 above the cooking region 12 in the outgoing extraction airflow 15/waste gases 11 to improve extraction and containment efficacy. The aerofoiled inlet 18 has one or more aerofoil ducts 20, that physically couple the aerofoiled inlet 18 to the hood 16 and/or duct 14, and also pneumatically couple aerofoil inlets (e.g. see embodiment Figure 6) to the extractor duct inlet 25. An exhaust fan 21 for creating the outgoing extraction airflow 22 is provided, along with an air curtain fan 23 for providing an air curtain airflow 17 for the air curtain through the plenum. Preferably, the exhaust fan 21 and air curtain fan 23 are provided in a housing 7 around the extractor duct 14, but this is not essential. They could be placed elsewhere.

The extractor unit 10 can have a control panel and/or a graphical user interface. The extractor unit has a controller 9 for controlling the exhaust fan and the air curtain fan and any other operations of the hood.

When installed, the hood 16 and aerofoiled inlet 18 will be provided above the cooking region 12, and the extractor duct 14 will be coupled to an outlet (exhaust) of the kitchen to expel waste gases. Reference to waste gases herein also refer to any particulate matter also, such as any that is carried in the waste gases.

First possible embodiment – with aerofoil

A possible embodiment will now be described with reference to Figures 2A to 7. This embodiment should not be considered limiting, and those skilled in the art will appreciate that variations are possible. Reference numerals already used in relation to the general embodiment will usually be used in relation to this embodiment, without any limitation on this embodiment or lack of generalisation of the first embodiment being intended.

The general form of the extractor unit 10 can be seen in Figures 2b, 3A, 3B. Further internal detail is shown in the cross-section front and side elevations of Figure 2A. The extractor unit 10 has an extractor duct 14 with an external duct housing 7. The housing 7 preferably has a longitudinal (and preferably vertical when installed) rectangular (which can include square) cross-section and is formed from stainless steel or other metal or other suitable material. Other cross-section shapes of the duct are possible.

Referring to Figure 2A, 2B, the extractor duct 14 comprises at one end an outlet 28 that is coupled to the exhaust of the kitchen for expelling waste gases 22 to ambient. At another "cooking region" end 24 end, the extractor duct is coupled to a scroll 14A, which has an inlet 25 positioned above in the vicinity of the cooking region 12 (enveloped region) for receiving waste gases 11 from the cooking region 12. The scroll can be considered as part of the extractor duct. The extractor duct 14 also comprises a second outlet 26 at the cooking region end 24 for coupling to an air curtain chamber (plenum) 50 to be described later. As well as providing part of the extractor duct 14, the scroll 14A forms a sub-housing in the extractor duct. The sub-housing 14A provides a chamber that houses an exhaust (extractor) fan 21. The exhaust fan 21 creates a negative pressure flow (extraction airflow) from the inlet 25 of the extractor duct/scroll to the outlet 28 of the extractor duct 14 to suck waste gases 11 from the cooking region 12. The exhaust fan 21 will be described in further detail with respect to Figure 7 later. The extractor duct 14 also houses an air curtain fan 23 for providing a positive air flow (air curtain airflow) 17 from the housing 7 to a hood 16 and beyond to the cooking region 12. The scroll provides a sub-housing wall 14B inside the extractor duct 14 which separates the exhaust fan 21 and extraction airflow 15 from air curtain fan 23 and air curtain airflow 17.

The extractor unit 10 has a cooking region hood 16 which is coupled to or integrated with the extractor duct 14, and when installed is suspended therefrom and extends (preferably horizontally) above the cooking region (T-shaped extractor unit). The hood 16 has an outer housing 52 (see Figure 5B) which is U-shaped and is preferably generally rectangular in shape and comprises a central gap 54 (see Figure 5B). The U-shaped housing 52 comprises an air chamber (plenum) 50. The plenum 50 has an inlet 53 coupled to the cooking region end 24/second outlet 26 of the extractor duct. The sub-housing/scroll 14A of the main extractor duct 14 extends partially out of the housing 7. The U-shaped housing 52 is coupled in a manner to the extractor duct such that the housing 52 itself connects to and sits underneath the main extractor duct 14 (so that the inlet 53 on the hood couples to the air curtain fan 23) and the central region 54 of the "U" sits around the extending portion of the scroll 14A. In this manner the scroll and the waste gases inlet 15 therein extends through the central region/U-shaped region 54. The plenum 50/housing 52 has an air curtain outlet 51 for directing an air curtain to the cooking region 12. The plenum will be described in further detail with respect to Figure 5A, 5B**.** The arrangement means that the waste gases/extraction airflow 15 is pneumatically separated from the air curtain airflow 17.

As can be seen in Figure 6, the extractor unit 10 comprises an aerofoiled inlet 18, which is coupled to and suspended from the cooking region hood 16 and suspends above the cooking region 12. The aerofoiled inlet 18 has a three-sided U-shaped configuration, with three sections 18A, 18B, 18C and a central region 64. Each section combines to provide a contiguous an inlet 63 for receiving waste gases 11 from the cooking region 12. Each section 18A, 18B, 18C is pneumatically coupled to outlet of the extractor duct (and in particular scroll 14A of the extractor duct) so that the negative pressure extraction airflow created by the exhaust fan 21 (and therefore waste gases 11 from the cooking region) can pass from the cooking region 12 through the aerofoil inlet 18 into the extractor duct 14 via the inlet 25. Each section 18A, 18B, 18C is pneumatically coupled to the inlet 25 by way of aerofoil ducts 62A, 62B, 62C. These aerofoil ducts also physically couple the aerofoiled inlet 18 the hood 16 and extractor duct, via for example a frame that inserts into the central U gap 54 in the hood. The aerofoiled inlet 18 will be described in more detail with respect to Figure 6 later.

In use, the extractor unit 10 is installed above a cooking region 12 and the outlet of the extractor duct is coupled to an exhaust duct/outlet 28 or similar of the kitchen so that waste gases 11 can pass to ambient 28. The air curtain fan 23 is operated to provide the curtain of air 17 (see Figure 3A) downwards to surround the cooking region 12, thus containing waste gases 11 within the region. Further, the exhaust fan

21 is operated to create a negative pressure extraction flow of air 15 from the cooking region 12 through the aerofoiled inlet 18 through into the aerofoil duct 18A, 18B, 18C and then into the extractor duct 14 an out the outlet 28 to ambient. In addition, in a manner to be described further later, the aerofoiled inlet 18 creates three-dimensional convection currents 19 in the airflow created by the air curtain 17 and the extraction flow 15.

Looking at the side elevation in Figure 2A, the air curtain 17 is directed down by the plenum 50, nozzle 51 and deflector 57, but also by the aerodynamics created by the aerofoiled inlet 18 that sucks the air curtain flow inwards and to the back of the cooking region up through the central region 64 of the U shaped aerofoiled inlet towards the back wall and back down again in a circular convection pattern 19. Eventually, that airflow which carries waste gases 11 make its way into the inlet 63 of the aerofoiled inlet 18. Likewise, looking at the front elevation of Figure 2, the air curtain 17 is directed on both lateral sides of the cooking region 12 downwards by the plenum 50 but by the aerodynamics of the aerofoiled inlet 18 is then sucked inwards to the centre and around to the centre of the cooking region 12 up towards the central region 64 of the aerofoil inlet through and around and back down again in a circular convection pattern 19. This convection pattern 19 helps retain the air curtain 17 in place to contain/envelop the cooking region 12 ("enveloped region") to prevent release of or at least reduce the escape of waste gases 11 out the sides/front of the cooking region. The waste gases 11 are retained in the cooking region 12 until they are extracted 15 through the extractor unit 14. The air curtain also:

- encourages air circulation within air curtain enclosed volume,
- moves extraction point to centre of air volume,
- improves curtain stability at higher extraction rates,
- powered height adjustment of foil.

Figure 4 shows various tests indicating how the air curtain contains waste gases. The top left-hand Figure shows the containment of the enveloped region of steam with just the air curtain operating. The top right-hand Figure shows containment and extraction of steam with a low-speed air curtain and a low-speed extraction (low air curtain flow rate and low extraction airflow flow rate). The bottom left-hand Figure shows containment and extraction of steam with a high-speed air curtain and high-speed extraction airflow. The bottom right-hand Figure high extraction airflow flow rate and with no air curtain. Various components of the extractor duct will now be described in more detail.

Hood (canopy) and plenum

Figure 5A shows a side elevation cross-section view of part of the hood (also called a "canopy") 16 showing the plenum 50 and Figure 5B shows the hood. The plenum comprises an air chamber formed in the housing 52 of the cooking region hood 16. The plenum is large enough volume to dissipate turbulence created by the air curtain fan pushing air into it. The plenum 50 receives the flow of air 17 from the air curtain fan 23 via the opening 53 and directs this through an air curtain outlet 51. The air curtain outlet 51 is formed as a thin slot (slotted outlet) 55 around the perimeter of the hood/plenum, which has lips 56 formed on either side to form an elongated nozzle 51 (which is shown in more detail in the inset). Preferably, the slot 55 extends round three sides of the hood 16 (front and sides) and partially bends round to extend a little past the back corner of each side and into the back side of the hood (see circled region 55A, 55B of Figure 2A). But the slot could instead extend around all sides of the hood, or just partially around, such as three sides, two sides or just one side, or even partially around one or more sides. Preferably, the corners of the slot are curved.

Generating a laminar flow that is constant over the entire slot is preferably. A non-uniform flow along the slot will cause uneven pressure/flows laterally and cause turbulent air flow which is undesirable. Various alternative plenum configurations and their air curtain flow profiles will be described later. The nozzle directs the air downwards around the perimeter of the cooking region to create the air curtain 17. Preferably, the slot is continuous by means of the plenum at the front of the hood 16, and in addition preferably there is a curved slot 55A that bends back round at the back ends of the hood 16. Tests has shown that in particular at the sides of the hood, in the corner against the back wall there is most leakage of cooking smoke. This is due to convection by the heat sources. So, the dedicated shape slot towards the back to prevent smoke escaping in the back corners is preferable. Other non-limiting features of the slot can comprise in a non-limiting implement of the embodiment:

- 15° angle,
- 2.5mm slot width,
- large radius between sides,
- 45° tucked in sections at rear to seal curtain to back wall,
  high volume plenum for more laminar curtain.

In a variation as shown in Figure 5C, the deflector 57A can be formed integrally with the nozzle. as shown in figure 5C,

- w is the width of the nozzle

- θ is the angle of the nozzle/deflector relative to a vertical plane through the front of the plenum
- L_D is the length of the deflector plate
- Ls is the effective length of the air curtain
- H is the vertical height of the deflector

Other variations are possible also.

The nozzle 51 can be configured to optimise laminar flow - this can include the length and angle of the lips, and the width of the slot. For example, the lips 56 of the nozzle 51 are long enough to create a stable laminar curtain of air 17 but not so long as to induce a greater pressure drop. In one possibility (non-limiting), the lips 51 have e.g. a 15° angle and 2.5mm slot width. Alternatively, an adaptive nozzle could be provided. Such an adaptive nozzle could be a rubber/flexible strip that open/close is depending on the amount of air flow. Alternatively, the angle of the lips increases or reduces the opening of the slot under influence of the controller.

The plenum also contributes to the laminar flow that is constant across the entire slot 55. A non-uniform flow along the slot will cause uneven pressure/flow is laterally and compromise the airflow curtain.

A deflector ("canopy flange") 57 can be provided proximate the slot to redirect the recirculating air 19 so it can rejoin new airflow 17 provided in the air curtain. Again, the length and angle of the deflector can be configured to optimise aerodynamics. The deflector improves curtain stability at higher extraction rates. Preferably the deflector extends around at least three sides of the hood 16 (front and sides) adjacent the internal perimeter of the slot and partially bends round to extend a little past the back corner of each side and into the back (fourth) side of the hood (see 57A, 57B Figure 2A). Preferably the corners of the deflector are curved. Preferably the deflector plate is flush (or at least as close as possible) to the back wall to minimise leakage. Furthermore, the deflector is angled and/or curved in cross-section so that it starts at the hood adjacent the internal perimeter of the slot, but ends at least partially over/covering the slot – that is sitting between the slot and the cooktop. This helps direct the air curtain and/or lateral flow to be described later. The slot and the deflector also bend around partially or completely (or could even go around all four sides) towards the back of the hood (57A, 57B of Figure 2A) as previously described. This helps mitigate leakage of waste gases from the enveloped region. The hot air of waste gases from a cooking region can create turbulence, which makes it more difficult to contain the waste gases in the enveloped region using an air curtain.

In prior art range hoods, the turbulent waste gases (from convection and/or turbulent airflows) cause lateral flow outwards 100 (see Figure 10) at the top near the air curtain slot 55 that an expelled air curtain cannot keep up with, thus leading to leakage from the enveloped region. Conventional thinking among those skilled in the art is that most of the leakage of hot waste gases occurs through the front of the range hood/enveloped region. However, the present inventors have found that most (or at least non-trivial volumes/flows) of the hot waste gases in prior art range hoods can escape to the left and right from the range hood at the top near the air curtain slot/exit close to the back wall. The curved slot 55 and deflector 57 improves performance of the air curtain 17 so there is better containment on these back corner regions up near the slot 55. The deflector helps redirect the remaining lateral flow 100 in the correct direction. The flow can be turbulent, and it can for example be directed downwards by the deflector. The size, shape, angle and positioning of the deflector 57 can be arranged to optimise the redirection of flow of the lateral gases within the air curtain 17 to keep them contained until they are extracted. The air curtain 17 flow rate and extractor airflow 15 flow rate can also be modified such that the ratio between them optimises the interaction between the air curtain 17, extractor airflow 15 and the waste gases 11 to optimise extraction.

An air bleed path 58 is provided in the hood 18 underneath the plenum 50. As extraction is increased, the pressure inside the air curtain 17 drops. Provision of an air bleed path 58 acts to support the inward force on the curtain 17 during these conditions. The bleed path 58 brings in additional new clean air to support curtain when extraction is high and air volume inside the curtain area is at a lower pressure. The bleed path improves curtain stability at higher extraction rates.

A sensor can be provided that detects a user crossing the air curtain 17 and the controller can be configured to modify behavior accordingly. For example, it could stop the air curtain 17 in a localized location. For example, the air curtain could take over the function of an air conditioner or air purifier, and work independently even if there is no cooking happening. The air can be cleaned/filtered/cooled air. Filtering would be used so that the exhausted air from cooking could be re-used and re-purposed for cooling etc. In this way less, air is extracted from the room. This is preferably over other method as it’s not desired in most cases to have a lot of extraction from the room, because the make-up air from outside is likely to be dirty in big, polluted and/or industrial cities.

Filters could be provided to treat the air flowing out of the air curtain 17. Ionisation other filtration could be provided. The air could be temperature controlled.

Variations of the plenum and deflector are described later.

Aerofoiled inlet

The aerofoiled inlet 18 is shown in more detail in Figure 6.

The aerofoil inlet 18 led comprises a U-shaped housing 65 that is suspended underneath the cooking region hood 16. The U-shaped housing comprises a bottom portion 66 with a vertical wall 66A perimeter and a lip 66B that runs around the bottom of the wall 66A. A U -shaped oil and grease labyrinth filter 67, which is commensurate with the shape of the housing 65, is disposed on the lip 66B. The perimeter wall 66A and lip 66B defined a U-shaped opening 63 which is the inlet for the aerofoil 18 for receiving waste gases 11 from the cooking region 12. The labyrinth filter 67 comprises a plurality of curved cross-section elongated extrusions 67A that are arranged along the filter alternately and overlapping upwards and downwards with convex/concave orientations in a side-by-side manner so that they overlap. Extraction airflow "A"/15 that comes in through the inlet 63 will pass through the filter 67 and flow through the labyrinth/serpentine channels. Waste is collected by the curved extrusions 67A, thus extracting the waste from the airflow 15. The arrangement extracts grease et etc. while minimising pressure drop. The filter 67 can have wedge shaped side walls 67B so that waste grease and the like can flow down was through the curved extrusions 67A into a collection tray 66C. The collection tray 66C can couple to the bottom portion of the U-shaped housing 66 and is removable and washable.

The aerofoil inlet housing 65 has an upper portion 62. Aerofoil ducts 62A, 62B, 62C on top of the aerofoil inlet in this embodiment are integrally formed with the upper portion. The aerofoil upper portion top surface 62D has an aerofoil curved shape, shown in further detail in Figure 6. As can be seen the aerofoil shaped top redirects airflow 19 sucked up from the central region 64 of the aerofoiled inlet 18 and redirects it back downwards so that it re-joins the air curtain 17. Some of the air 15 will continue up into the outlet for extraction out through the extractor duct. The aerofoil shaped top surface extends into aerofoil ducts, one for each section of the aerofoil which are coupled to the inlet and the extractor duct.

Exhaust fan and air curtain fan

The exhaust fan 21 is shown in more detail in Figure 7. The exhaust fan 21 comprises a moulded inlet duct 71 for coupling to the aerofoil ducts 62A, 62B, 62C. The exhaust fan 21 comprises a motor 72 (e.g. and induction or brushless DC motor) with an impeller 74 sitting in a volute 73 connected to the moulded inlet duct 71. The motor is controlled to spin at the desired RPM to create a negative pressure extraction airflow 22 from the cooking region 12 through to the outlet of the extractor duct 14. In this specification, the extraction airflow 22 is specified as m^3/min, a volume per time (rather than as a velocity, although it could be measured as a velocity also).

Similarly, the air curtain fan 23 comprises a moulded outlet duct 76 for coupling to the inlet 53 on the top of the hood 16. The air curtain fan 23 comprises a motor 76 (e.g. an inductor or brushless DC motor) with an impeller 79 sitting in a volute 78 connected to the moulded outlet duct 76. The motor is controlled to spin at the desired RPM to create a positive pressure and airflow from the extractor duct to the cooking region 12 through to the outlet 51 of the air curtain. The air curtain flow ("curtain airflow") can be specified by two parameters:

- air velocity exiting the slot in m/s, and
- flow rate (also termed "volume air flow" or "air volume per time period") exiting the slot in m^3/min

The flow rate and the velocity of the air curtain flow can be controlled to optimise or at least improve extraction efficacy. It can be possible to increase extraction flow rate, which might lead to increased extraction of waste gases; however, this can also interfere with the air curtain, which might lead to reduced waste gases containment and lower overall extraction efficacy (that is, the particle count is higher than desired). Therefore, the relationship between air curtain flow and the extraction flow are configured to improve the outcome. For example, each can be controlled to fall within a certain range, and/or the ratio between them will be controlled for within a certain range. Preferably flow rate is below a preferred value, while the velocity is above a preferred value. The relationship between these values and the extraction airflow might fall between preferred ratios or other measures also. When referring to air velocity, it is the air velocity measured at a particular distance from the slot. This is because, as you move away from/closer to the slot, the air velocity will change.

Therefore, any reference to air velocity will be with respect to a distance at which it is measured, and the relationship of, or ratio of air velocity to some other parameter (including another airflow) and the values and/or ranges that those measurements, ratios or relationships fall within, are defined with respect to measurement of air velocity at a particular distance. Unless otherwise stated, herein the measurement distance is 57 mm, but that is by way of example only and is not limiting. The air velocity can be measured at any suitable point and controlled to reach a value at that point to achieve the required outcomes.

There are other alternatives for arranging the exhaust fan 21 and air curtain fan 23. The air curtain fan motor could be replaced with belt pulley coupled to the exhaust fan motor. This would reduce cost but would remove some control flexibility.

Other possibilities also comprise:

- 2 blowers, 1 motor: Direct drive blowers from a single motor
- 2 blowers, 1 motor: Pulley drive to achieve a speed reduction
- 2 blowers, 1 motor: 'turbo' style system and use outlet air to drive turbine
- 1 blower, 1 motor: Redirect some outlet airflow through filter which becomes air curtain
- 1 blower, 1 motor: Split the blower into 2 sections, one segment extracts, one pressurizes air curtain
- Primary motor, initially drives just extraction unit, but has the power to drive both. Single motor gives motor cost reduction but also control hardware and software simplicity
- Single motor for pressurizing plenum (air curtain fan) and extraction fan could be by way of supercharger/turbocharger, turbine/belt driven.
- There could be smart motor control, to give constant flow option or calibrate to installation environment.

Control UI

The extractor unit can have a control Panel and/or a graphical user interface. The extractor unit has a controller for controlling the exhaust fan and the air curtain fan and any other operations of the hood.

Second possible embodiment - without the aerofoil

In an alternative embodiment, the aerofoil inlet 18 is omitted. This provides a direct suction from an opening in the plenum. In this case the deflector provides the required air flow aerodynamics. This can be combined with any of the aspects of the other rangehood embodiments.

For this embodiment, as an example, and without limitation, the air curtain motor is controlled to spin such that the flow rate of the airflow of the curtain is about 6-12% (in m^3/min) (preferably about 9%) of that of the flow rate of extraction airflow (in m3/min). This is a preferred percentage, and those skilled in the art will all appreciate that other ratios between the two flow rates are possible. However, it has been determined that for efficacy it is desirable that is does not vary more than a few percent, although it can vary from system to system. Therefore, some preferred ratios between the air curtain flow rate and the exhaust air flow flow rate could be between 2% and 18%, more preferred of between about 4% and about 15%, and more preferred between about 6% and about 12%. This will be described later with reference to further examples. Another metric to be used to describe the optimal air curtain flow, is the air velocity (in m/s). Measured at 57mm from the slot, tests show that the minimum required air velocity is about 1.1 m/s, and maximum air velocity is about 2 m/s (measured at 57mm distance from the nozzle exit). This translates to about 2m/s and about 4m/s at the nozzle exit. Below about 1.1 m/s the air curtain speed is not sufficient to capture smoke escaping, above about 2 m/s the air curtain causes a turbulent air stream. As a percentage of extraction rate, the air curtain velocity (in m/s) should be in between about 12%-17% of the extraction flow rate (in m3/min). Or between about 10-20%, or about 5-25%.

Third possible embodiment – baffle and second chamber in plenum

In an alternative embodiment, there is a baffle and/or second chamber provided in the plenum, as will be explained further below. This can be combined with any of the aspects of the other rangehood embodiments. This can provide more uniform or tuned exit velocity distribution, which can provide for improved containment of waste gases, itself improving the extraction efficacy. A baffle can take any suitable form to separate regions and/or separate/divert air flow. For example, a baffle might take the form of a plate, optionally with openings. Such a plate might be movable and/or the openings can be increased or decreased in size through manual, mechanical and/or automatic means.

The air curtain flow (flow rate and/or velocity) can vary between different points of the slots. For example, referring to air curtain flow velocity out the slot ("exit velocity") as measured at 57mm, this can vary along the slot 55. This results in an exit velocity profile along the slot, which can be seen in Figure 14. Referring to Figure 14, air curtain flow exit velocity of a first prototype P1 (which has a plenum variation #1 as described below) varies between about ~ 1.1 m/s and about 1.6 m/s. A second plenum prototype P2 (which has a plenum variation #4 as described below and is smaller in volume) varies along the slot with peaks and troughs between about 1 m/s at point 3, to about 2m/s at point 5 and back to another trough at point 7 at about 1.25m/s. When P2 is equipped with a baffle, the variation significantly reduces: the minimum speed is about 1.5 m/s (instead of about 1m/s without baffle) and maximum speed is about 1.9 m/s (instead of about 2.1 m/s).

The present inventors determined that containment of waste gases within the cooking region can be worse (that is, leakage of waste gases from the containment region is worse) if the air curtain flow (e.g. exit velocity) varies along the slot. On the flipside, if the air curtain exit velocity along the slot can be kept constant, or at least the variability is reduced along the slot, this can improve containment of waste gases within the cooking region (that is, reduce leakage of waste gases from the containment region). Therefore, controlling the air curtain flow exit velocity along the slot so that it is less variable (that is, exit velocity profile is a constant as possible) is desirable for improving containment of waste gases (or reducing waste gases leakage). As a good starting point, a uniform exit velocity is best to create a balanced system, without significant variations. Uniform air velocity is preferred to have a symmetric and uniform airflow. Non-uniform air flow tends to cause imbalance. Air curtain flow exit velocity preferably is not below about 1 m/s, and not above 2 m/s on average. Again as starting point, using a plenum/baffle that gives uniformity/symmetry is preferred. Improvement could be achieved with certain profiles, which can also be achieved by the baffle/pre/post chamber approach, or even a dynamically adjusting system.

