



- (51) **International Patent Classification:**
F24F 1/00 (2011.01) *F24F 7/06* (2006.01)
- (21) **International Application Number:**
PCT/GB2012/051774
- (22) **International Filing Date:**
24 July 2012 (24.07.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
1112859.2 26 July 2011 (26.07.2011) GB
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- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States (unless otherwise indicated, for every kind of regional protection available):** ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) **Title:** AIR CONDITIONING UNIT, SYSTEM AND METHOD OF COOLING OR HEATING