Without a baffle, the air curtain air enters the plenum from one position - for example from the top from the air curtain fan outlet 26 as shown in Figure 5A. A baffle in the plenum locally blocks air flow at the point where air flow would be too high – this somewhat equalizes the flow and therefore somewhat equalizes air curtain exit velocity variance, or at least reduces exit velocity variability.

Referring to Figure 15, to create a uniform (constant) air velocity along the slot (or at least to reduce the air velocity variance along the slot) in a further improvement the plenum 52 is provided with two chambers 52A, 52B separated by a baffle. Figure 15 shows a possible arrangement in diagrammatic form. The plenum comprises a baffle with an opening 151 that separates the plenum into a pre-chamber 52A and post chamber 52B. The inlet 53 of the plenum 52 goes into a pre-chamber 52A so that inlet air first enters the pre-chamber, and then that air passes through the opening 151 in the baffle 150 into the post-chamber 52B. The air then exits out through the nozzle from the post-chamber as the air curtain 17.

The pre-chamber 52A in the plenum 52 is pressurised as the inlet air accumulates in the pre-chamber 52. That air flows 152 through to the post-chamber 52B that guides the air to the slot 55/nozzle 57. The baffle provides a wall/obstruction that can distribute the flow/pressure from pre-to post-chamber by configuring the opening size – this could be fixed or variable. Air flow simulations show that the air curtain exit velocity distribution/profile along the slot becomes more constant as plenum size increases. So, preferably the plenum is as big as possible. Clearly, practical considerations for the appliance have to be considered when designing the size of the plenum.

The arrangement of Figure 15 with pre and post- chambers 52A/52B separated by a baffle 151 provides extraction efficacy as per below and with reference to Figure 16

- At 12m^3/min extraction and 600RPM AC (with good results between 600-800RPM). This corresponds to:
    - Air curtain volume flow rates of between 0.9 to 1.4 m^3/min along the slot, and
    - Air curtain exit velocities of between 1.5 – 2 m/s, along the slot

In general, the baffle 150 can have an opening(s) of any shape or size that are suitable. The opening could be fixed size and/or shape, but it might also be adjustable to help configure and improve the air curtain exit velocity profile along the slot. In one option as shown in Figure 15, there could be a range of openings of different sizes, and a plate could move left and right and/or up-and-down to cover one or more of the holes, either partially or completely. By controlling the coverage of the holes, the aerodynamics and the plenum can be controlled to get the desired profile of air velocity across the slot. In a variation there could be more than one plate, such as 2 plates with half circles that move left/right. In another embodiment, the openings themselves could open and close The opening(s) 151 and/or plate(s) could be altered by mechanical movements during operation, either manually or by a controller. Or, the plate/openings could be fixed. The controllable plates and/or openings could also be changed in real time, to change the airflow velocity distribution over time - this might be useful for controlling e.g. crossflow, as will be mentioned later.

Variations of baffles and chambers configured to provide a desired exit velocity profile are described later.

It is also possible that having an air curtain flow velocity that varies across the slot, but configured in a particular manner, could provide a better waste gases containment outcome. In that case, the baffle might be arranged to achieve this preferred air velocity profile. While such a velocity profile might not be constant, because it is configured in a particular manner (as opposed to being a profile that is simply an artefact of aerodynamics that have not been controlled in a particular manner), it can provide an improved outcome.

Therefore, in a more general case, the velocity profile across the slot is controlled to provide a preferred velocity profile that optimises, or at least improves the containment of waste gases.

Operation of Rangehood according to embodiments described

Overview

Operation of the extraction unit 10 will now be described. Control embodiments described herein can incorporated into any of the extraction unit embodiments described herein.

The controller 9 is coupled to the air curtain fan 23 and the exhaust fan 21, and is configured to operate those vans with flow rate/velocities and extraction rates in accordance with embodiments described herein.

Conventionally, designers of range hoods attempted to maximise the extraction airflow 15 flow rate, on the basis that this improves extraction of waste gases and reduces leakage of waste gases (from the enveloped region). However, this design philosophy was misguided. First, simply increasing the extraction airflow flow rate does not necessarily lead to increased extraction of waste gases and reduction of leakage of waste gases (from the envelope region). Also, higher extraction airflow flow rates will suck more clean air from the dwelling in which it is operating, which in big, polluted and/or industrialise cities is not desirable as it puts pressure on the air conditioning and other ventilation systems. Further, higher extraction airflow flow rates and noisier.

The present inventors have found that what is preferable for an optimised outcome is to have the minimum extraction airflow flow rate required to achieve the desired waste gas flow extraction/minimised leakage. To assist with this, they have made observations which lead to the features of the present embodiments.

First, they note that the heat generated on a cooking region during operation actually creates turbulence, which then makes extraction of waste gases much more difficult. It has become apparent to the inventors that there is a lateral flow 100 of (waste gases) air from the centre to the sides of the range hood towards the bottom surface of the range hood/top of the enveloped region. This lateral flow of air 100 can become so vigorous the extraction airflow 15 was insufficient to suck the lateral airflow out, and that a prior art air curtain 17 on its own cannot contain the lateral flow 100, and is insufficient. This can be seen in Figure 10.

The present inventors have determined that the lateral flow leakage can be mitigated by:

- using a deflector 57
- controlling the ratio between the air curtain 17 flow rate and the extraction airflow flow rate 15.

The inventors have found that an air curtain 17 flow rate that is too low will not contain the waste gases 11, but an air curtain 17 flow rate that is too high will not be extracted by the extraction airflow 15 rate due to turbulence and volume of air. Therefore, they have determined that the arrangement between the deflector 57, the slot 55, and the ratio between the air curtain 17 flow rate and extraction airflow 15 flow rate helps improve/optimise the following outcomes:

- sufficient extraction 15 so that there is mitigated leakage of waste gases
- noises kept to an acceptable level
- reducing the level of air extracted from the dwelling.

First control embodiment – extraction rate, and air curtain exit velocity and flow rate control

In one control embodiment, which can form part of/ be implemented any of the extractor unit embodiments described herein, the controller 9 is configured to control the extraction fan 23 and air curtain fan 21 to operate within certain parameters, as described below. These control parameters have been determined to produce a desirable extraction efficacy.

The parameters that form part of the control embodiment are as follows:

- Extraction flow rate: This is the extraction rate (air flow rate) 22 of waste gases in m^3/min.
- Exit velocity: This is the velocity of the air curtain as it exits the slot 55 in m/s
- Exit flow rate: This is the flow rate of the air curtain as it exits the slot 55 in m^3/min.

The parameter that the embodiments try to improve is the smoke leakage during cooking (or smoke containment) (more generally, extraction efficacy), at an extraction flow rate that is as low as possible in view of noise and power consumption.

To provide an optimum, or at least improved, extraction efficacy, the extraction fan 23 and air curtain fan 21 are controlled so that their operation parameters preferably meet the following criteria. It should be noted that even if operating parameters fall outside the following criteria, good performance can still be achieved. However, the operating parameter criteria below lead to improved or even optimum performance.

- It has been observed that extraction efficacy (that is optimization of extraction flow rate) depends more on the air curtain exit velocity than the air curtain flow rates.
- The air curtain fan 21 is controlled so that the air curtain flow exit velocity to extraction flow rate has a ratio in a desired range. In a possible embodiment, the air curtain velocity (m/s) to extraction rate (m^3/min) ration is between about 12% to about 17%).
- The air curtain fan 21 is controlled so the air curtain exit velocity is between about 1m/s (where the velocity is not enough to contain exhaust) and about 2 m/s (where too much turbulence is created for efficient extraction.
- The distribution in air velocity along the nozzle should be kept to a minimum, but never exceed the minimum of about 1 or max of about 2 m/s. As a guideline, ideally the uniformity should be within about 20%, or even better about 10%

The controller 9 operates the air curtain fan 21 and the extraction fan 23 by controlling voltage/power/current so that they operate at the right speed/RPM and to achieve the desired flow rates.

One possible implementation of this embodiment is now described. As noted earlier, the shape, position size angle and curvature of the deflector 57 and the slot 55 can reduce leakage of the lateral flow and in general the waste gases, as well as the positioning of the slot and the deflector towards the back of the hood. This is achieved by redirecting the air curtain 17, redirecting the lateral flow 100 into the air curtain, and also preventing the lateral flow from exiting the air curtain at the top at right angles. See Figure 10. Also, referring to Figure 11, the ratio of the air curtain flow 17 rate to the extraction airflow 15 flow rate should be optimised to a preferred. The table in Figure 13 shows extraction flow rate of 8.4 m^3 per minute, and varied curtain flow rates and their ratios to the extraction airflow flow rate. The graph on the right shows the level of particle readings by a sensor, which indicates how much particulate matter has escaped from the enveloped region (thus indicating how much leakage has happened of the waste gases from the enveloped region). From the table and graph in Figure 11, it can be seen that an air curtain flow rate to extraction airflow flow rate ratio of about 13% provides the optimise (lowest) particle reading. Of course, other ratios are possible, perhaps less effective but still sufficiently effective. A range of 11% to 15% is acceptable, although even other ranges are possible. What this does show is that in combination with the deflector, the inventors have determined how to optimise at least improve the extraction of waste gases to minimise or improve the level of particles sensed outside the enveloped region.

Figure 12 also shows the particle count (grease particle count) of the embodiments described without an aerofoil compared to two existing units (T8; CXW-219-T892 and Haier Air Curtain; CXW-219-T895U1) at various positions. Figure 13 shows the CO2 and CO leakage data of the embodiments described without an aerofoil compared to the (T8; CXW-219-T892 and Haier Air Curtain; CXW-219-T895U1).

From the test result, the inventors have determined the following.

- Fine tuning the air curtain flow to the extraction flow is important for efficacy.
- The deflector improves the air curtain and extraction.
- It is preferred to have low, but effective suction rather than large sucking out a lot of air: not only for noise reasons but also to prevent the clean air in your room to be exhausted

Fourth possible embodiment – reducing cross-flow

In an alternative embodiment, the extraction unit (including the controller) are configured to reduce the effects of air flow imbalance. This can be due to an imbalance/asymmetry in the extractor unit environment (e.g. due to air conditioning, windows, people moving) or operational factors (e.g. the cooking region has only one hot plate being used creating heat conduction currents). An air flow imbalance could manifest itself as an air flow cross-flow ("cross-flow"), as will be explained further below. This can be combined with any of the aspects of the other embodiments described herein.

A common issue for extraction units is that the extraction efficacy is reduced due to cross-flow. As shown in Figure 17, cross-flow is where there is a net airflow across the cooking region. This can be because of open windows, doors, or some other source of cross-flow (ventilator, blower, air conditioner, human or the cook top itself). Cross-flow disturbs the extraction flow of rangehoods.

In this embodiment, the extraction unit and controller are configured to work together to operate the air curtain airflow 17 to counter cross-flow, or at least to reduce its effects on extraction efficacy. This maintains the balance of air flow (if imbalance has already been eliminated) or to reduce the imbalance. To achieve this, the extraction unit is configured to:

a) determine the balance/imbalance e.g. by sensor or other means (such as flow sensor, camera or the like, optionally in combination with a controller), and/or

b) have information of the balance/imbalance e.g. by the controller being preconfigured with relevant data or other information.

Typically what is determined/preconfigured is the existence, magnitude and/or direction of crossflow. Note, a sensor can be broadly interpreted to mean any suitable device including sensors and cameras.

The controller could be preconfigured with relevant information, or the information could be provided by a user through the user interface. The user could provide the existence, magnitude and/or direction of crossflow; or instead provide information from which this can be determined – e.g. a configuration the environment (such as positioning of windows, air-conditioners etc.), movement of humans and/or configuration and/or use of the cooktop.

The extractor unit is configured to control the extraction airflow and/or air curtain airflow to maintain balance in air flow or at least reduce imbalance in air flow. For example, the air curtain exit velocity/flow rate through different parts of an air curtain outlet (e.g. slot) are controlled to create airflows to counteract/compensate for the cross-flow (or more general reduce imbalance).

In one example, the extractor unit has one or more sensors 101 or other means (such as a flow sensor, camera, cook top sensor, movement sensor, smoke sensor, IR sensor and/or controller) positioned at a suitable location to determine the existence, magnitude and/or direction of cross-flow is also configured so that the air curtain exit velocity/flow rate through different parts of the air curtain slot 55 can be dynamically controlled as required to create airflows to counteract/compensate for the cross-flow. For example, a flow sensor could be positioned at the cooktop to determine flow across the cooktop. A camera or IR sensor could be positioned near the cooktop to image smoke, steam or other gases which may indicate crossflow. A cooktop sensor could be in the cooktop itself to ascertain which hobs are being used. A movement sensor might be placed to monitor the environment to detect movement of humans or other objects in the environment. A smoke sensor could be positioned near the cooktop for example at the sides or front/back to sense smoke, steam or other gas movement from which crossflow can be determined.

Referring to Figure 17, for example, the range hood has a sensor 170 on the hood for detecting direction and magnitude of cross airflow 171, which is coupled to the controller. The air curtain fan 23, plenum 52, and nozzle 51 are designed such that the air curtain airflow 17 can be controlled independently for the left, right side and/or front side. This can be achieved by having two air curtain blowers – 23A, 23b one for left side of the extractor unit and one for right side. The two fans 23A, 23B can be controlled independently, along with optionally an adjustable nozzle 51 that can alter the direction of the air curtain flow 17 and/or the size of the opening of the nozzle so that in combination with the fans 23A/23B, the flow rate/exit velocity and/or direction of the air curtain flow 17 can be controlled separately on the left-hand side and the right-hand side.

So, for example if there is a cross-flow from the left-hand side to the right-hand side detected by the sensor, the air curtain fans 23A/23B can be controlled so that the exit velocity/flow rate of the air curtain on the right-hand side can be greater than that on the left-hand side and/or the direction of the air curtain flow 17 on the right-hand side can be directed towards the left-hand side. This can create a net flow from the right hand side to left hand side in the opposite direction to the cross-flow, to reduce the effects of the cross-flow. Of course, the cross-flow and opposite net flow might happen in the opposite direction – left to right, and the opposite control applies. By creating an imbalance in air curtain flow rate/exit velocity between left and right side, the overall extraction flow can be steered in preferred direction to counter cross flow

It will be appreciated also that the cross-flow may not happen completely laterally from left to right or right to left. Rather, there might also be some front/back cross-flow component (or even an entirely front/back crossflow). As an alternative, a third (or even fourth etc.) air curtain bank could also be provided along with adjustable nozzle to control the air curtain at the front of the hood, to compensate for any crossflow occurring in that direction.

In addition, or alternatively, a plate that can be moved within the plenum to block, entirely/open (or at least restrict flow) air flow between the pre-chamber and the post-chamber, under operation of the controller. This can then provide control of the relative exit velocity/flow rate through the nozzle between lateral sides of the extraction unit and/or the front/back size of the extraction unit.

Cross-flow can also be caused by cooking itself in the cooking region. For example, if only one cooking element is used, there will be an asymmetric convection from the side of the cooking element, to the opposite side, causing cross-flow. For example, if someone cooks on the right side of the cooking region, air rises on the right side that needs to be made up by air coming from left and right.

This cause of crossflow can also be compensated for by controlling the air curtain relative flows at different sides of the hood. For example, to avoid smoke escaping from the right side when cooking on the right, the air curtain flow/velocity on the right side of the air curtain can be adjusted such that it compensates for the cross-flow generated by the cooking on the right side. One or more sensors can be used to determine where the cooking is taking place, either by directly sensing the cooking, and/or looking at the resultant crossflows.

Any such compensation as described above could be implemented as a closed-loop control system whereby there might be an imbalance to begin with, but as the control system operates the imbalance is reduced significantly or even eliminated, and from that point on it is about maintaining balance through closed-loop control. That is, by determining any deviation from balance and correcting accordingly. Therefore, in general terms the extractor unit can be configured to reduce and almost eliminate crossflow (or more generally any imbalance in airflow), and once that is achieved, maintain balance and airflow (that is to try to ensure crossflow does not return).

The balance or imbalance of air flow can be static or dynamic, and determination and/or information of the balance or imbalance of airflow can be:

- generated once, e.g. during a calibration – for example in the case of static imbalance, and/or

- periodically or continuously (dynamically) determined or otherwise generated throughout the operation of the extractor unit – for example in the case of dynamic imbalance.

Fifth possible embodiment – deflector without an air curtain

In an alternative embodiment, the air curtain is omitted. In this case the deflector provides the required air flow aerodynamics. The inventors have determined that deflector by itself can a positive effect on extraction efficacy even without an air curtain. Hot air rising to the side is guided downwards and has a lower chance to escape. This can be combined with any of the aspects of the other rangehood embodiments.

In embodiments, one or more of the following is possible.

- The depth (recess) of the deflector shape is between 10mm and 50mm, and preferably between about 20mm and about 40mm.
- The angle of the deflector relative to the hood is between about 5 and about 20 degrees, and preferably between about 10 and about 15 degrees.
- The deflector is positioned and/or extends at least along three sides, and preferably along four sides of the hood.
- The deflector is recessed in the hood and optionally positioned as far as possible to the edge of the hood to enlarge the effective envelope of the hood.

Sixth possible embodiment –plenum/hood with internal deflector

Figure 18 shows an alternative embodiment of the hood/plenum and deflector. As previously described, for example with reference to Figure 5A, a deflector 57 is provided. In another embodiment, the plenum is configured such that the deflector 57B is internal to the housing of the hood.

In this embodiment, the plenum 50 has a raised floor 180 that integrally forms into the deflector 57B. The deflector 57B forms part of the nozzle 51 and therefore sits within the housing 52 of the plenum/hood, rather than extending beneath the plenum 50. In Figure 18, the cross-section shows the original embodiment of Figure 5A is shown overlaid the new embodiment for comparison. Other views show the new embodiment by itself

Further embodiments – alternative plenums

Each of the embodiments already described utilise a plenum with a nozzle (slot), and optionally a baffle to create two chambers, for providing an air curtain. As previously noted, controlling the air curtain flow velocity across the slot is desirable for improving containment of waste gases in the cooking region. Variations of the plenum are now described that provide improved or at least alternative air curtain velocity profiles, which can in some arrangements provide improved outcomes. Any of the plenum variations described below can be used with any of the embodiments previously described, as appropriate. The plenum configurations described here can include any of the nozzle, deflector, baffle and other structural arrangements as described with reference to any of the previous embodiments of the range hood, and insofar they are appropriate. Also, the plenum configurations described here can be used in combination with controlled extraction airflows and air curtain flows, and their relative ratios to achieve a desired air curtain velocity profile.

It is noted that the air velocities mentioned (typically about 7m/s on average) are the velocities measured (or calculated) directly at the nozzle exit, which is different from the velocities measured and described above (in the range of about 1-2 m/s) which were determined at a 57mm distance from the nozzle exit. This translates to about 2-4 m/s at the nozzle exit, which is still smaller than the about 7 m/s in the simulations described below. This difference is not consequential because the simulations described below have as main purpose to address the air curtain velocity distribution, not the absolute velocity values.

The salient features will be described in the airflow and exit velocity profile characteristics that come from those features.

Plenum variation #1 – First embodiment ("P1")

Referring to Figure 19A, the plenum 50 described in relation to the first embodiment above, will be described in more detail. The plenum shown in Figure 19A is a partial cutaway and comprises a perimeter wall 190 and a base 191. The nozzle/slot 51 extends within the perimeter of the wall, with curvature at the corners 192. This plenum 50 can be combined with any of the aspects of the other embodiments described herein.

The plenum of figure 19A provides an air curtain flow velocity profile (distribution) 195 from the slot as shown in Figure 19B. As can be seen, and referring to the table 1 below, the velocity profile 195 of the slot is relatively flat gradually increasing from the rear to the front of the plenum, with only a 5m/s difference and a std deviation of just

18% between the air curtain velocity at the front 193 of the plenum and at the rear 194 of the plenum.

		Qv = 2.5 m3/min
		V166_N3_P100_NB
		V#1, P1
Velocity [m/s]	Front (max)	10.0
	End (min)	5.0
	Velocity	5.0
	DVelocity [% max]	50%
	v mean	7.0
	v std. dev.	1.3
	s.dev. [% mean]	18%
Pressure [Pa]	DPstatic	-39.0
	DPdyn	32.0
	DPtot	-7.0
	slot width	3.0
	air volume [m3]	1.66E-02
	porosity [%]	100%

Table 1

Various alternative plenums will now be described.

Plenum variation #2 –wide/large plenum with half baffle (diverted plenum)

- This variation of plenum 200 has a structural configuration, exit velocity profile and internal airflow, as shown in Figures 20.
- This variation of plenum 200 comprises a U-shaped channel 201, with a nozzle and deflector 203. The plenum 200 also has an inlet 203, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan 23 and providing it to the plenum 200 .
- There is a partial baffle 202 in and partially across the front channel 204 of the plenum 200.

- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- As can be seen, and referring to the table 2 below, the velocity profile 207 of the slot is relatively flat gradually increasing from the rear to the front of the plenum, with a with a 6.5m/s difference and a std deviation of just 21% between the air curtain velocity at the front 205 of the plenum and at the rear 206 of the plenum. There is also some variation of air curtain velocity across the front of the plenum.

		Qv = 2.5 m3/min
		V78_N3_P100_HB
		V#2 P2 LARGE HALF BAFFLE - V6
Velocity [m/s]	**Front (max)**	11.5
	End (min)	5.0
	DVelocity	6.5
	Dvelocity [% max]	57%
	v mean	7.7
	v std. dev.	1.6
	s.dev. [% mean]	21%
Pressure [Pa]	**DPstatic**	-30.0
	DPdyn	14.0
	DPtot	-16.0
	slot width	3.0
	air volume [m3]	7.80E-03
	porosity [%]	100%

Table 2

Plenum variation #3 – two plenums with inner baffle (“wall”)

- This is a variation of the plenum 240 (variation #5, P2, described below).

- This variation of plenum 210 has a structural configuration, internal airflow, and exit velocity profile as shown in Figures 21A, 21B
- This variation comprises a relatively U-shaped channel 211, with a nozzle and deflector. It also has an inlet, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan 23 and providing it to the plenum. A baffle ("wall") 213 extends around the inner perimeter of the plenum splitting the plenum into a first 211A and second 211B chamber. The baffle 213 has openings 214 for passage of airflow
- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- The exit airflow velocity profile is relatively constant where: poor constancy is about >40% variation, moderate constancy is about 20-40% variation, good constancy about <20% variation. As can be seen, and referring to the table 3 below, the velocity profile 215 of the slot is relatively flat from the rear to the front of the plenum, with just a (about) 4m/s difference and a std deviation of just (about) 14.7% between the air curtain velocity at the front 216 of the plenum and at the rear 217 of the plenum. There is also a relatively constant air curtain velocity across the front of the plenum.

		Qv = 1.5 m3/min
		V67_N2_P45_NB
		V#3
Velocity [m/s]	**Front (max)**	9.5
	End (min)	5.5
	DVelocity	4.0
	Dvelocity [% max]	42%
	v mean	7.0
	v std. dev.	1.0
	s.dev. [% mean]	15%

Pressure [Pa]	**DPstatic**	-119.0
	DPdyn	8.0
	DPtot	-112.0

slot width	2.0
air volume [m3]	6.74E-03
porosity [%]	45%

Table 3

Figure 22 shows the following in terms of performance of some possible variations.

Results show that the separation wall in Plenum variation #3 – two plenums with inner baffle ("wall") really helps to reduce the velocity distribution to a (record) value of 15%. This is smaller than plenum variation #1 (18%) which has much bigger volume. It is also much smaller than like variation #3 but with no inner baffle (35%) which has similar volume and nozzle width, but no separation wall. Plenum variation #9 – two plenums with multiple baffles ("wall"), which has even more features to it has even lower velocity distribution, but at increased pressure. Increased pressure means the blower needs to work harder. Overall, the half baffle and plenum variation #3 are the best, next to plenum variation #1.

Some further plenums will now be described. These may not necessarily achieve a relative constant air curtain velocity, but show other configurations that can achieve alternative air curtain velocity profiles that might be advantageous in some situations, where constant air curtain velocity profile is not necessarily required.

Plenum variation #4 – narrow/small plenum ("P2 - small")

- This variation of plenum 230 this has a structural configuration, exit velocity profile and internal airflow, as shown in Figures 23A, 23B.
- This variation comprises a relatively narrow U-shaped channel, with a nozzle and deflector. It also has an inlet 231, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan and providing it to the plenum.
- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- As can be seen, and referring to the table 4 below, the velocity profile 232 of varies from the rear to the front of the plenum, with about a 15m/s difference and a std deviation of about 49% between the air curtain velocity at the front 233 of the plenum and at the rear 234 of the plenum.

Plenum variation #5 –wide/large plenum ("P2 - large")

- This variation of plenum 240 this has a structural configuration, exit velocity profile and internal airflow as shown in Figure 24A, 24B.
- This variation comprises a relatively wider U-shaped channel, with a nozzle and deflector. It also has an inlet 241, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan and providing it to the plenum.
- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- As can be seen, and referring to the table 4 below, the velocity profile 242 of varies from the rear to the front of the plenum, with a 13m/s difference and a std deviation of 50% between the air curtain velocity at the front 243 of the plenum and at the rear 244 of the plenum.

		Qv = 2.5 m3/min	
		V78_N3_P100_NB	V27_N3_P100_NB
		V#5, P2 LARGE	V#4, P2 SMALL
Velocity [m/s]	Front (max)	17.5	19.0
	End (min)	4.5	4.0
	DVelocity	13.0	15.0
	Dvelocity [% max]	74%	79%
	v mean	7.5	7.3
	v std. dev.	3.8	3.6
	s.dev. [% mean]	50%	49%
Pressure [Pa]	DPstatic	-31.0	-96.0
	DPdyn	15.0	2.0
	DPtot	-16.0	-94.0
	slot width	3.0	3.0
	air volume [m3]	7.80E-03	2.74E-03
	porosity [%]	100%	100%

Table 4

Plenum variation #6 –wide/large plenum with full baffle

- This variation of plenum 250 this has a structural configuration, exit velocity profile and internal airflow, as shown in Figures 25A, 25B, 25C
- It comprises a relatively wider U-shaped channel, with a nozzle and deflector. It also has an inlet 251, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan and providing it to the plenum.
- There is a baffle 255 in and across the front channel of the plenum.
- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- The exit airflow velocity profile is relatively constant. As can be seen, and referring to the table 5 below, the velocity profile 257 of the slot is relatively

flat gradually increasing from the rear to the front of the plenum, with a 12m/s difference and a std deviation of 36% between the air curtain velocity at the front 253 of the plenum and at the rear 254 of the plenum. There is also some variation of air curtain velocity across the front of the plenum.

		Qv = 2.5 m3/min
		V#6 full baffle -v7-
Velocity [m/s]	**Front (max)**	15.0
	End (min)	3.0
	DVelocity	12.0
	Dvelocity [% max]	80%
	v mean	7.6
	v std. dev.	2.74
	s.dev. [% mean]	36%

Pressure [Pa]	**DPstatic**	-30.0
	DPdyn	14.0
	DPtot	-15.0

slot width
air volume [m3]
porosity [%]

Table 5

Plenum variation #7 –wide/large plenum with tapered lateral channels

- This plenum variation 267 has a structural configuration, internal airflow, and exit velocity profile as shown in Figures 26A, 26B, 26C.
- this is similar in nature to the large plenum variations above, except for tapering in the lateral channels.

- It comprises a relatively wider U-shaped channel, with a nozzle and deflector. It also has an inlet 261, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan and providing it to the plenum.
- The lateral portions of the U-shaped channel are tapered 264.
- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- As can be seen, and referring to the table 6 below, the velocity profile 267 of the slot is relatively flat gradually increasing from the rear to the front of the plenum, with a 13.5m/s difference and a std deviation of 49% between the air curtain velocity at the front 263 of the plenum and at the rear 264 of the plenum. There is also some variation of air curtain velocity across the front of the plenum.

		Qv = 2.5 m3/min
		V#7, tapered wing -v12-
Velocity [m/s]	**Front (max)**	18.5
	End (min)	5.0
	DVelocity	13.5
	Dvelocity [% max]	73%
	v mean	7.6
	v std. dev.	3.73
	s.dev. [% mean]	49%

Pressure [Pa]	**DPstatic**	-30.0
	DPdyn	15.0
	DPtot	-15.0

slot width
air volume [m3]
porosity [%]

Table 6

Plenum variation #8 –wide/large plenum with full baffle and tapered baffle

- This variation of plenum 250 this has a structural configuration, exit velocity profile and internal airflow, as shown in Figures 27A, 27B.
- It comprises a relatively wider U-shaped channel, with a nozzle and deflector. It also has an inlet 251, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan and providing it to the plenum.
- There is a tapered baffle 256 in and across the front channel of the plenum.
- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- The exit airflow velocity profile is relatively constant. As can be seen, and referring to the table 7 below, the velocity profile 257 of the slot is relatively flat gradually increasing from the rear to the front of the plenum, with a 12m/s difference and a std deviation of 36% between the air curtain velocity at the front 253 of the plenum and at the rear 254 of the plenum. There is also some variation of air curtain velocity across the front of the plenum.

		Qv = 2.5 m3/min
		full + tapered baffle -v8-
Velocity [m/s]	**Front (max)**	24.0
	End (min)	2.0
	DVelocity	22.0
	Dvelocity [% max]	92%
	v mean	6.2
	v std. dev.	2.71
	s.dev. [% mean]	44%

Pressure [Pa]	**DPstatic**	-274.0
	DPdyn	58.0
	DPtot	-215.0

slot width
air volume [m3]
porosity [%]

Table 7

Plenum variation #9 – two plenums with multiple baffles ("wall")

- This is a variation of the plenum described in the third possible embodiment.
- This variation has a structural configuration, internal airflow, and exit velocity profile as shown in Figures 28A, 28B, 28C
- This variation comprises a relatively U-shaped channel, with a nozzle and deflector. It also has an inlet 281, which is equivalent to the duct 76 previously described for receiving airflow from the air curtain fan and providing it to the plenum. A primary baffle ("wall") 282 extends around the inner perimeter of the plenum splitting the plenum into a first 280A and second chamber 280B. The baffle has openings for passage of airflow. In addition there are smaller secondary baffles 282 extending from the primary baffle.
- The airflow pattern is provided in the Figure to support how the velocity distribution is established.
- As can be seen, and referring to the below, the velocity profile 287 of the slot is relatively flat gradually increasing from the rear to the front of the plenum.
- The resulting air velocity distribution is very small, just 11% STDEV of the mean (see v2 in one of the tables above).

Variations

There are numerous variations which we evident to those skilled in the art.

Other shapes of aerofoil and configurations are possible. For example, while the aerofoil has 3 sections arranged in a U-shaped around a rectangular polygon, different numbers of sections could be used around different shape polygons. For example, the U-shaped might be more triangular in shape, or there could be even more than 3 sections creating a more curved U-shaped. Other alternatives are possible also. A four-sided closed central section aerofoil is possible, for example

The air flows of extraction and air curtain are preferably separated. But that is not essential. Alternatively, they may not be pneumatically separated and that would enable use of a filter that cleans exhaust air very well, such that the extraction airflow can be re-circulated into the air curtain air flow.

The range hood could be combined with an air purifier and/or air conditioner (enabled by including clean air exhaust).

The outlet could be configured to direct airflow upwards in a purification mode. The housing could be configured to change airflow paths through filters and the like.

There could also be more than three sides to the air curtain. For example, a four sided air curtain as possible. It is also possible that there is fewer than three sides to the air curtain, such as two sides or even one side.

When used, the deflector can go around all four sides, or just three sides, or just two sides, or even one side.

The slot, could extend around all sides of the hood, or just partially around, such as three sides, two sides or just one side, or even partially around one or more sides.

When used, a baffle can go partially or entirely through the plenum, in any direction in any position that is suitable. For example, it might go partially or entirely across the front of the plenum, along the sides of the plenum, and/or at the back of the plenum; or go laterally through the plenum in some manner. One or more baffles can be used in any suitable manner as described above.

The orientation of the extraction fan 23 can impact overall performance of air curtain. For example,

- if the inlet of the extraction fan 23 is oriented sideways, there could be more extraction from the sides, which may be beneficial.
- if the inlet of extraction fan is oriented to the front of the hood, the main extraction flow may be from the front inwards.

Benefits

- The arrangements of the embodiments described provide an air curtain that improves the overall extraction air flow that is needed to achieve a good extraction of cooking smoke that can actually be reduced compared to conventional range hoods. Initial indications suggest the embodiments can reduce the extraction airflow to 50% of extraction airflow compared to conventional range hoods. Preliminary results show that at 80% of extraction airflow, performance of the present embodiments is significantly better. For kitchens and apartments other housing or commercial setting is in big, polluted and/or industrial cities, it is very much desired to not suck a lot of air out of the dwelling (called “make up air”) by the range hood, because it removes the clean air within the dwelling that was just generated by the air purifier that was in the room. The graph in Figure 9 it can be seen that the air purifier can’t keep up with cleaning the air while the Range Hood is on. This graph shows measurement results using particle sensor in a real life Chinese apartment.

- It shows that an air purifier indeed helps to reduce air pollution.
- It also shows that a Range Hood suck so much clean air out of the room that the air purifier can’t keep up cleaning the new (dirty) air that is coming from outside.

Claims

1. An extractor unit comprising:

at least one fan for creating:

an extraction airflow, and

an air curtain airflow,

an extractor duct for the extraction airflow for extracting waste gases from a region,

a hood coupled to the duct for receiving the air curtain airflow from the fan and expelling an air curtain to envelop the region, and

an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct.

2. An extractor unit according to claim 1 wherein the hood comprises a plenum with an inlet opening for receiving air curtain airflow from the fan and an outlet for expelling the air curtain to the region.

3. An extractor unit according to claim 2 wherein the outlet comprises a slot around at least part of the perimeter of the plenum and lips around the slot for directing the air curtain.

4. An extractor unit wherein the hood has a plenum and slotted outlet at least partially around the perimeter of the hood for expelling the air curtain, and a deflector on proximate the slotted outlet to direct the air curtain.

5. An extractor unit according to claim 4 wherein the deflector and/or slot extend at least partially to the back of the hood.

6. An extractor unit according to any preceding claim wherein there are at least two fans, a first exhaust fan for creating the extraction airflow and a second air curtain fan for creating the air curtain airflow.

7. An extractor unit according to claim 5 wherein the exhaust fan and the air curtain fan are disposed in the extractor duct housing.

8. An extractor unit according to claim 6 or 7 wherein the plenum with an inlet opening receives air curtain airflow from the air curtain fan and an outlet for expelling the air curtain to the region.

9. An extractor unit according to any preceding claim wherein the inlet comprises an aerofoil cross-section to form at least one circulating current with the extraction airflow, air curtain airflow and/or waste gases.

10. An extractor unit according to any preceding claim wherein the inlet is U-shaped with three aerofoil inlet sections positioned around the region.

11. An extractor unit according to any preceding claim wherein the region is a cooking region of a cooktop.

12. An extractor unit according to any preceding claim wherein the hood comprises a deflector to guide lateral flow (from convection and/or turbulent airflows) downwards.

13. An extractor unit according to any preceding claim wherein the convection current mixes air from the air curtain, extraction airflow and the waste gases.

14. An extractor unit according to claim 1 wherein there is a single fan for creating an extraction airflow and an air curtain airflow, wherein extraction airflow through the fan is filtered and recirculated into the air curtain flow.

15. An extractor unit according to any one of claims 10 to 14 wherein the deflector is positioned around the hood, or within the hood.

16. An extractor unit according to any one of claims 2 to 15 wherein the plenum comprises two chambers, optionally separated by a baffle that is optionally movable.

17. An extractor unit according to any one of claims 2 to 16 wherein the plenum comprises a baffle that goes at least partially across or through the plenum, and optionally goes entirely through the plenum.

18. An extractor unit according to claim 17 further comprising secondary baffles that extend from the baffle.

19. An extractor unit according to any preceding claim further comprising a controller for operating the fan to control the air velocity and flow rate of air curtain exiting the slotted outlet.

20. An extractor unit according to claim 19 wherein the controller controls the air velocity and the flow rate of the air curtain to be within a certain range and/or the ratio between them to be in a certain range.

21. An extractor unit according to claim 19 or 20 wherein the controller operates the fan to control the extraction airflow.

22. An extractor unit according to any preceding claim further comprising

one or more sensors or other means positioned at a suitable location to determine the existence, magnitude and/or direction of cross-flow,

wherein the extractor unit is configured so that the air curtain exit velocity/flow rate through different parts of the air curtain slot are controlled to create airflows to counteract/compensate for the cross-flow.

23. An extractor unit according to claim 19, 20, 21 or 22 wherein the extractor is configured, through structure and/or control of operation, to:

- provide a flow rate of the air curtain to a desired ratio of the flow rate of extraction airflow to improve performance, and/or
- provide an air velocity of the air curtain to between a desired range to improve performance, and/or
- provide the air velocity of the air curtain as a desired percentage of the extraction rate to improve performance, and/or
- provide an exit velocity of the air curtain across the slot to reduce the variability of the exit velocity across the slot.

24. An extractor unit according to claim 19, 20, 21, 22 or 23 wherein

- the flow rate of the air curtain is between about 6-12% and preferably 9% of that of the flow rate of extraction airflow, and/or
- the air velocity of the air curtain measured at 57mm is between about 1.1m/s and 2m/s, and/or

- the air velocity of the air curtain measured at 57mm as a percentage of the extraction rate is between about 12% to 17% of the extraction flow rate, or between about 10% to 20%, or between about 5% to 25%.

25. A method of controlling an extractor unit that:

- provides a flow rate of the air curtain to a desired ratio of the flow rate of extraction airflow to improve performance, and/or
- provides an air velocity of the air curtain to between a desired range to improve performance, and/or
- provides the air velocity of the air curtain as a desired percentage of the extraction rate to improve performance, and/or
- provides an exit velocity of the air curtain across the slot to reduce the variability of the exit velocity across the slot.

26. An extractor unit comprising:

at least one fan for creating:

an extraction airflow, and

an extractor duct for the extraction airflow for extracting waste gases from a region,

a hood coupled to the duct with a deflector, and

an inlet coupled to the extractor duct and above the cooking region for receiving waste gases from the region and passing them to the extractor duct.

27. An extractor unit according to claim 26 wherein the deflector is positioned around the hood, or within the hood.

28. An extractor unit according to any one of claims 4, 5, 12, 15 and 26 to 27 wherein the depth (recess) of the deflector is between about 10mm and about 50mm, and preferably between about 20mm and about 40mm.

29. An extractor unit according to any one of claims 4, 5, 12, 15 and 26 to 28 wherein the angle of the deflector relative to the hood is between about 5 and about 20 degrees, and preferably between about 10 and about 15 degrees.

30. An extractor unit according to any one of claims 4, 5, 12, 15, and 26 to 29 wherein the deflector is positioned and/or extends at least along three sides, and preferably along four sides of the hood.

31. An extractor unit according to any one of claims 4, 5, 12, 15, and 26 to 30 wherein the deflector shape is recessed in the hood and optionally positioned as far as possible to the edge of the hood to enlarge the effective envelope of the hood.

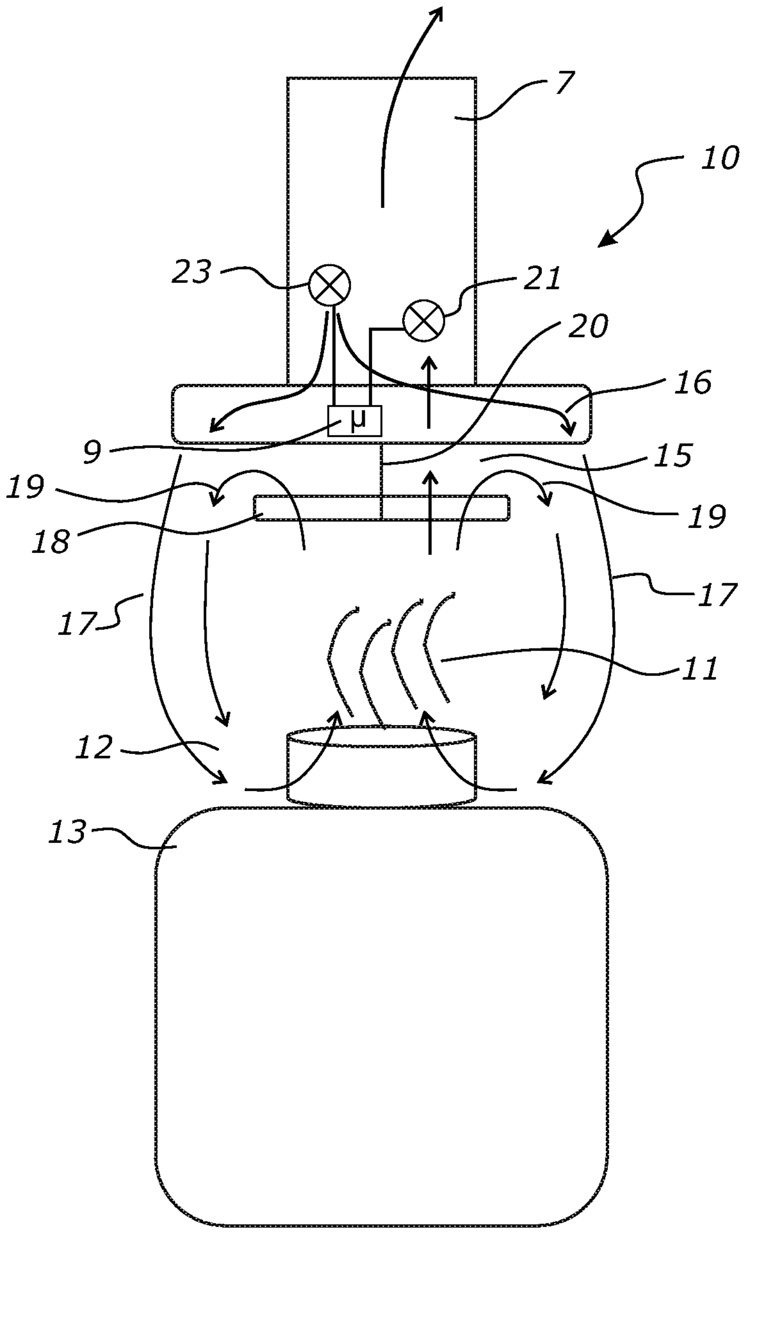
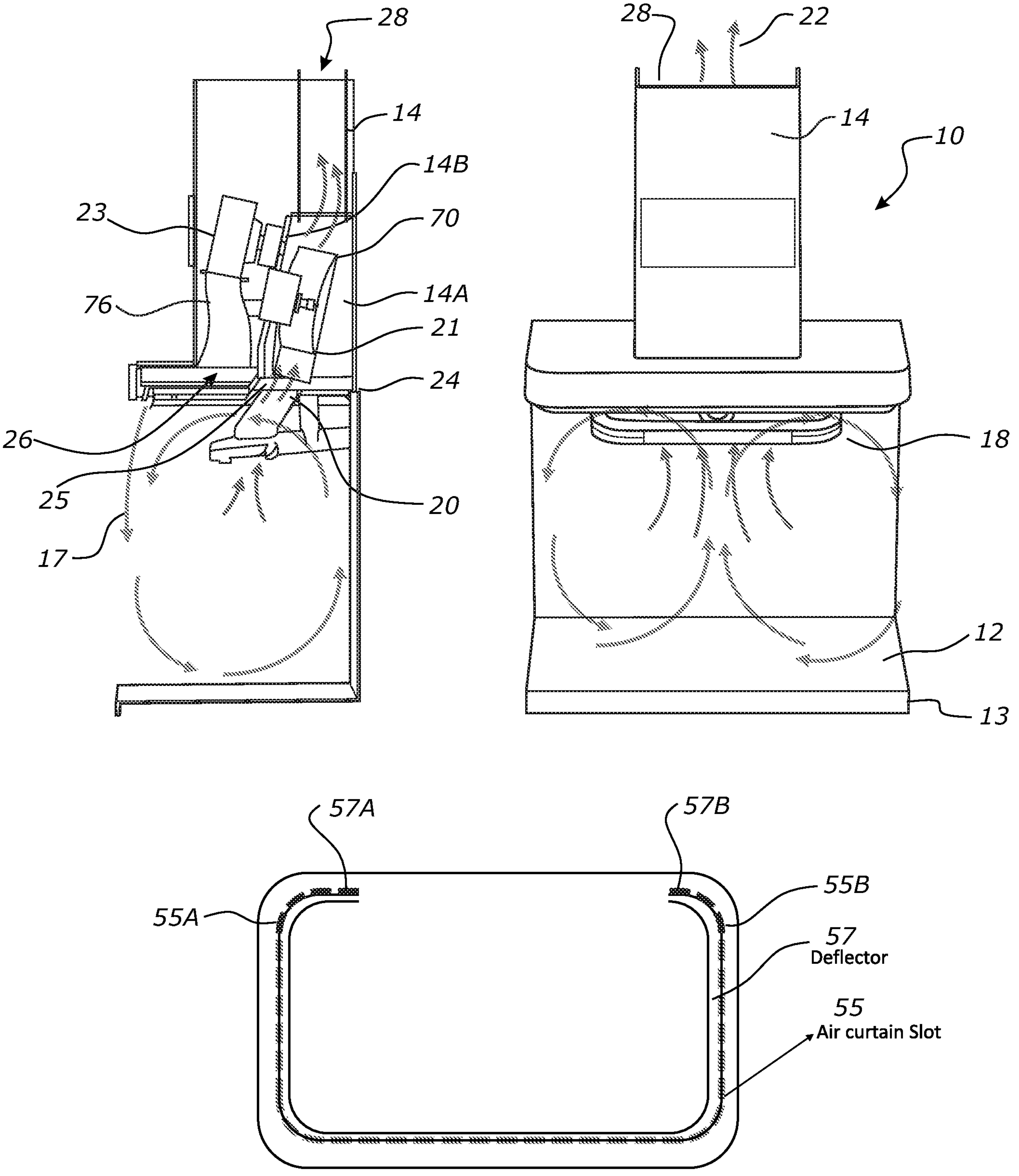


FIGURE 1



Underneath of hood

FIGURE 2A

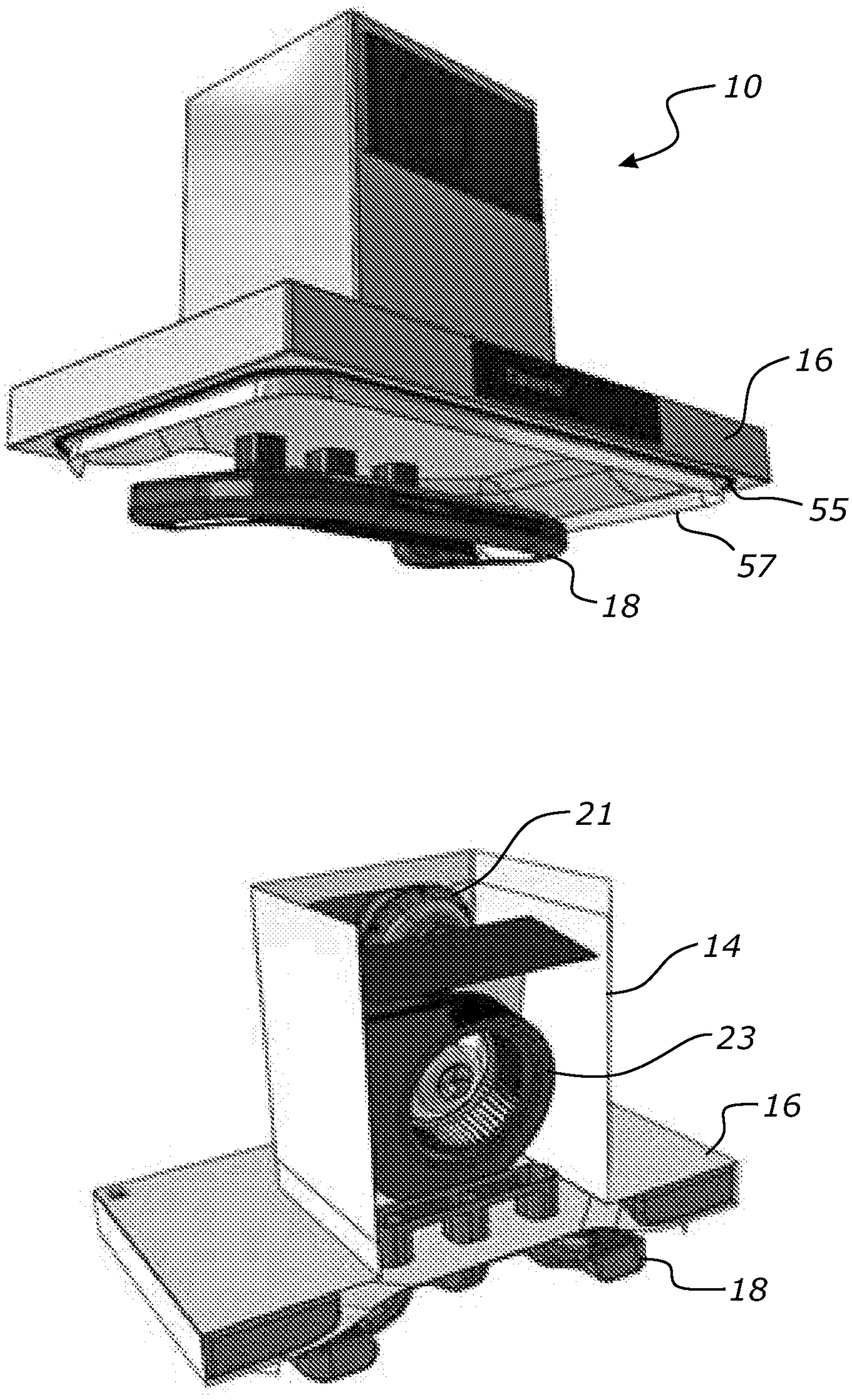


FIGURE 2B

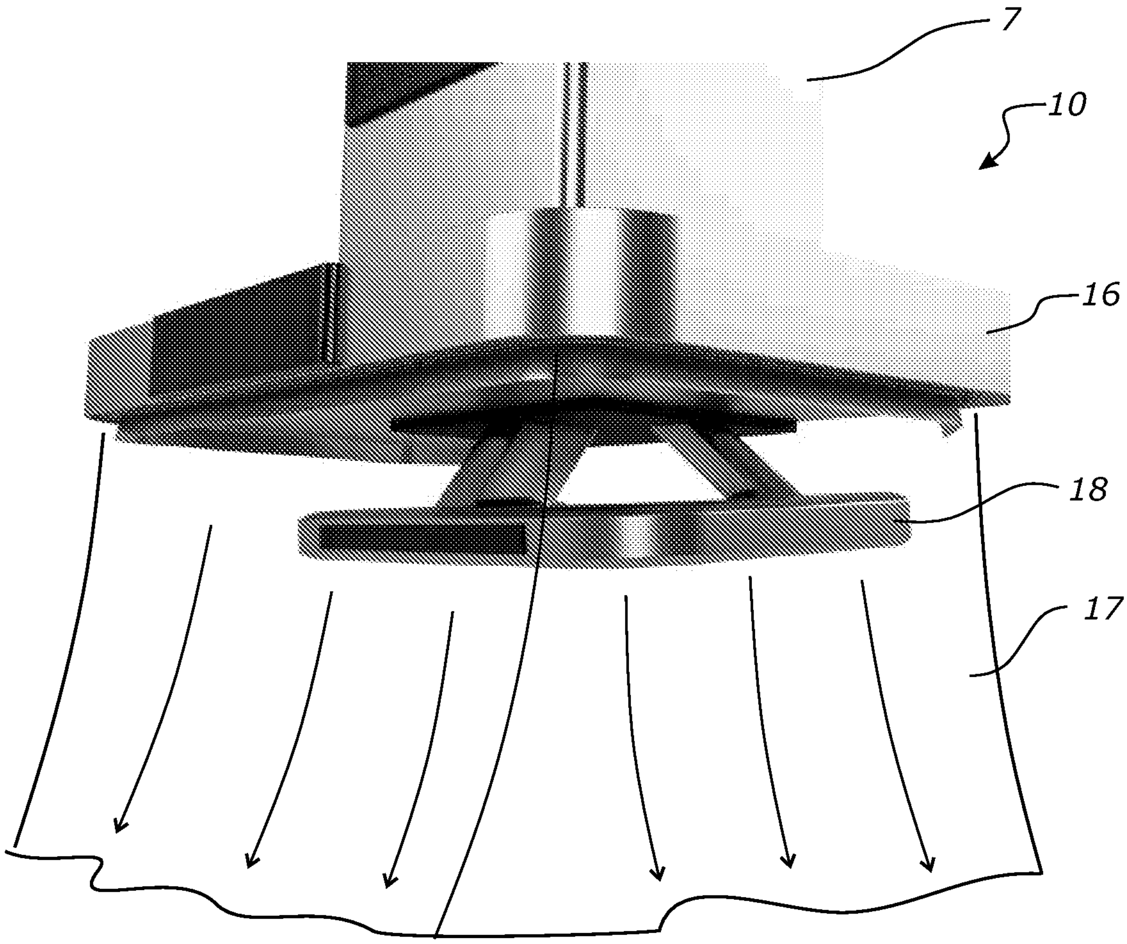


FIGURE 3A

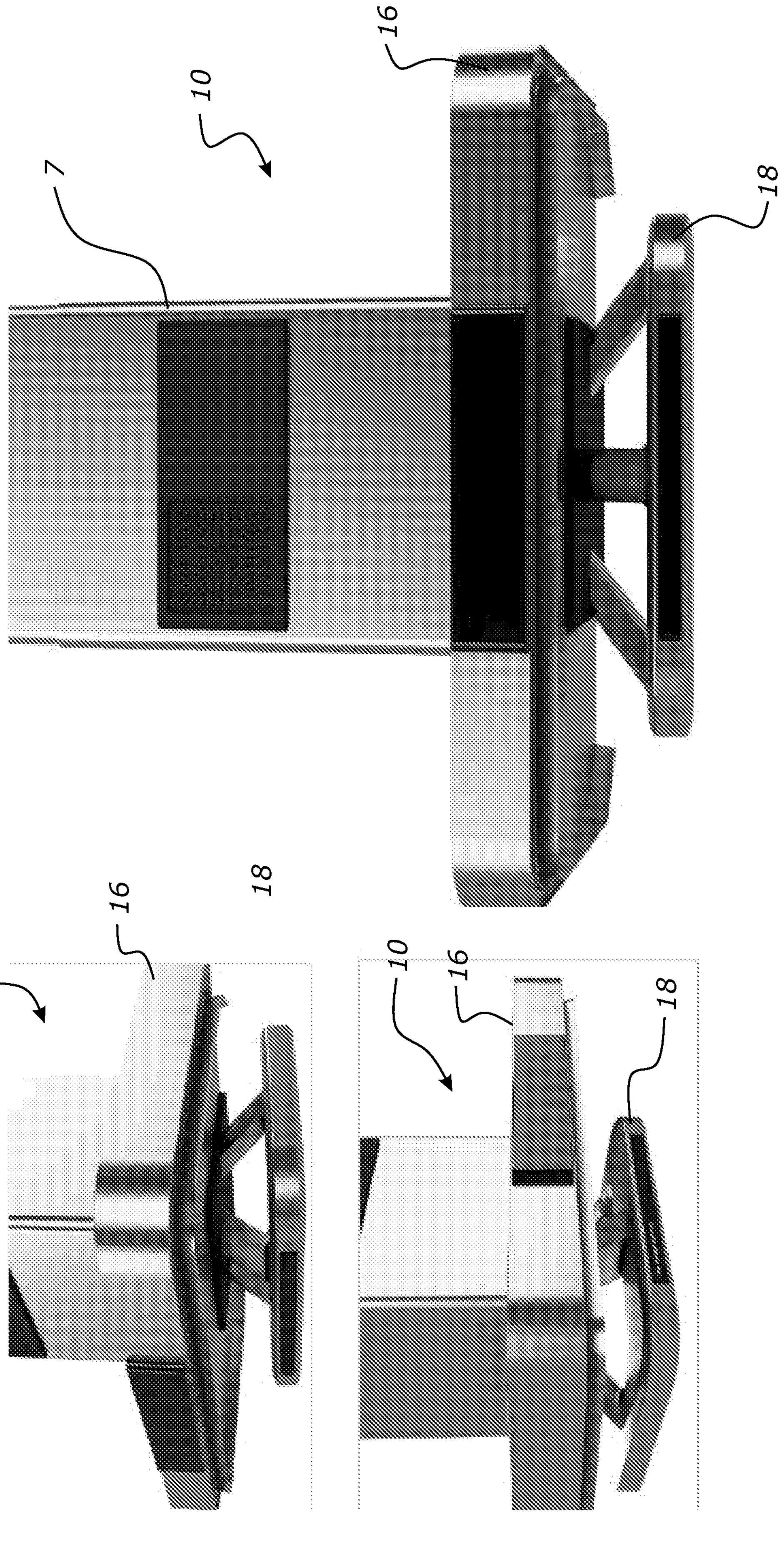


FIGURE 3B

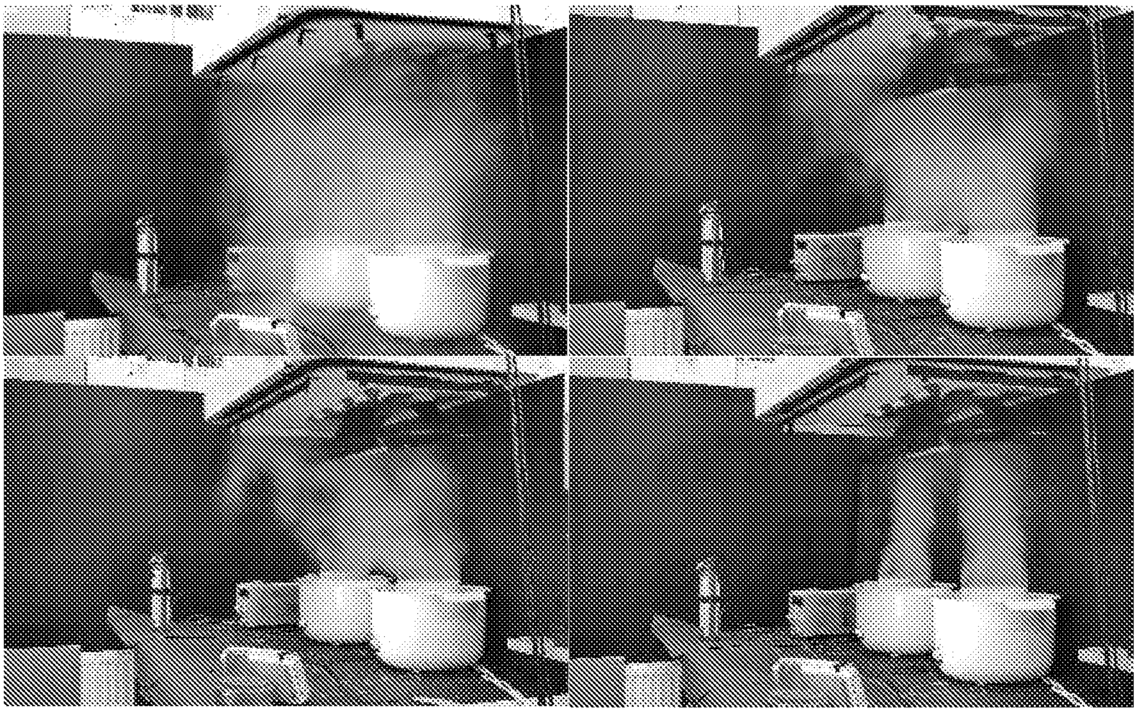


FIGURE 4

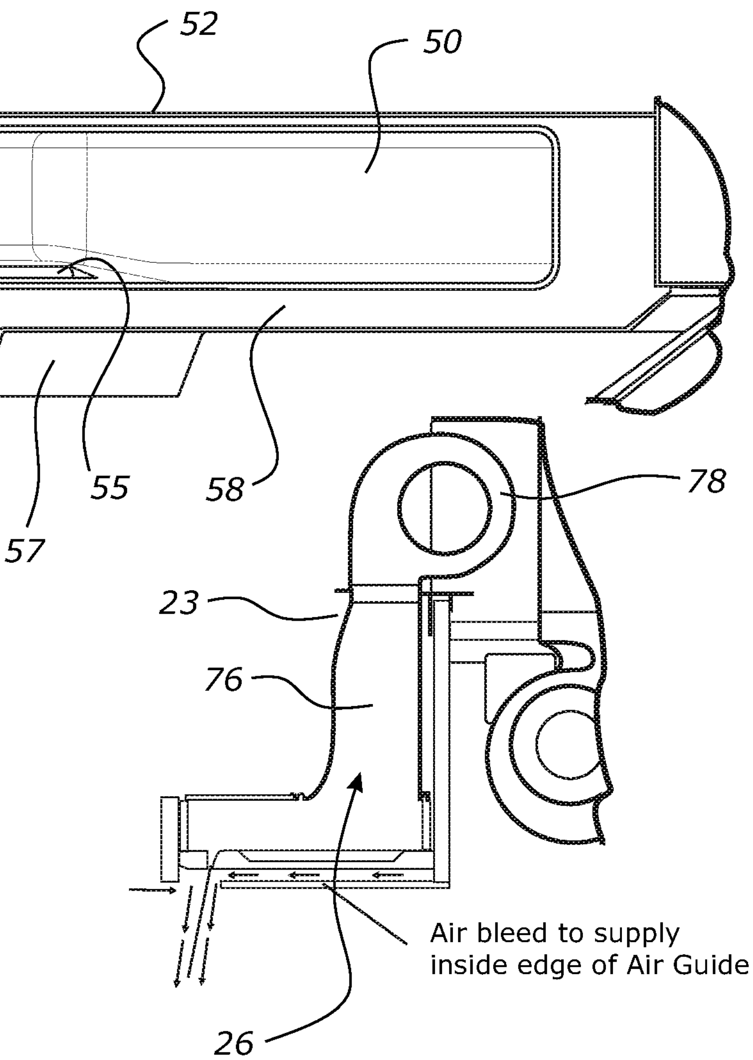
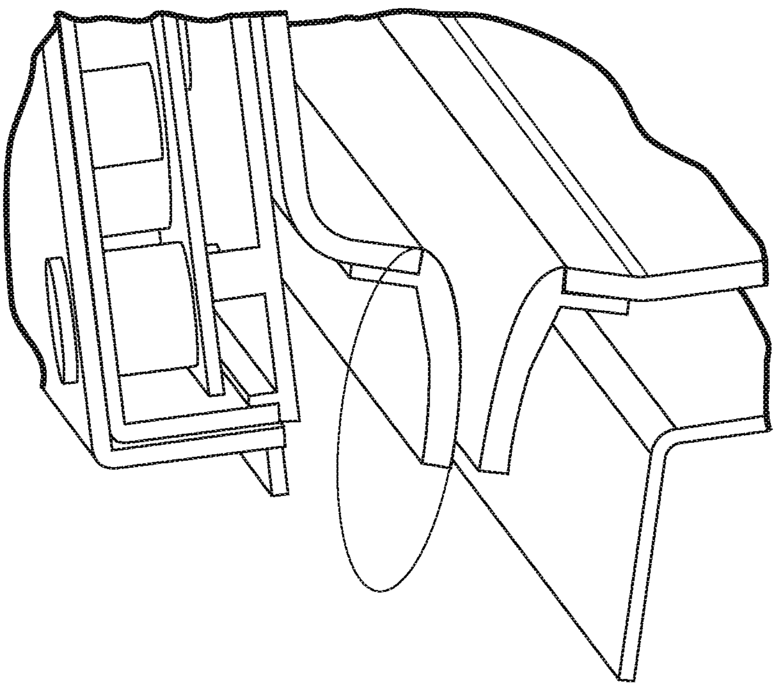

52
50
51
56
57
55
58
78
23
76
Air bleed to supply
inside edge of Air Guide
26

FIGURE 5A



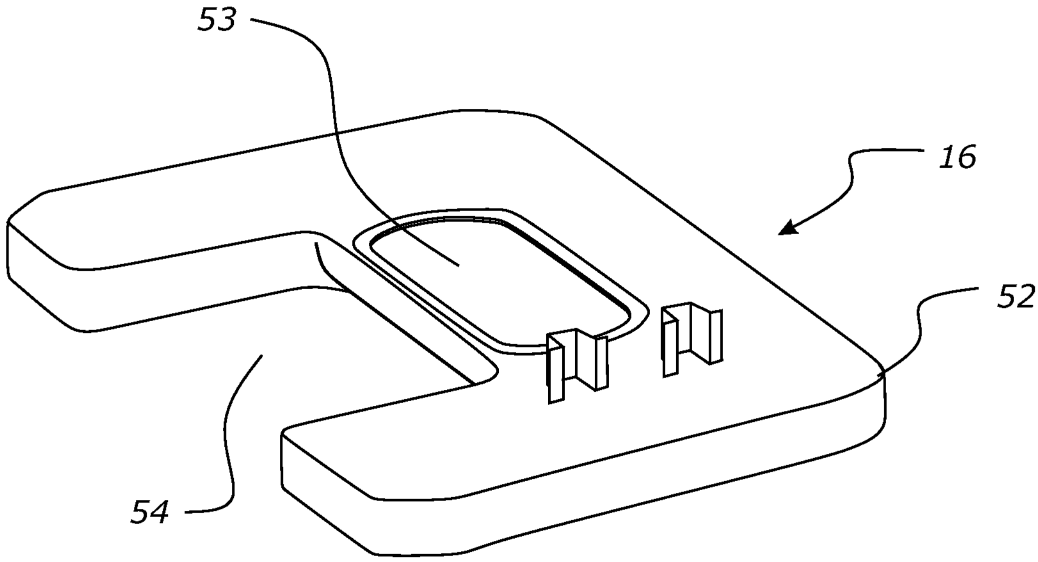


FIGURE 5B

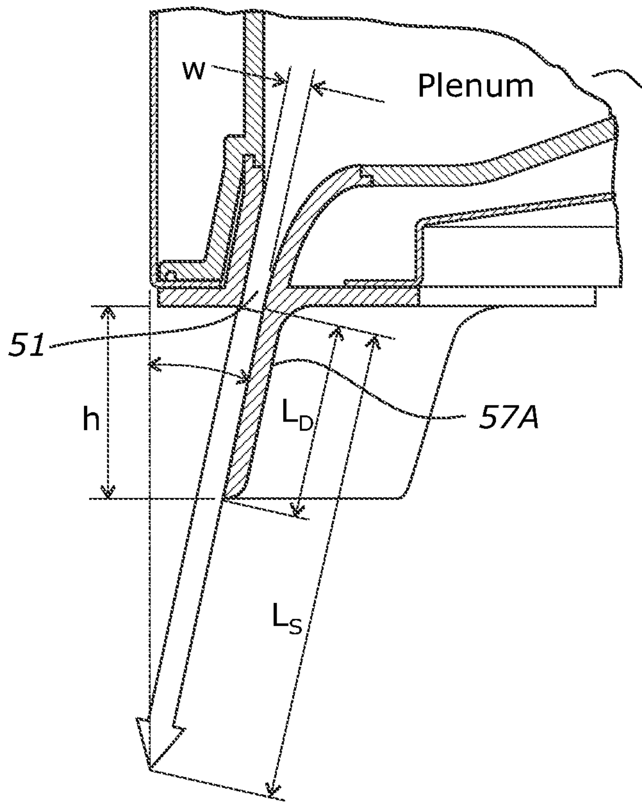


FIGURE 5C

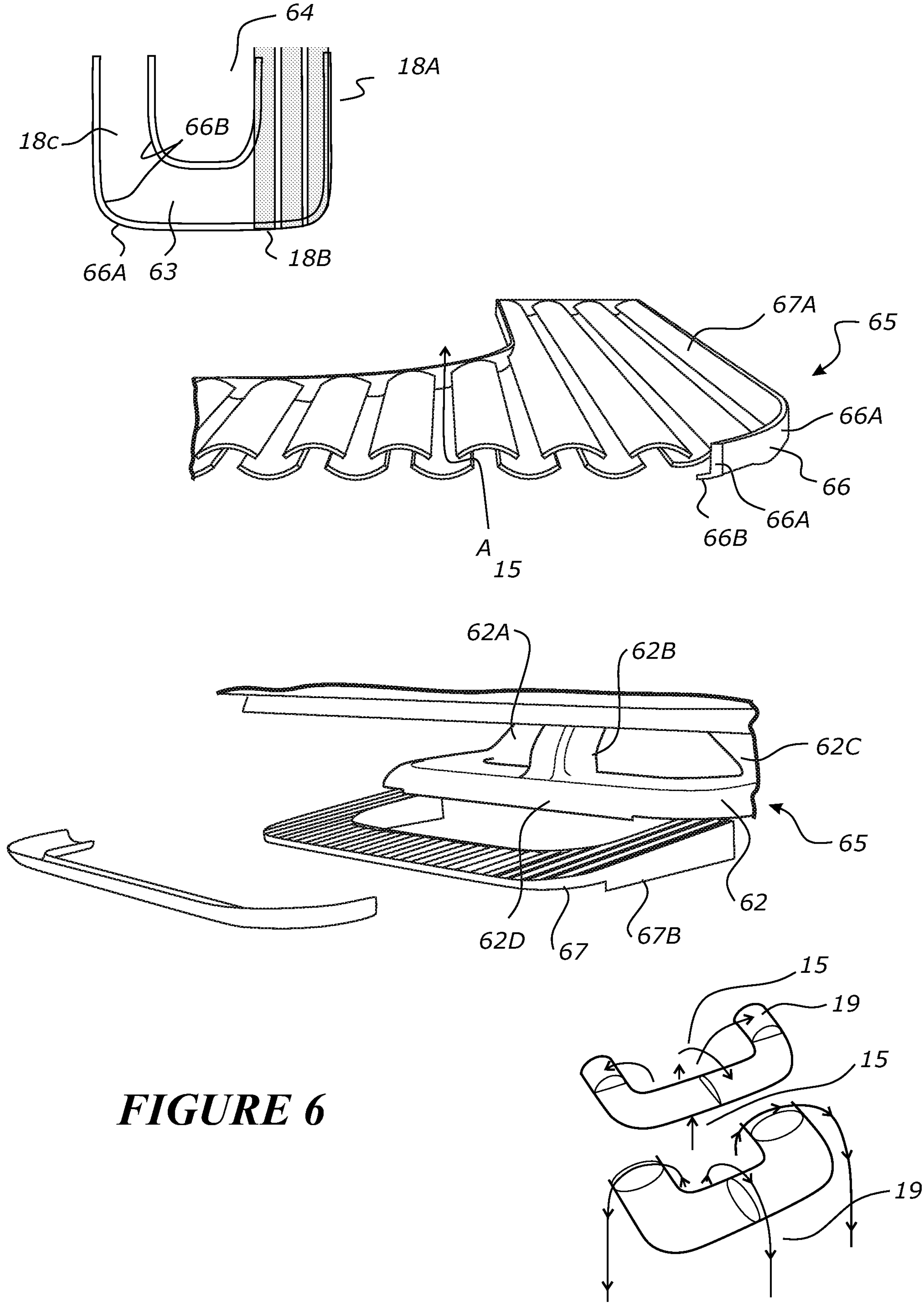

64
18A
18c
66B
66A
63
18B
67A
65
66A
66
66A
66B
A
15
62A
62B
62C
65
62
62D
67
67B
15
19
15
19

FIGURE 6

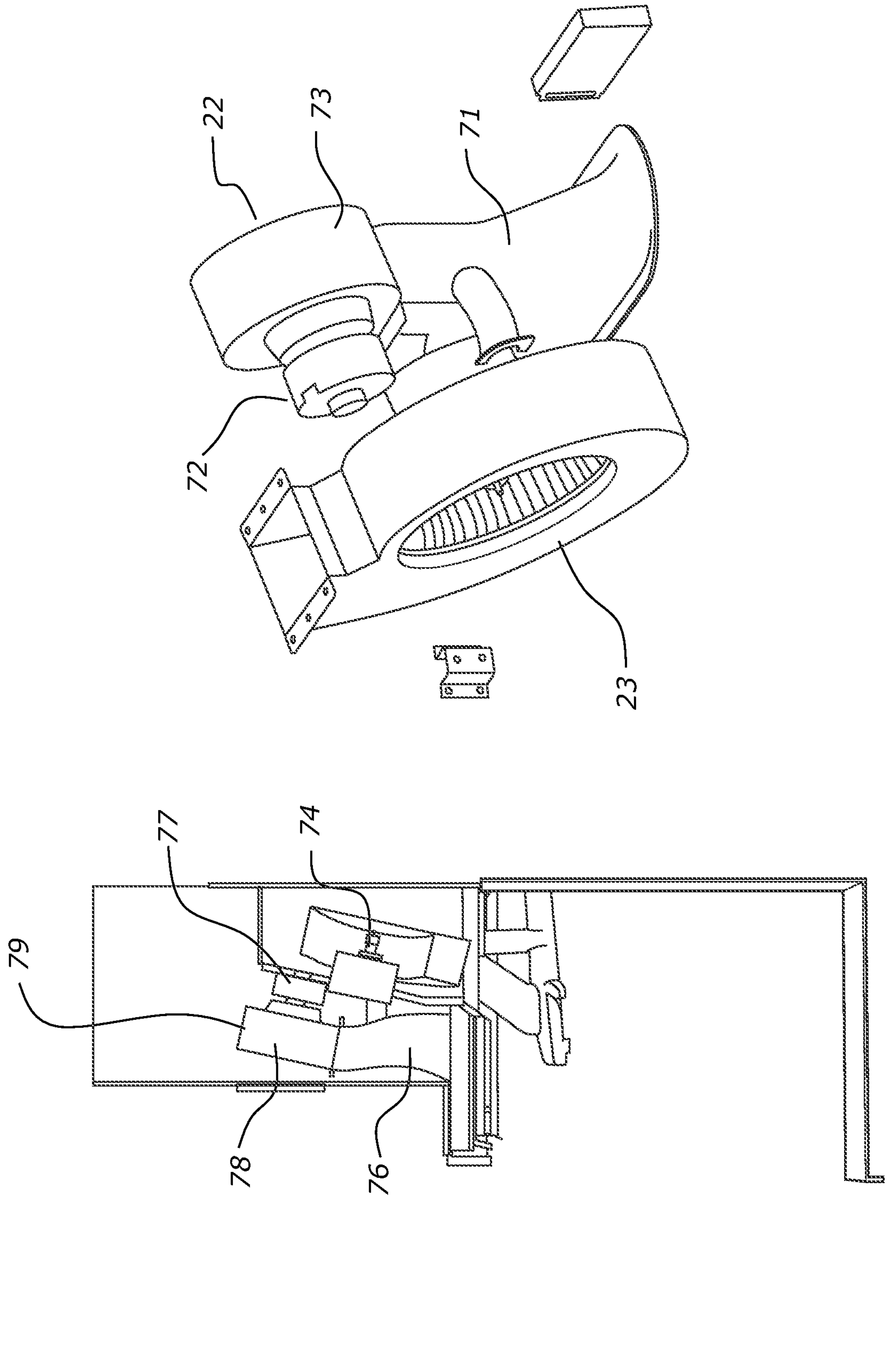


FIGURE 7

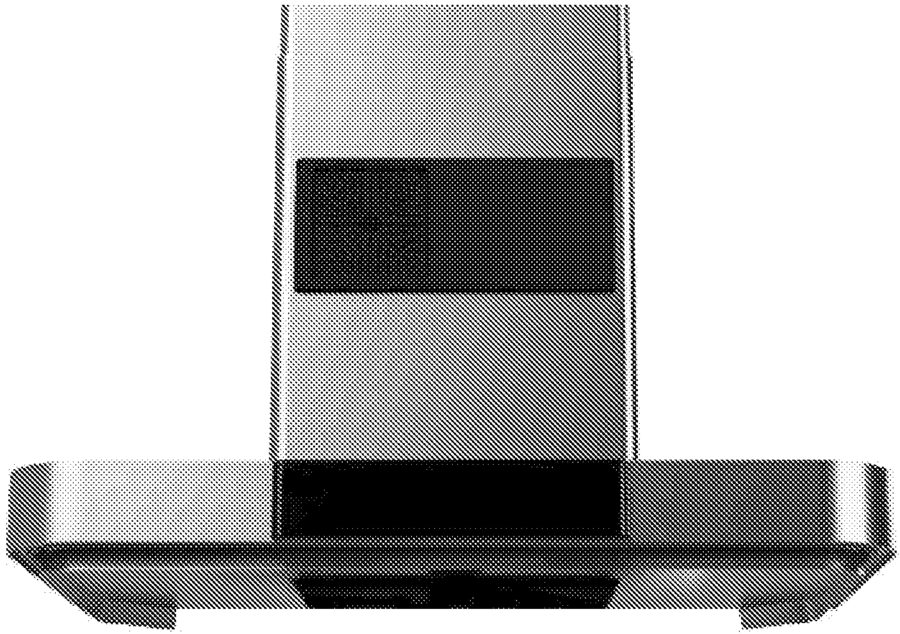


FIGURE 8

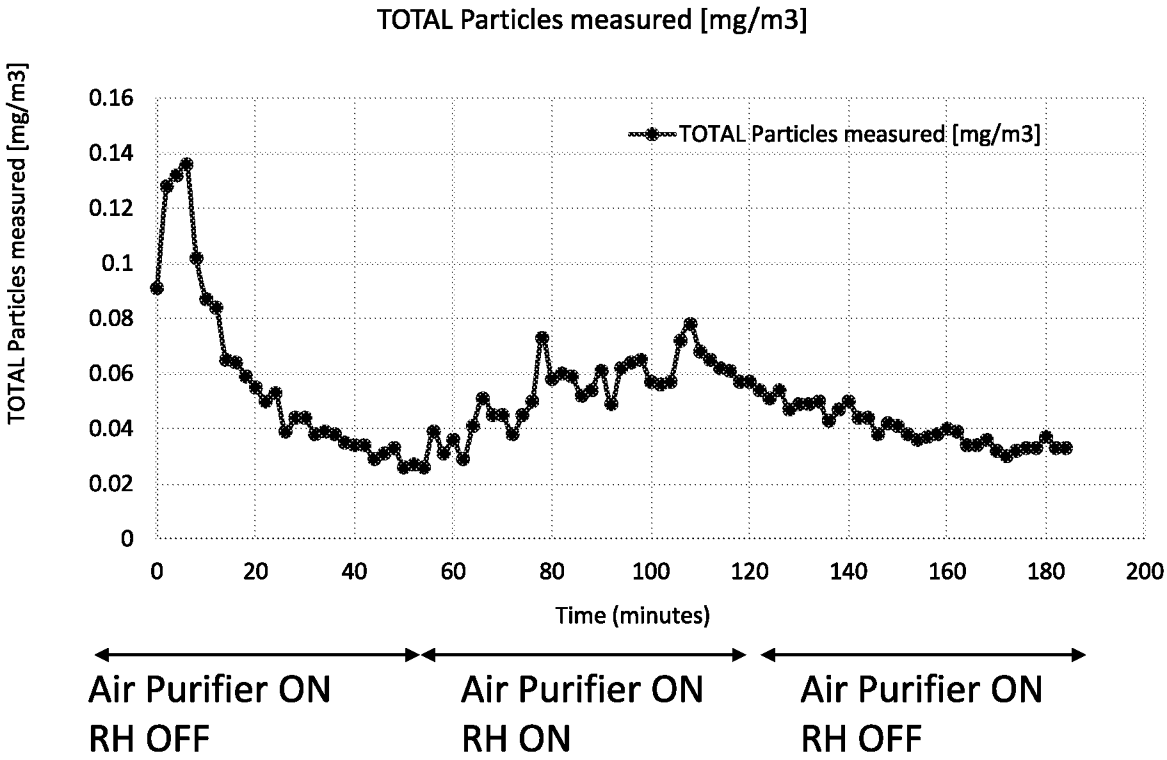
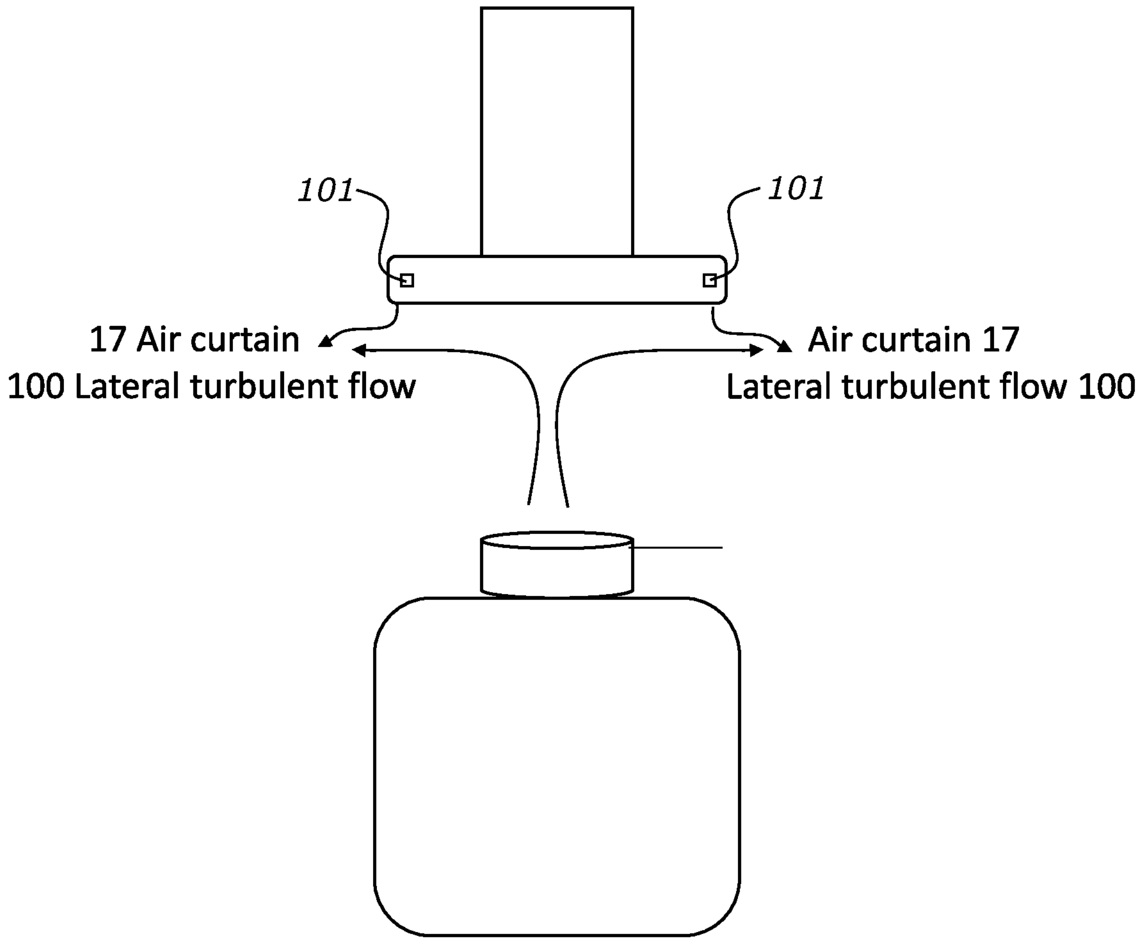


FIGURE 9


101
101
17 Air curtain
100 Lateral turbulent flow
Air curtain 17
Lateral turbulent flow 100

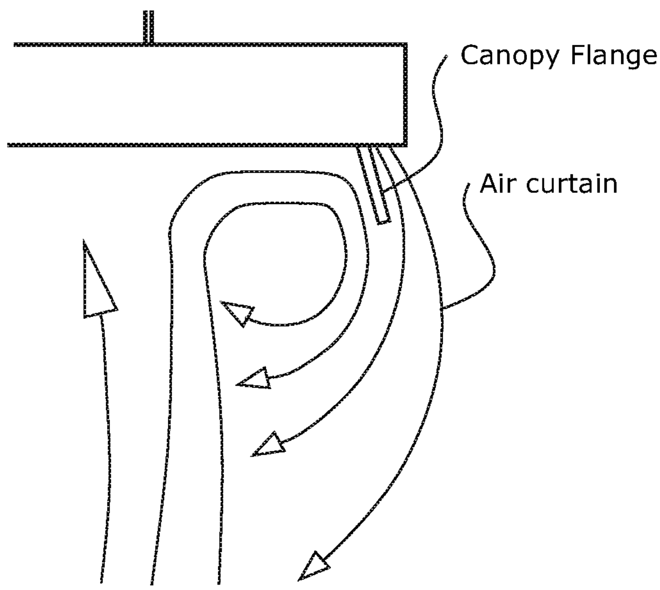
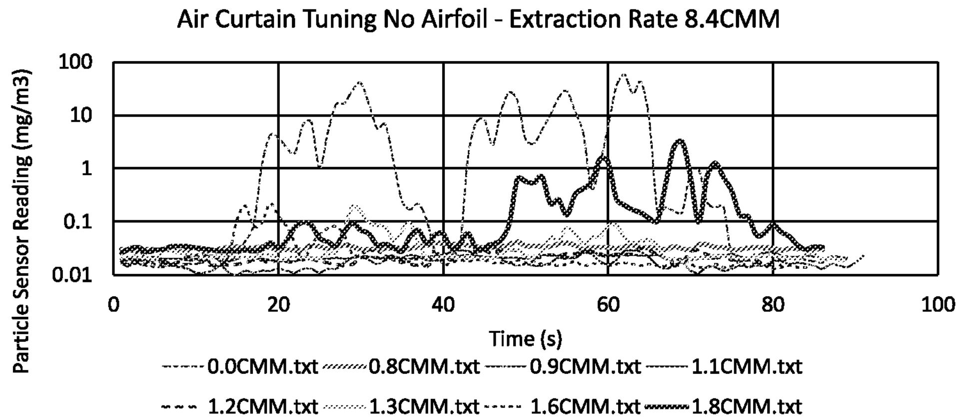

Canopy Flange
Air curtain

FIGURE 10

Air Curtain No Airfoil

Extraction		Air Curtain		
Setting	Flow Rate	RPM	Flow Rate	Ratio
		0	0	0.00%
5.1V	8.4	500	0.8	9.75%
		550	0.9	11.14%
		600	1.1	13.29%
		650	1.2	14.56%
		700	1.3	15.57%
		800	1.6	19.11%
		900	1.8	21.90%



- Air Curtain flow was optimized using particle sensor and smoke cartridge
- Results show it’s a very delicate job!

FIGURE 11

	T8				Haier Air Curtain				Air Curtain No Foil		
Pos	Left	Middle	Right		Left	Middle	Right		Left	Middle	Right
Top	0.3	2.3	31		2.7	0.02	47		0.2	0.2	0.1
Middle	0.3	0.3	0.1		0.6	0.1	0.9		0.2	0.1	0.1
Bottom	0.2	0.2	0.2		0.6	0.7	1.3		0.1	0.1	0.4

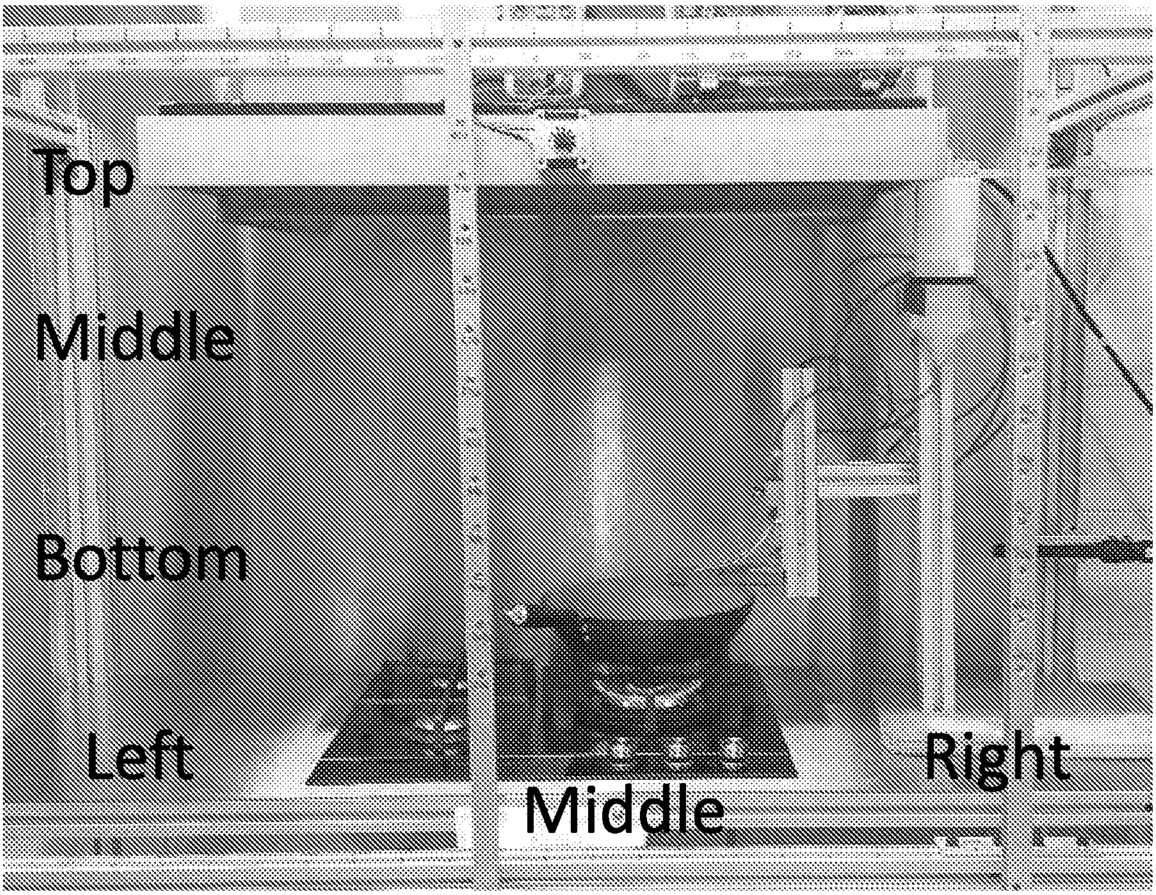


FIGURE 12

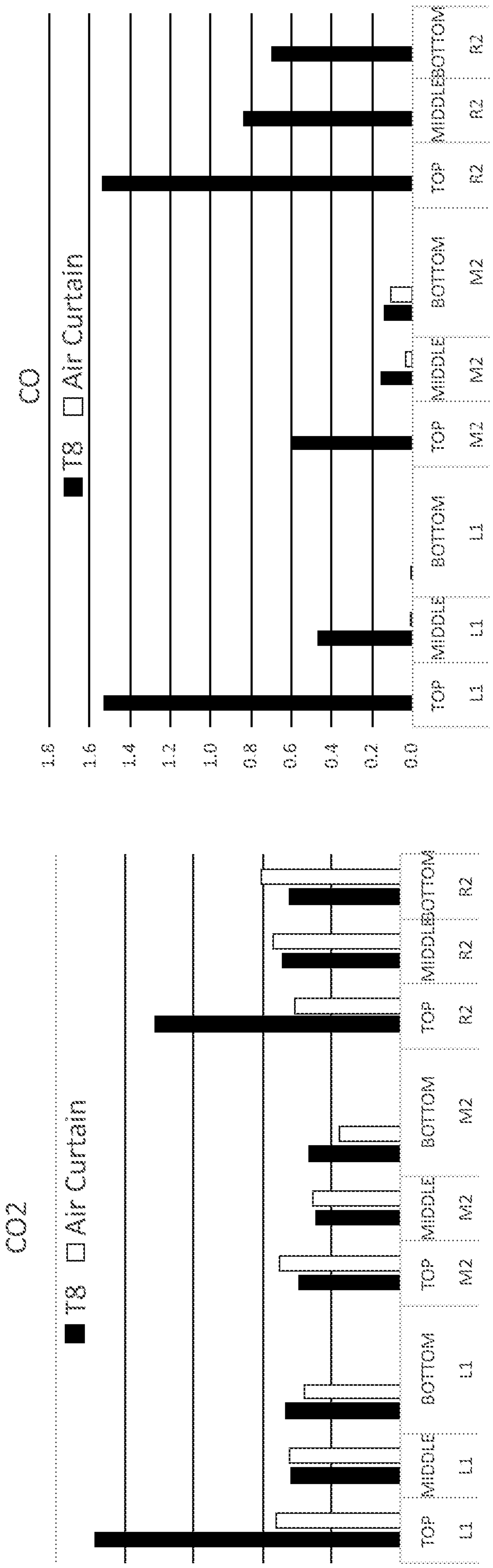
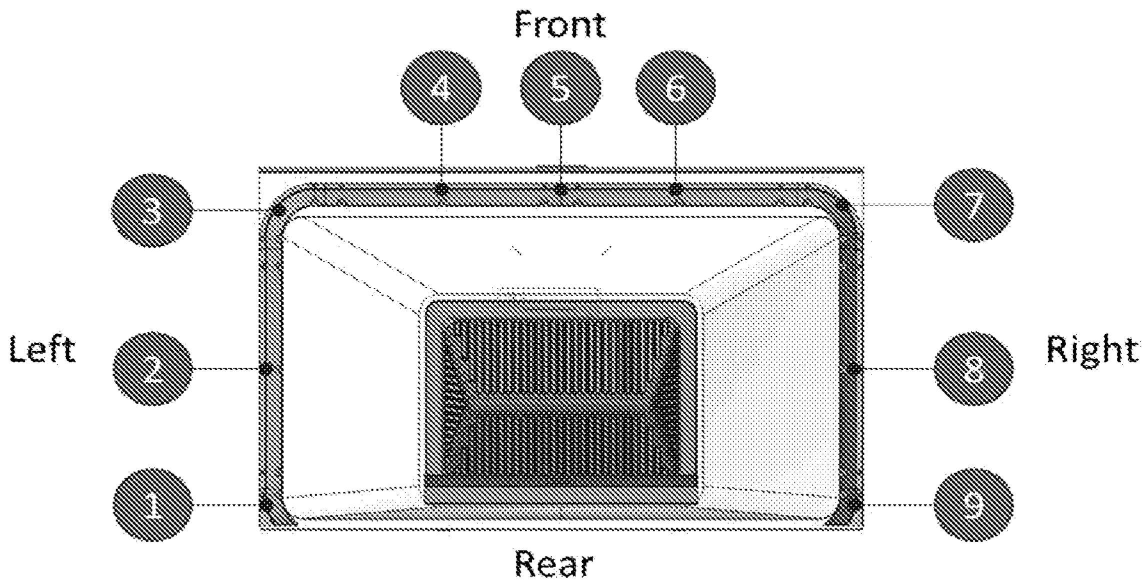

CO
T8
Air Curtain
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
TOP L1
MIDDLE L1
BOTTOM L1
TOP M2
MIDDLE M2
BOTTOM M2
TOP R2
MIDDLE R2
BOTTOM R2
CO2
T8
Air Curtain
650
600
550
500
450
400
TOP L1
MIDDLE L1
BOTTOM L1
TOP M2
MIDDLE M2
BOTTOM M2
TOP R2
MIDDLE R2
BOTTOM R2

FIGURE 13


Front
4
5
6
3
7
Left
2
8
Right
1
9
Rear

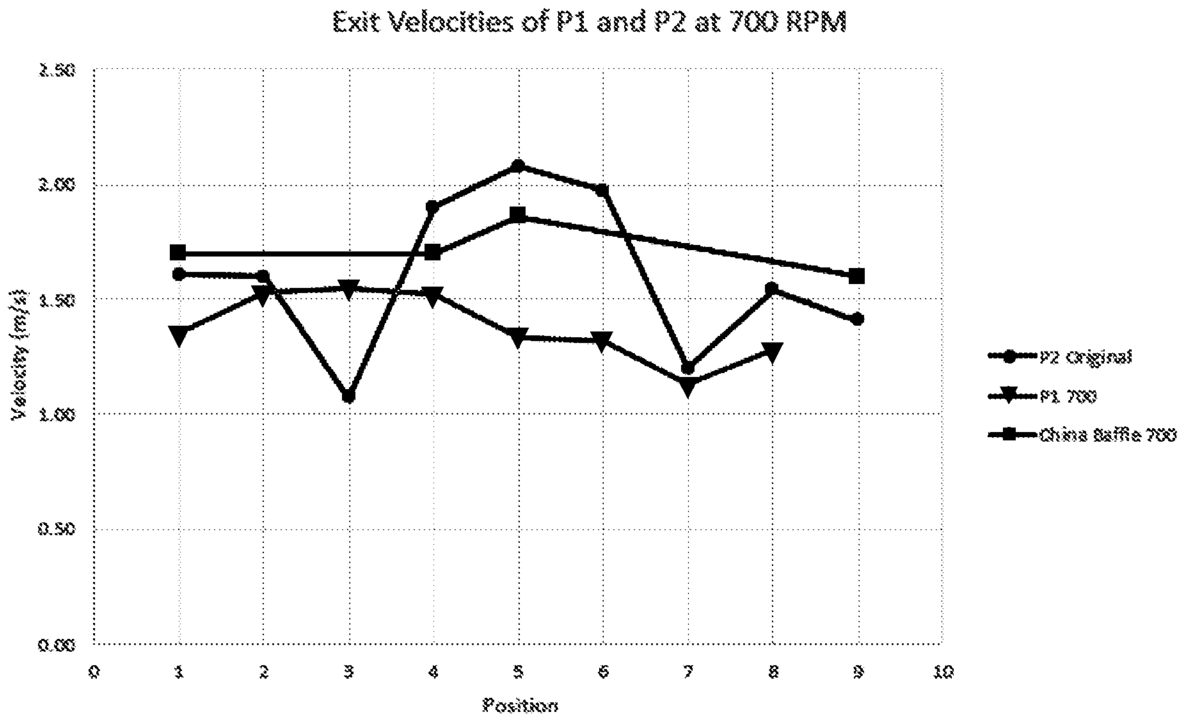

Exit Velocities of P1 and P2 at 700 RPM
2.50
2.00
1.50
1.00
0.50
0.00
Velocity (m/s)
0
1
2
3
4
5
6
7
8
9
10
Position
P2 Original
P1 700
China Baffle 700

FIGURE 14

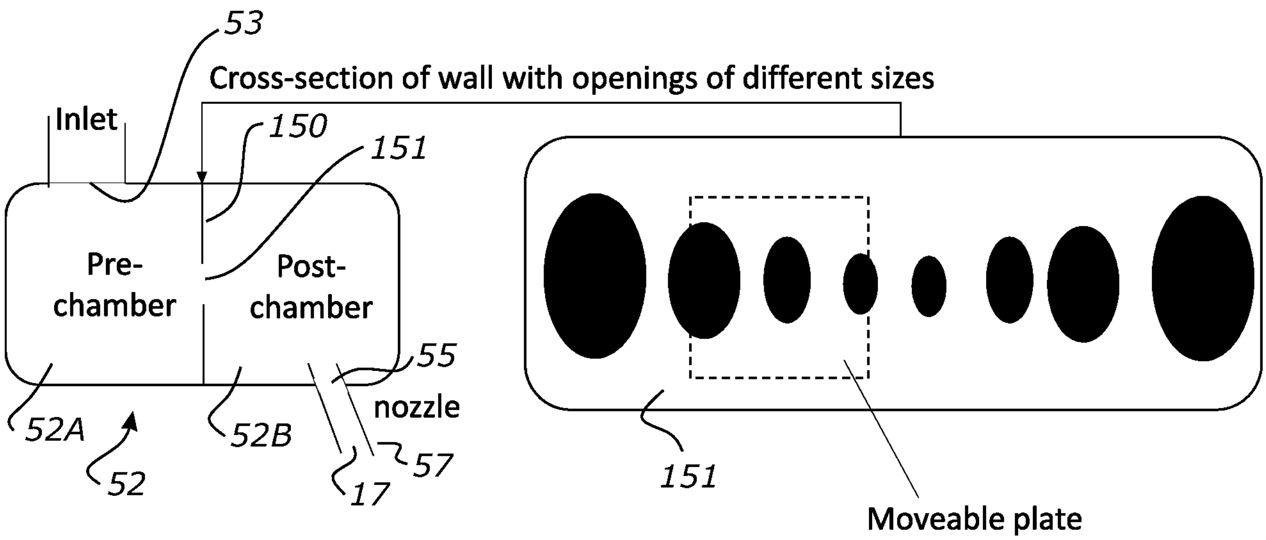


FIGURE 15

Prototype	Optimum Extraction (m^3/min)	Optimum Air curtain speed	Corresponding Flow Rate (m3/min)	Corresponding Exit Velocity (m/s)
P1	8-10	600-800	1.2 - 1.7	1.1 - 1.6
P2	12	600-800	0.9 - 1.4	1.5 – 2.0

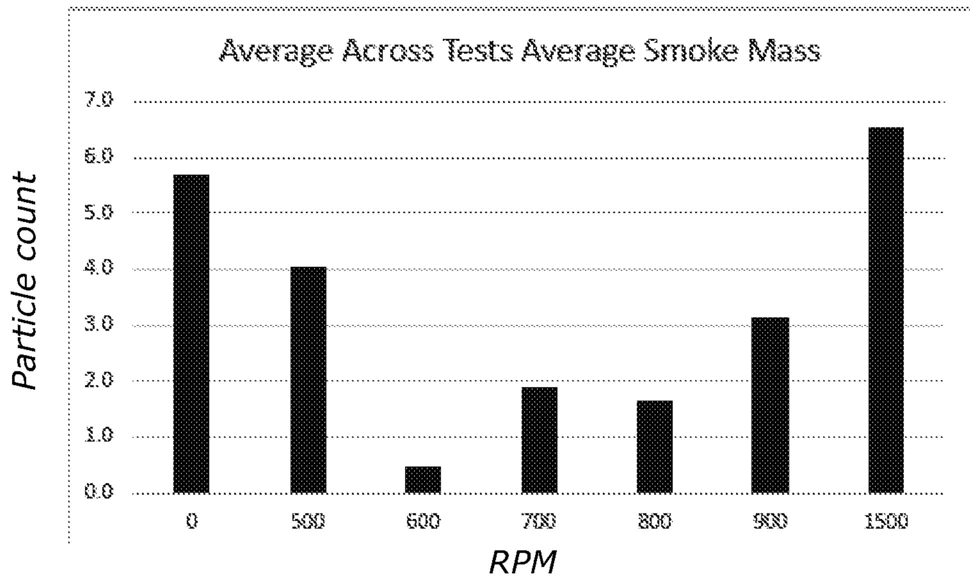
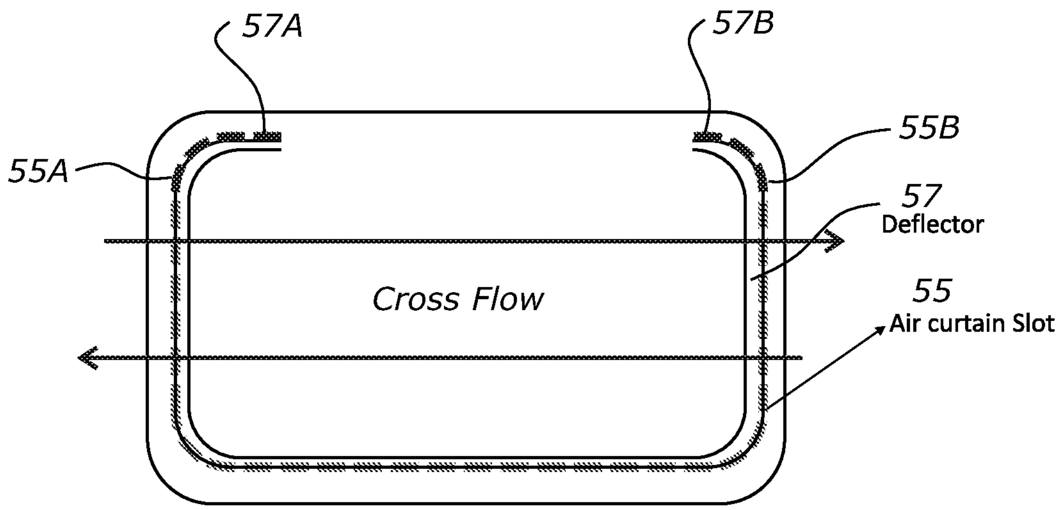


FIGURE 16



Underneath of hood

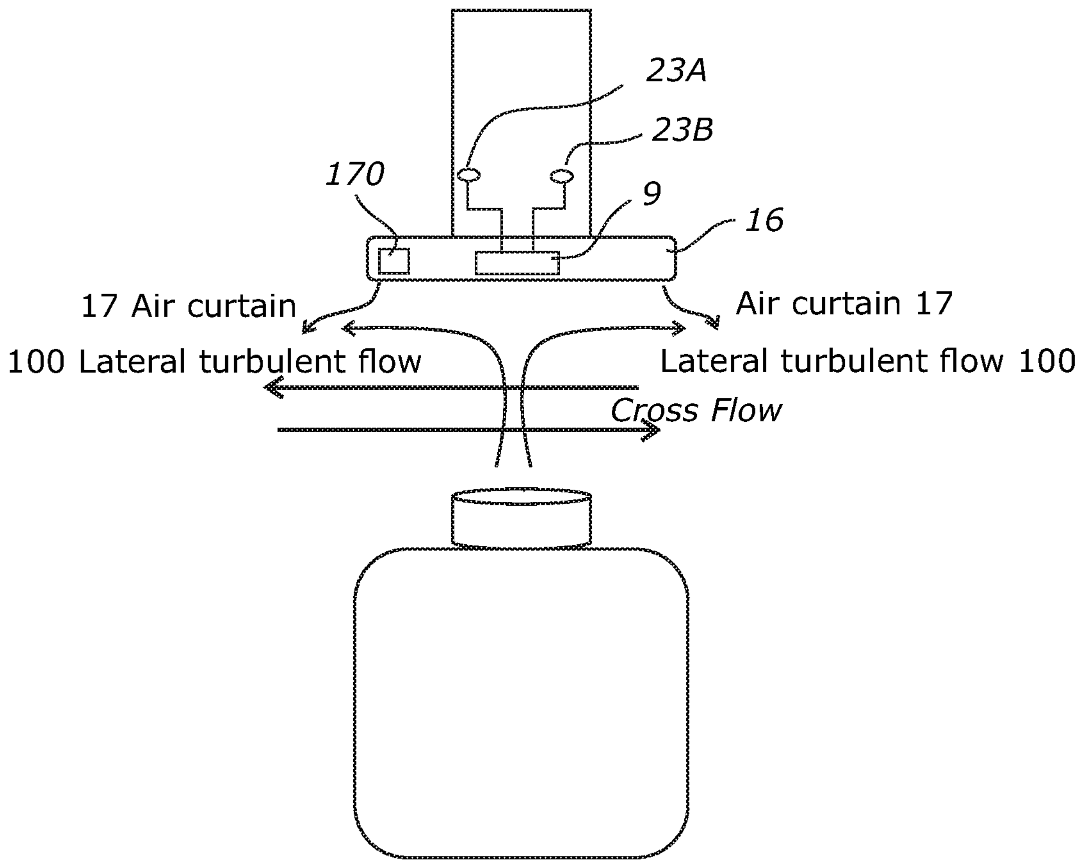
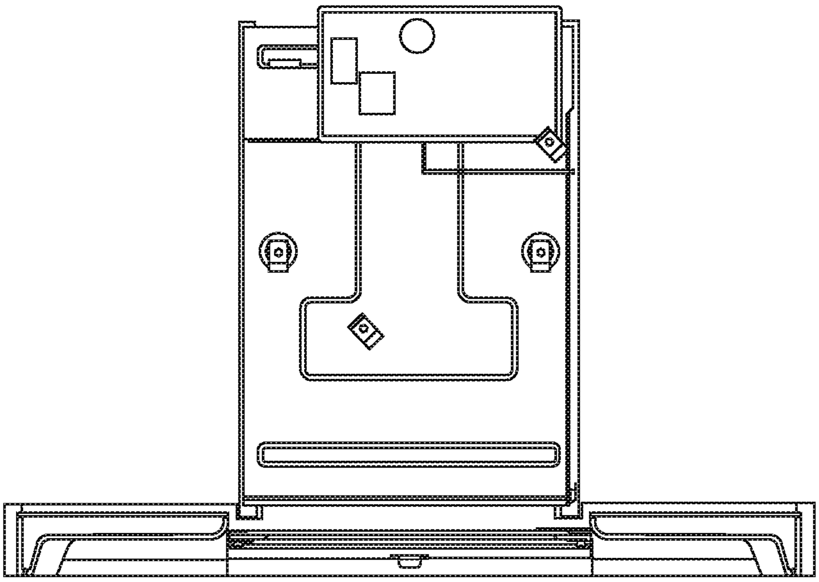


FIGURE 17



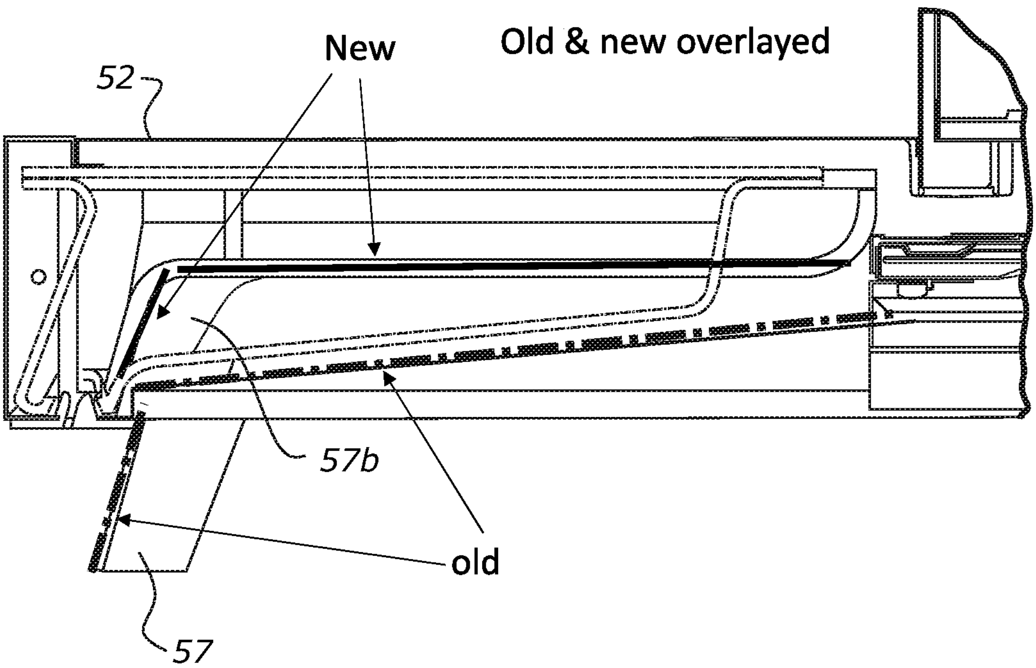


FIGURE 18

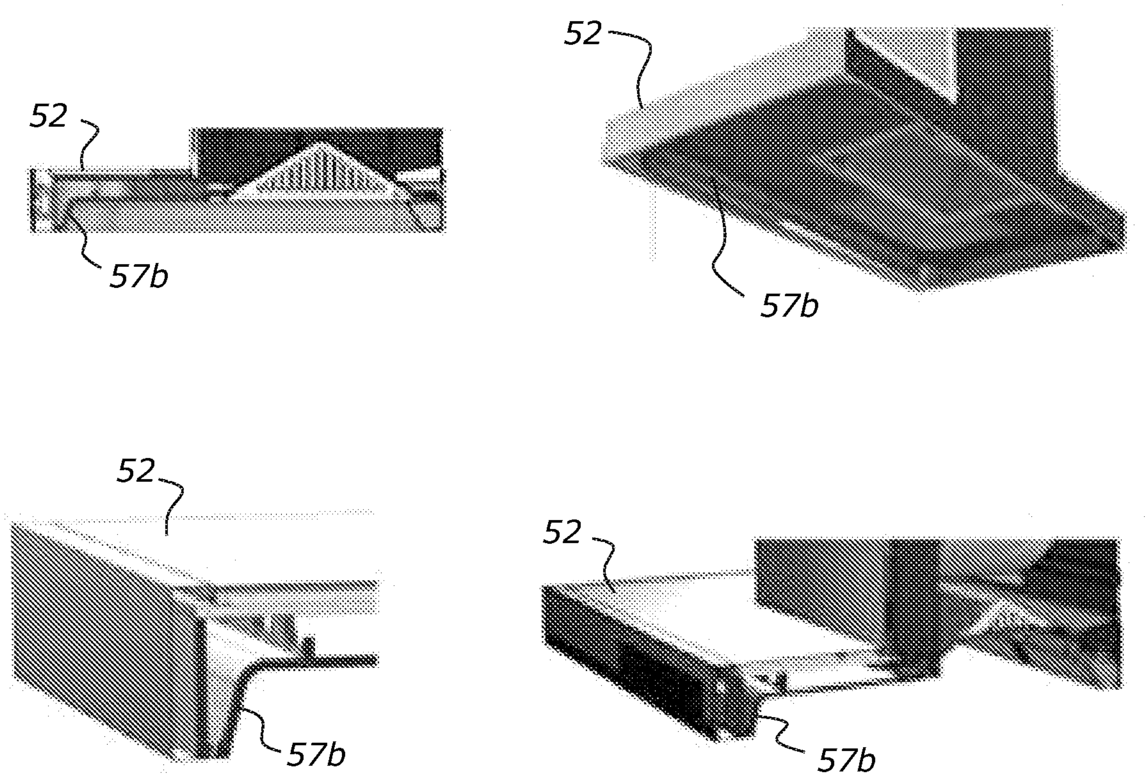


FIGURE 18
continued

P1 plenum

Baseline model

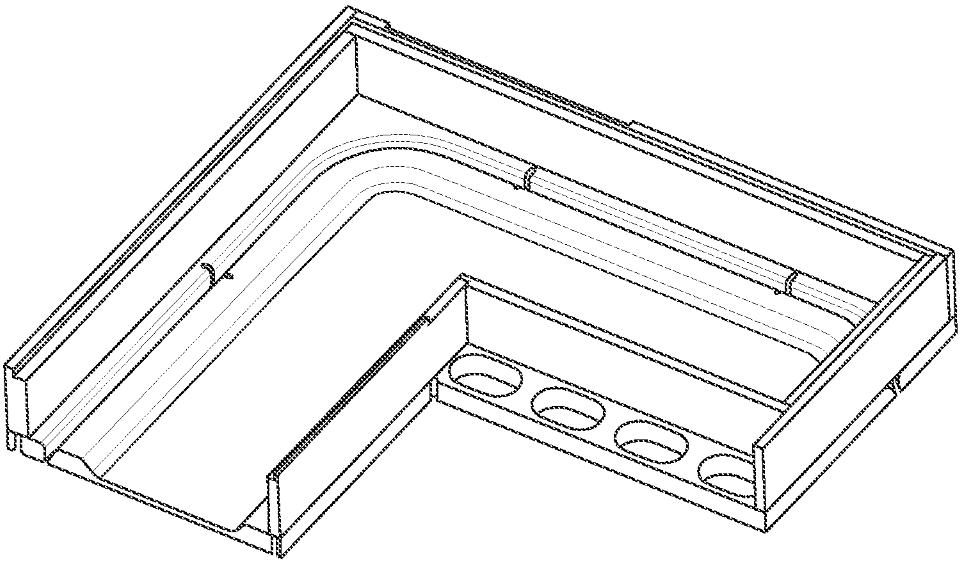


FIGURE 19A

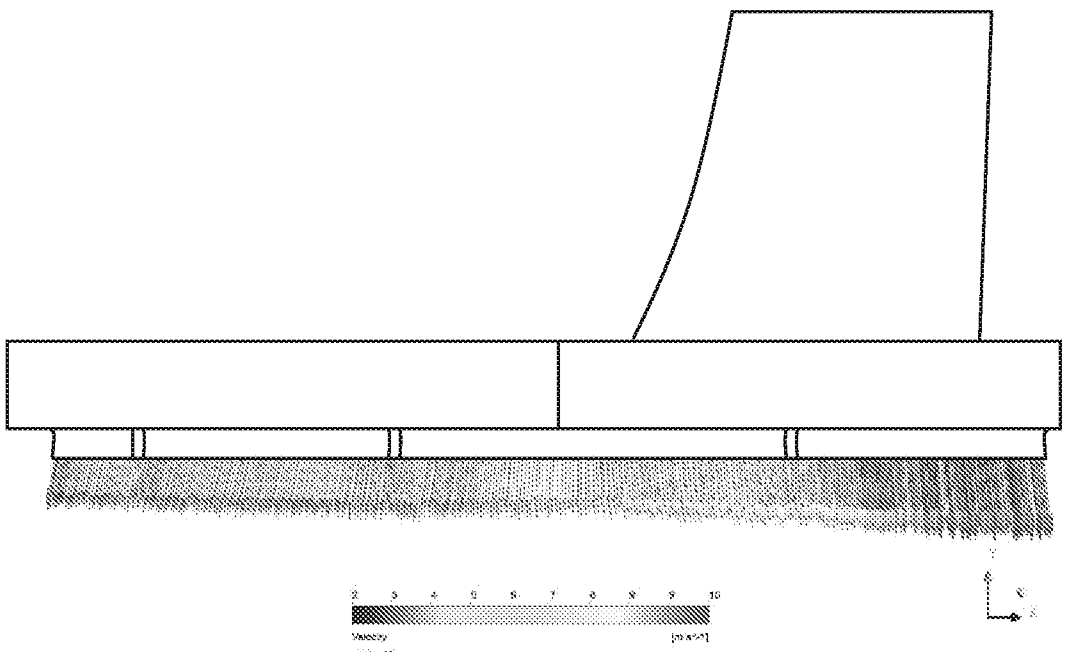


FIGURE 19B

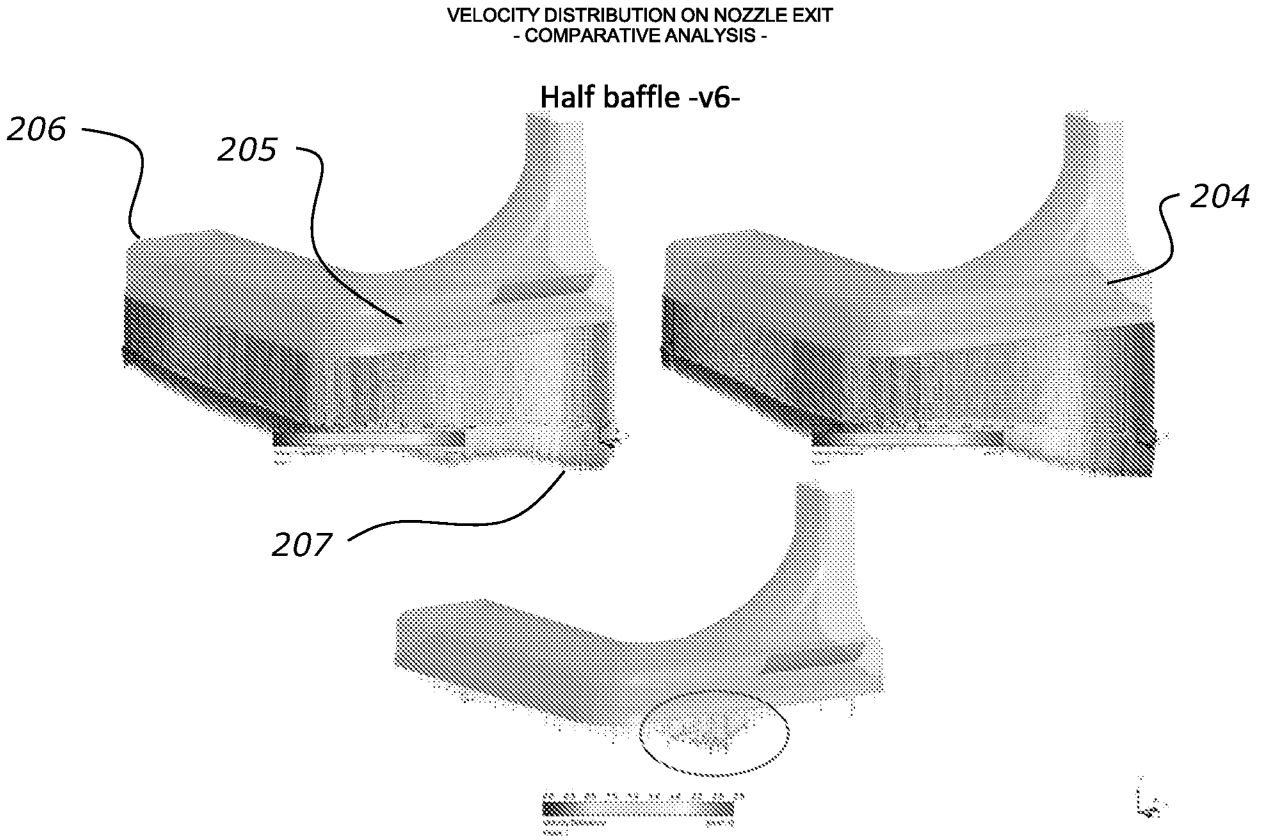

VELOCITY DISTRIBUTION ON NOZZLE EXIT
- COMPARATIVE ANALYSIS -
Half baffle -v6-
206
205
204
207

FIGURE 20

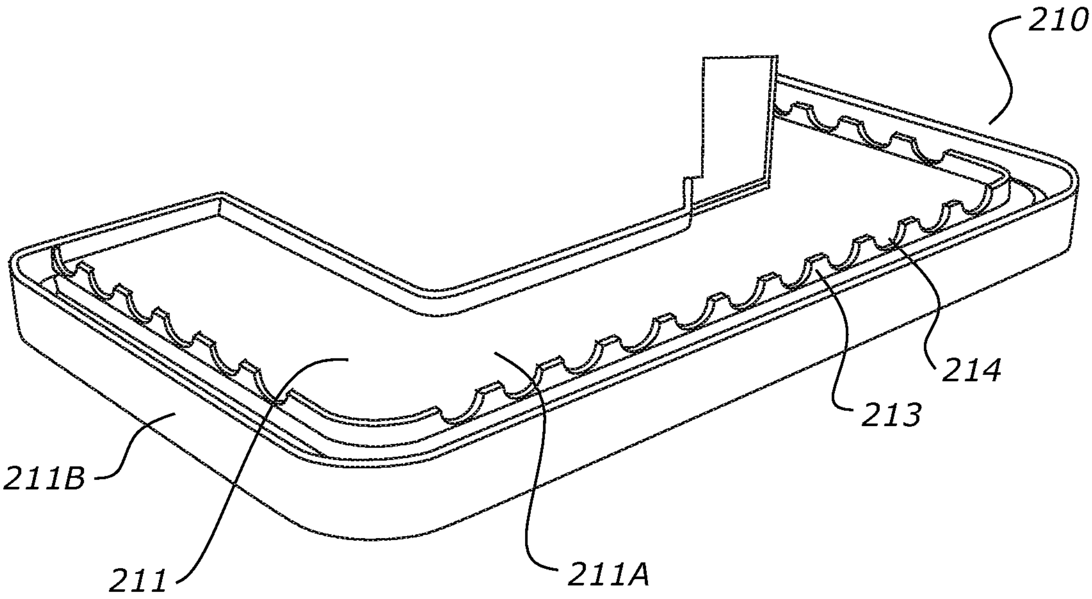


FIGURE 21A

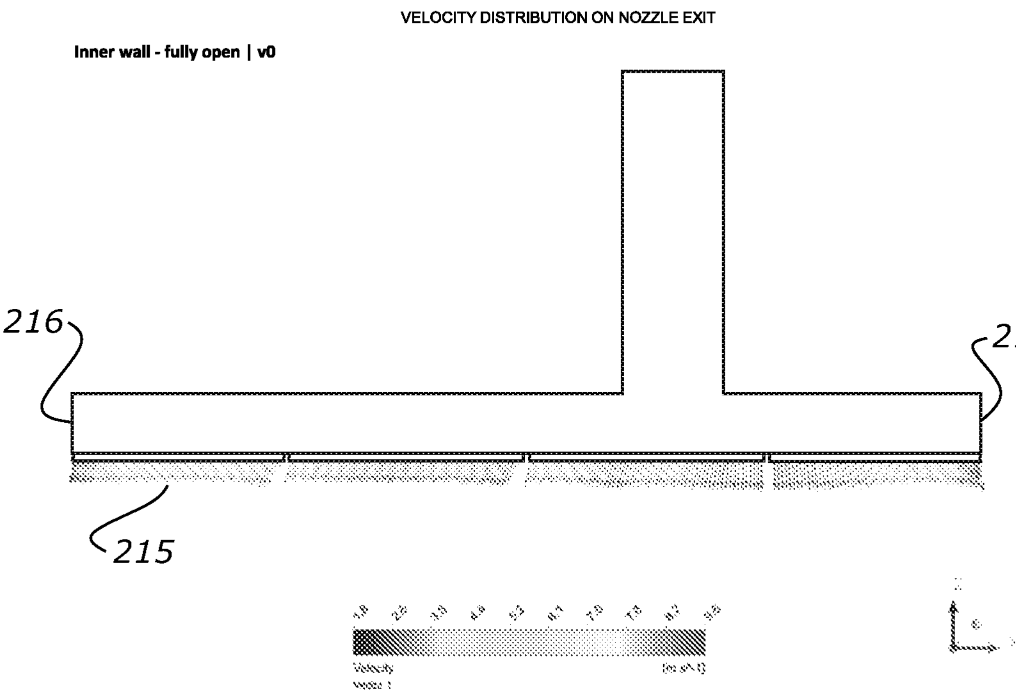
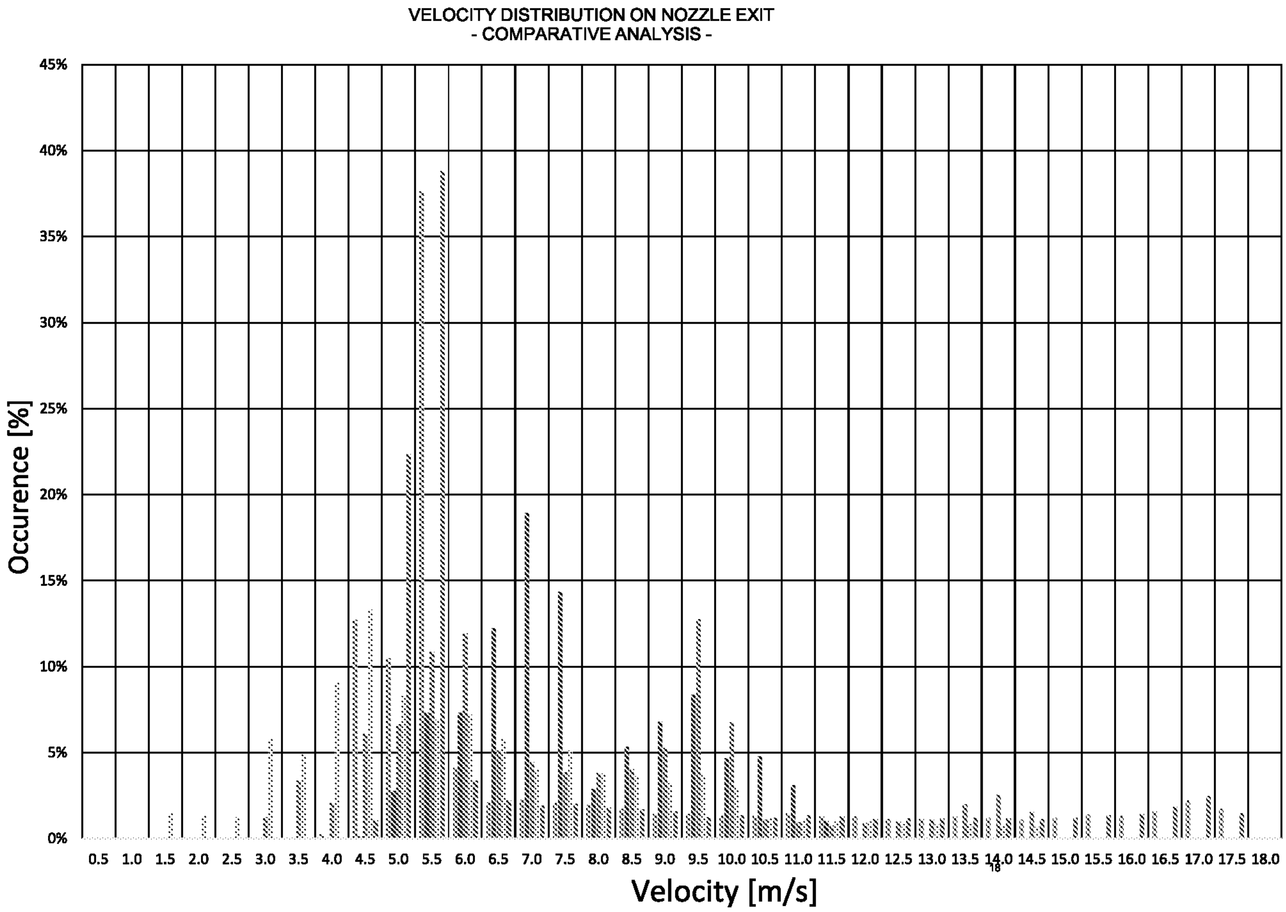


FIGURE 21B



- Large plenum – plenum variation#5, P2
- Large diverted front (half extended front diversion) – plenum variation #2
- Large diverted front (full front diversion) – plenum variation #6
- Large diverted front (full front diversion, tapered) – plenum variation #8
- Large taper wing – plenum variation #6

FIGURE 22

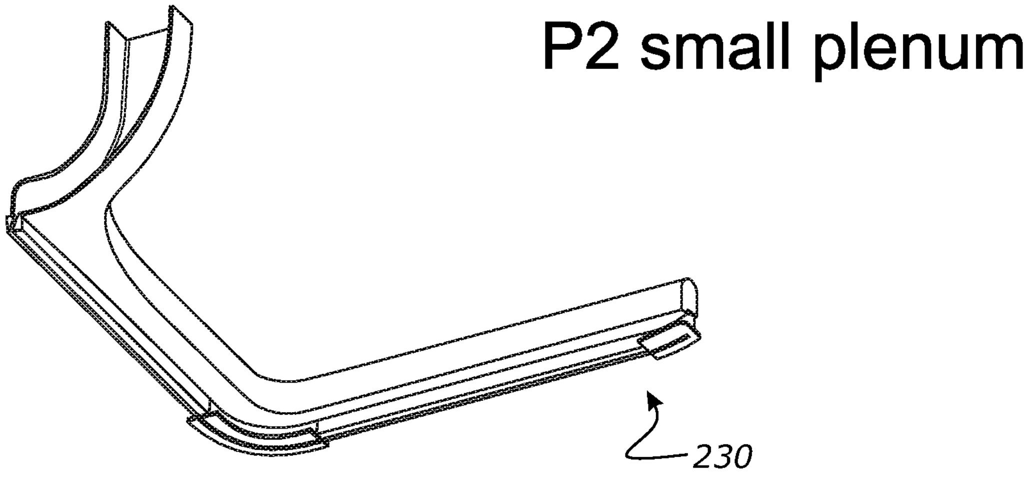


FIGURE 23A

Small plenum - VELOCITY DISTRIBUTION ON NOZZLE'S EXIT

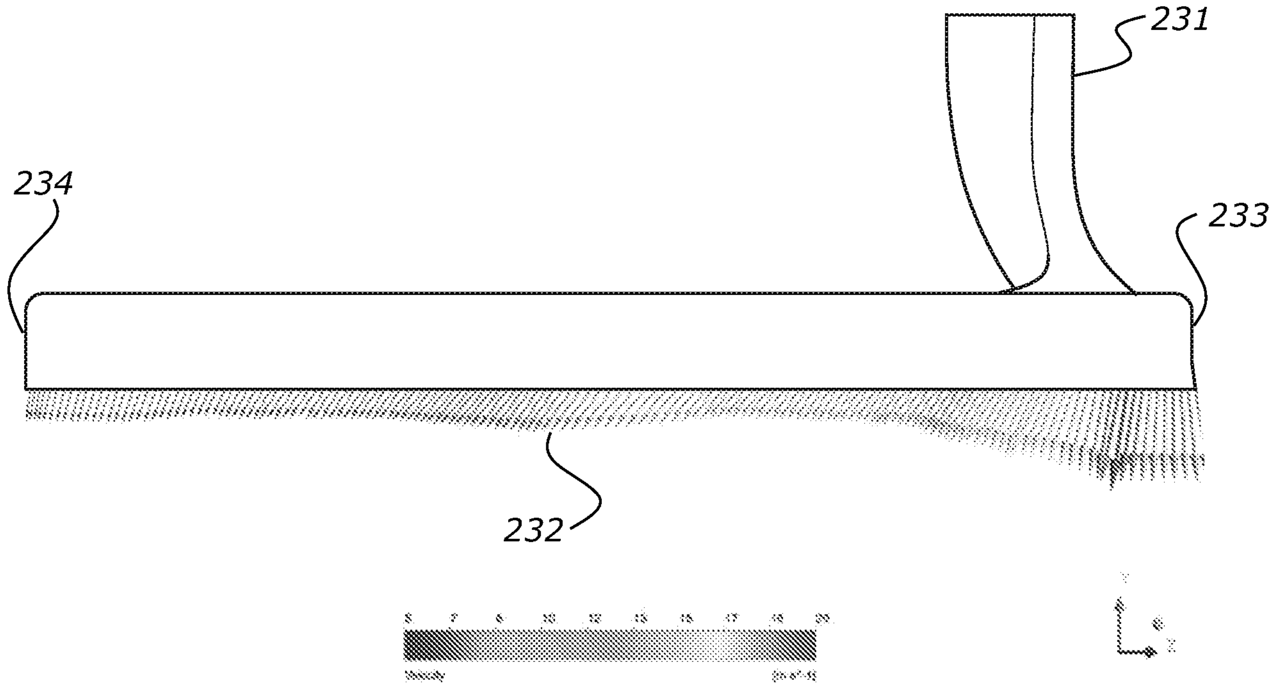


FIGURE 23B

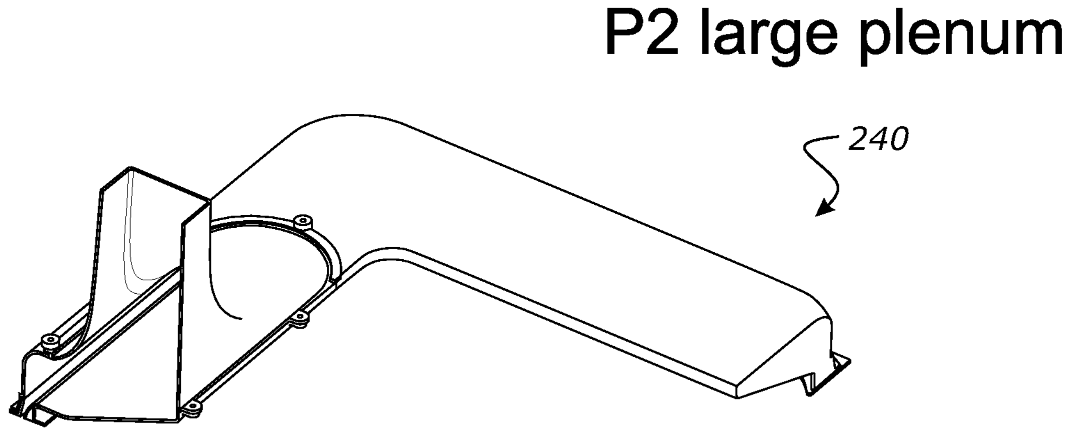


FIGURE 24A

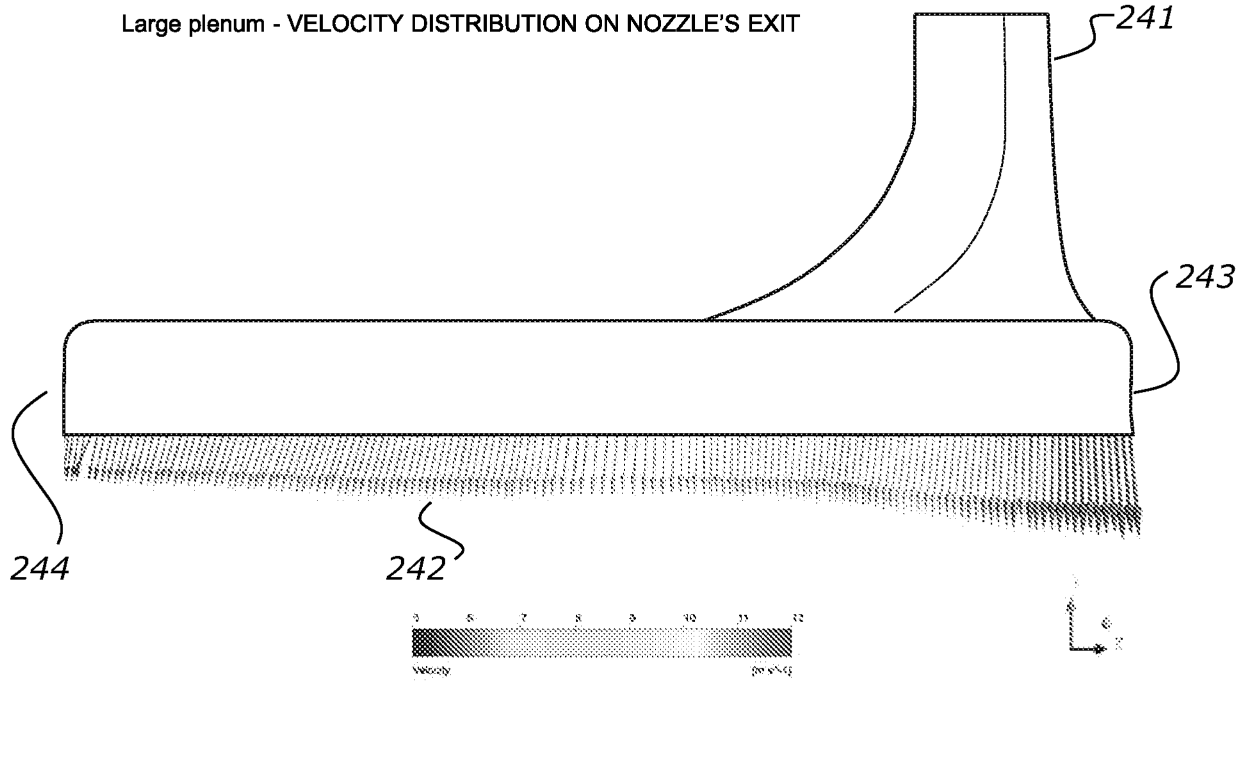


FIGURE 24B

Picture of the variation/full baffle???

Diverted Plenum

- Half baffle (v6)
- Full baffle (v7)

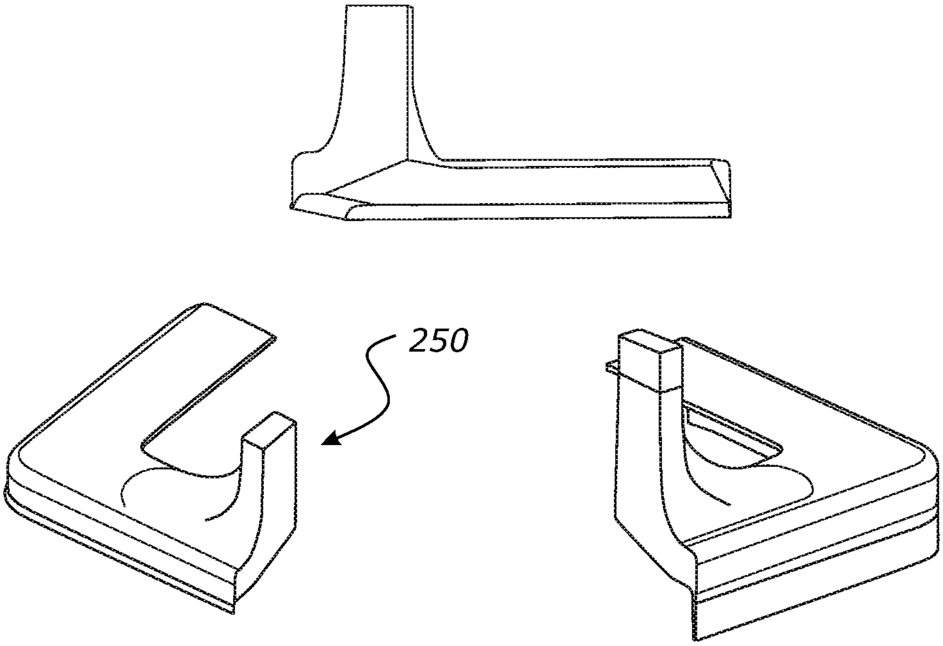


FIGURE 25A

VELOCITY DISTRIBUTION ON NOZZLE EXIT
- COMPARATIVE ANALYSIS -

Full baffle –v7-

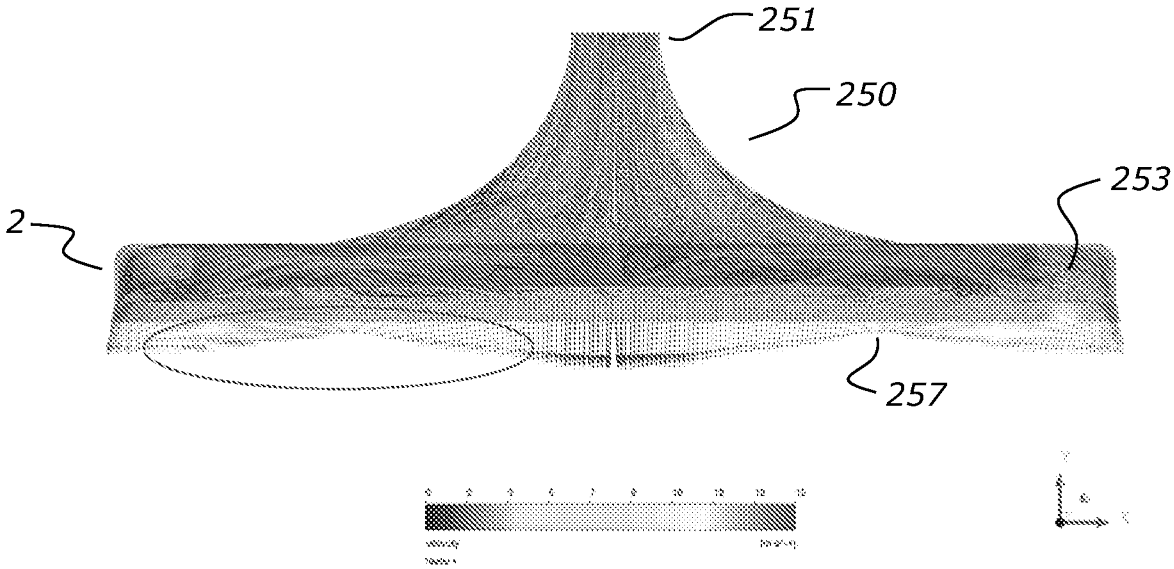


FIGURE 25B

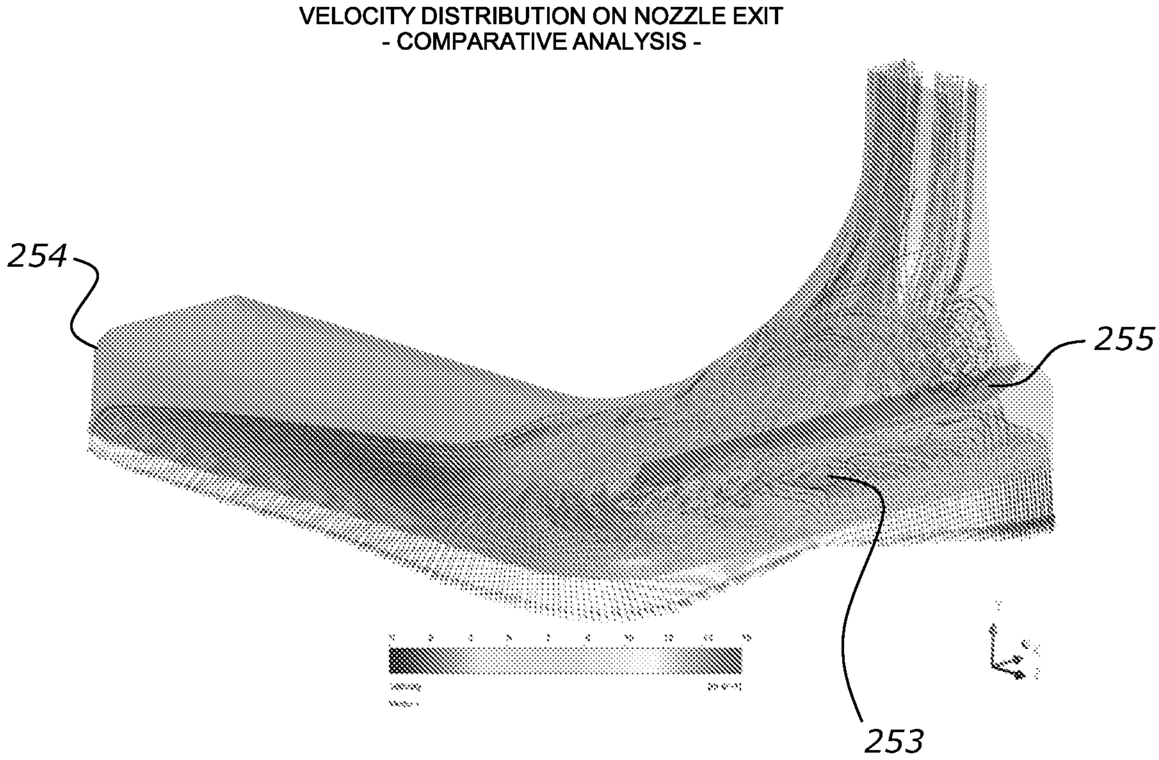


FIGURE 25C

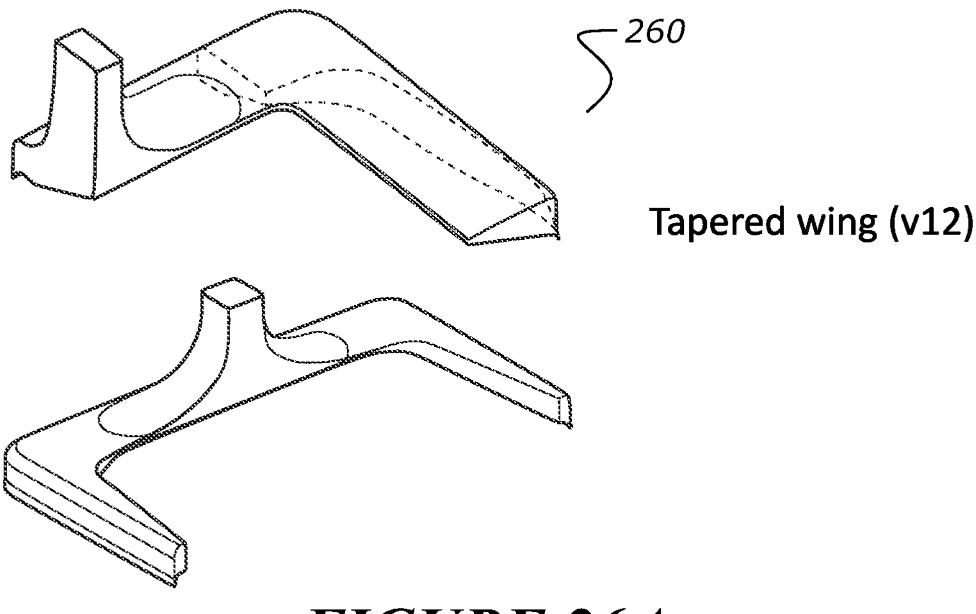


FIGURE 26A

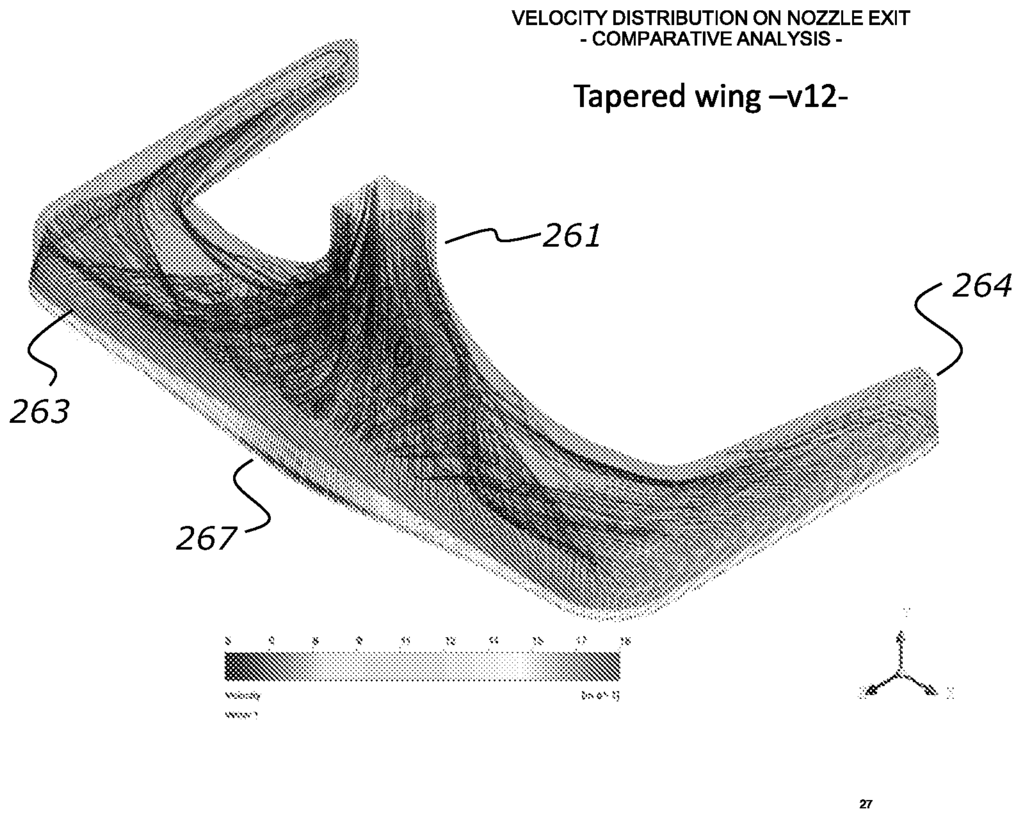


FIGURE 26B

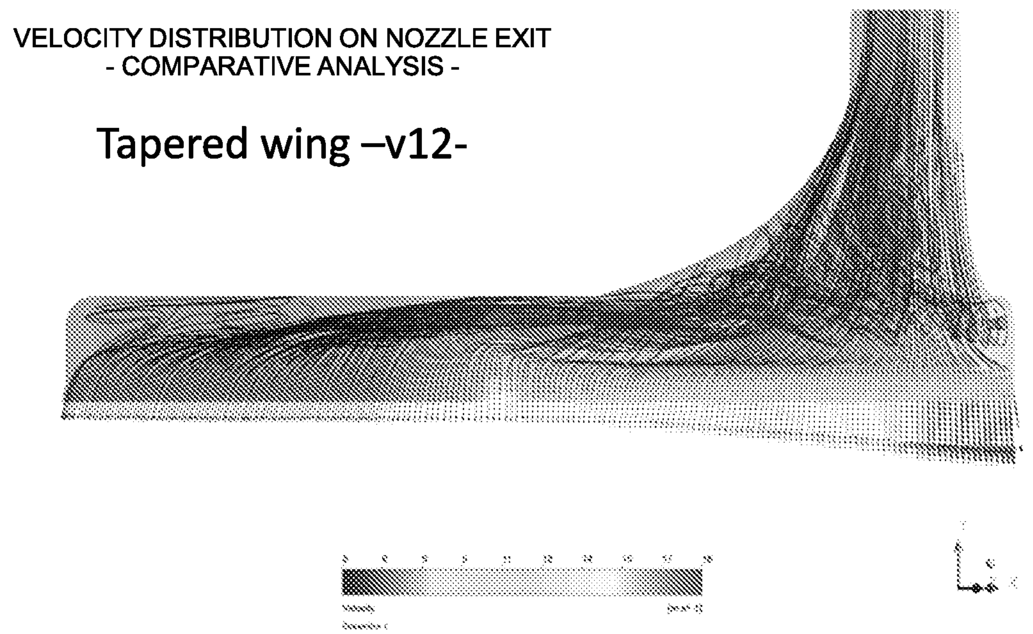


FIGURE 26C

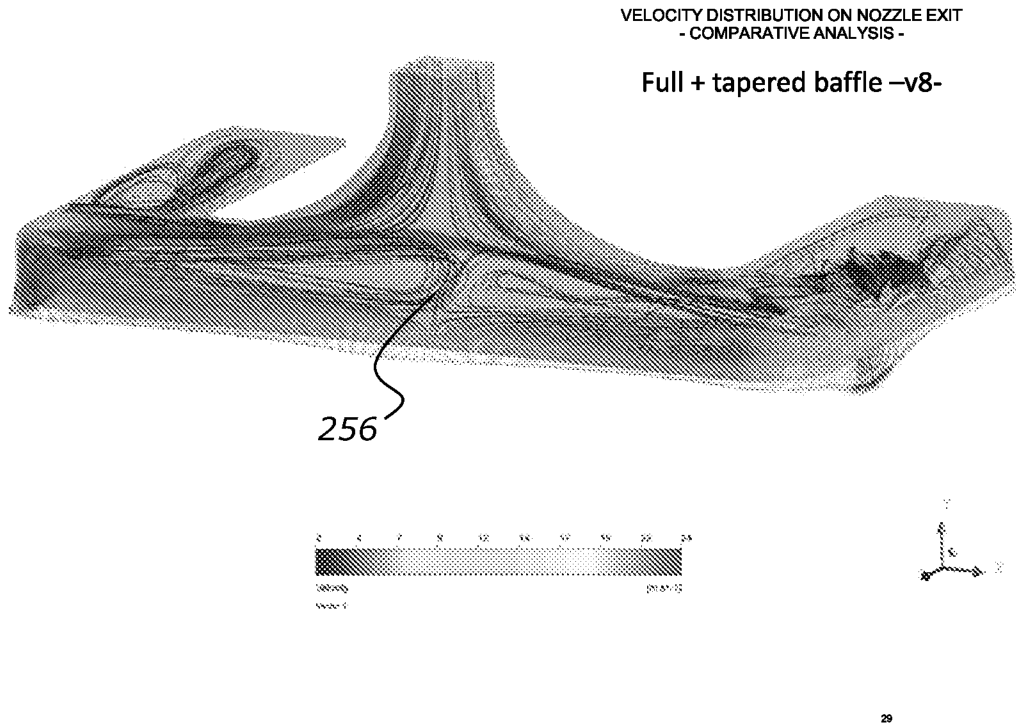


FIGURE 27A

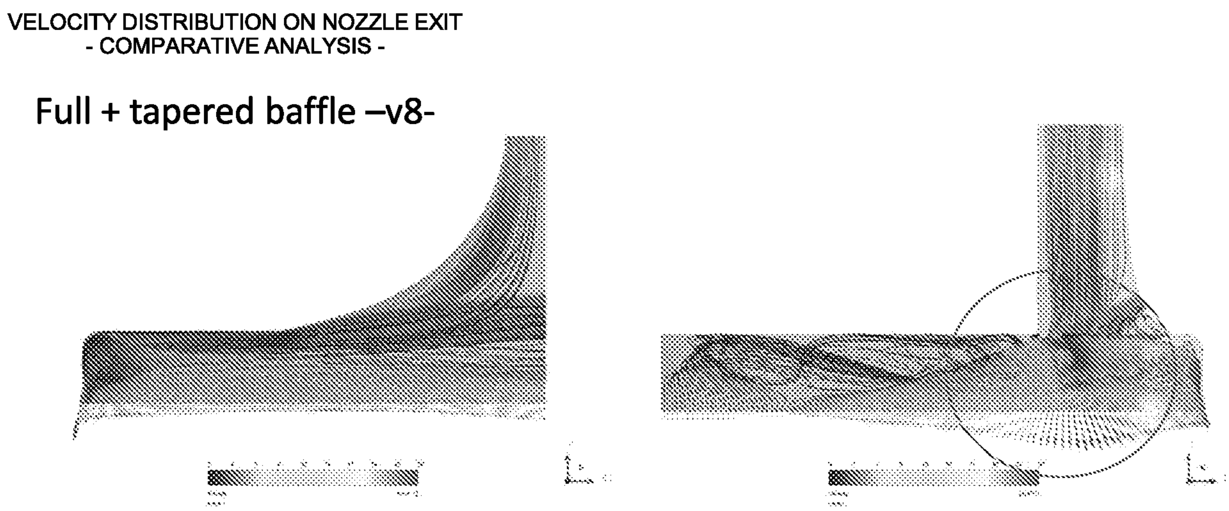
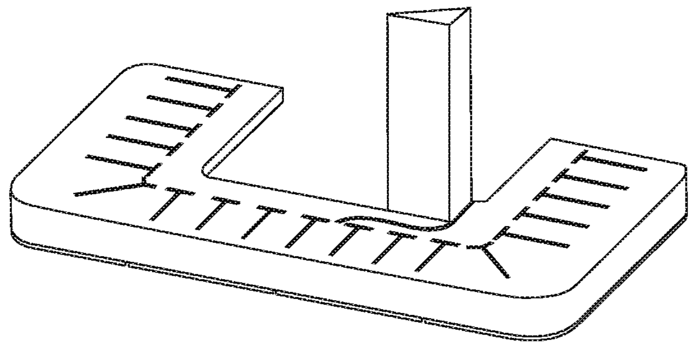


FIGURE 27B

v2 | Inner plenum splited
Outer plenum compartmentalized



Nozzle width = 3mm
Air volume = 0.0067m3

FIGURE 28A

VELOCITY DISTRIBUTION ON NOZZLE EXIT

Inner plenum splited & Outer plenum compartmentalized | v2

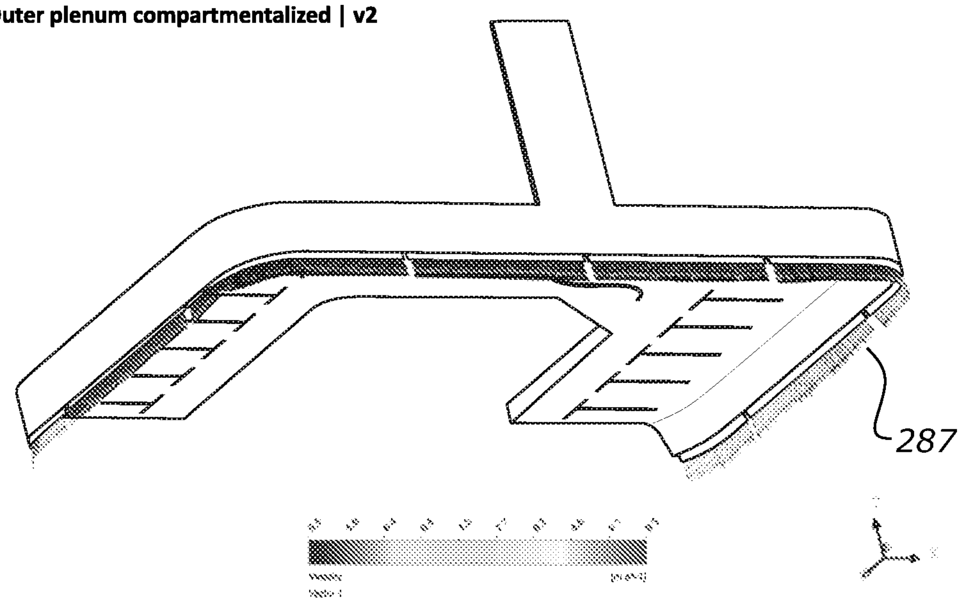


FIGURE 28B

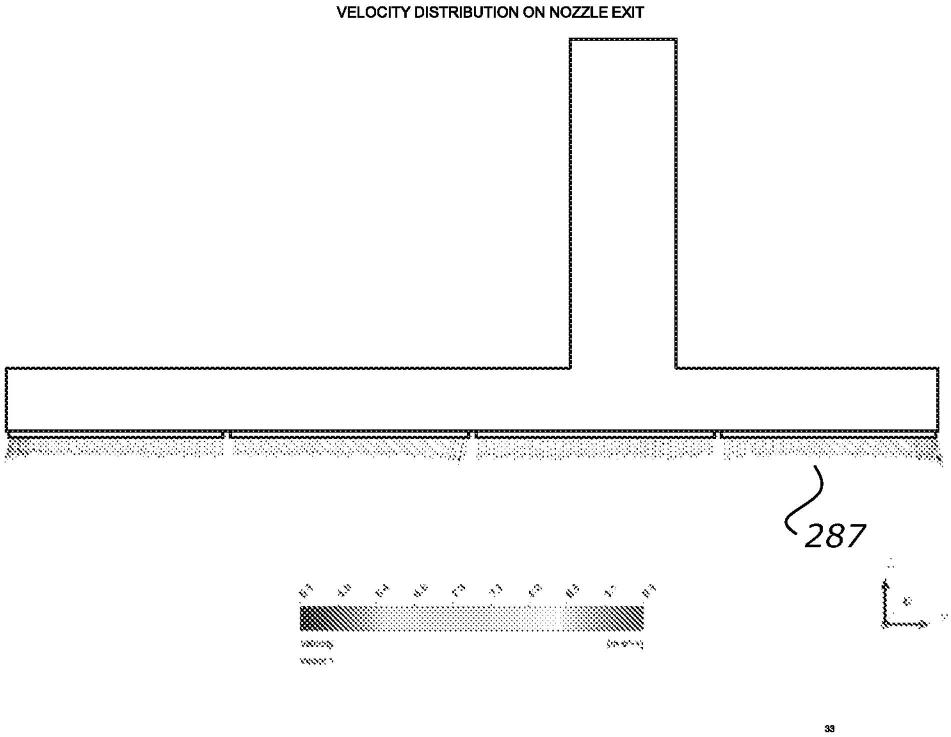


FIGURE 28C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2020/053068

A. CLASSIFICATION OF SUBJECT MATTER

F24C 15/20 (2006.01) F24F 9/00 (2006.01) F24F 3/16 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Databases: Google patents, AUSPAT, ESPACENET, PATENW. IPC and CPC marks: F24C15, B08B15, F24C15/20, F24C15/2028, B08B15/02, F24F9, F24F13, F24F7, Y10S55/36 Keywords: air curtain, deflector, extraction, exhaust, baffle, slideable, valve, aperture, suction, convection, vortex, eddies, fairing, aero, airfoil, wing, hood, plenum, cooktop, steam, odour, oil, fan, pressure, filter, recirculation, turbulence, *and similar terms.* The Applicant and Inventor were searched in AUSPAT, ESPACENET, and IP Australia internal databases.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 May 2020	29 May 2020
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	**Authorised officer** Alex Simmons AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262223620

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	**PCT/IB2020/053068**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6336451 B1 (ROHL-HAGER et al.) 08 January 2002 columns 2-11, figures 1-11, 13-23	1-18, 26-31
X	US 4450756 A (KLING) 29 May 1984 figures 2b, 3, 7a; column 4, line 62-68; column 5 line 65-column 6 line 15, column 6 line 30-line 46.	1-18, 26, 27, 30-31
X	EP 1967796 A1 (ITHO B.V.) 10 September 2008 figures 1, 3, paragraphs [0016]-[0018], [0021]-[0022]	1-18, 26, 27, 30-31
X	CH 682512 A5 (ZURECON AG) 30 September 1993, An English machine translation was obtained from Google Patents abstract, figures 4-6	1-13, 15-18, 26-31
X	CN 105485747 A (ZHENG JUNSHAN) 13 April 2016 abstract, figure 1, "detailed description of the invention"	1-6, 8-13, 15-18, 26, 27, 30 and 31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2020/053068

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:
   the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

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

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

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
   1-18 and 26-31

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box

Continuation of: **Box III**
This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

Group I: Claims 1-18 and 26-31 are directed to an extractor unit comprising a fan, an extractor duct, a hood coupled to the duct, and an inlet coupled to the extractor duct. The extractor unit apparatus arrangement is specific to this group of claims.

Group II: Claim 25 is directed to a method of controlling an extractor unit; said method involves providing a desired air curtain flow rate, air curtain air velocity, or exit velocity. The feature of controlling an extractor unit air flow is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore, there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied a priori.

This authority has not searched and reported on appended claims that introduce features of one of the claimed inventions and yet are additionally appended to claims directed to any other of the claimed inventions.

In particular, appended claims 19-24 introduce the features of the second invention (notably regarding air flow control) and yet are additionally appended to claims directed to the first invention.

In this regard, the International Search Report and the Written Opinion of this Authority has been restricted to the invention of 'Group 1' - Claims 1-18 and 26-31.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/IB2020/053068**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 6336451 B1	08 January 2002	US 6336451 B1	08 Jan 2002
		DE 19613513 A1	09 Oct 1997
		EP 0891519 A2	20 Jan 1999
		EP 0891519 B1	29 Sep 1999
		WO 9738266 A2	16 Oct 1997
US 4450756 A	29 May 1984	US 4450756 A	29 May 1984
		CA 1160095 A	10 Jan 1984
		DE 2837543 A1	13 Mar 1980
		GB 2029567 A	19 Mar 1980
		GB 2029567 B	22 Dec 1982
EP 1967796 A1	10 September 2008	EP 1967796 A1	10 Sep 2008
CH 682512 A5	30 September 1993		
CN 105485747 A	13 April 2016	CN 105485747 A	13 Apr 2016

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.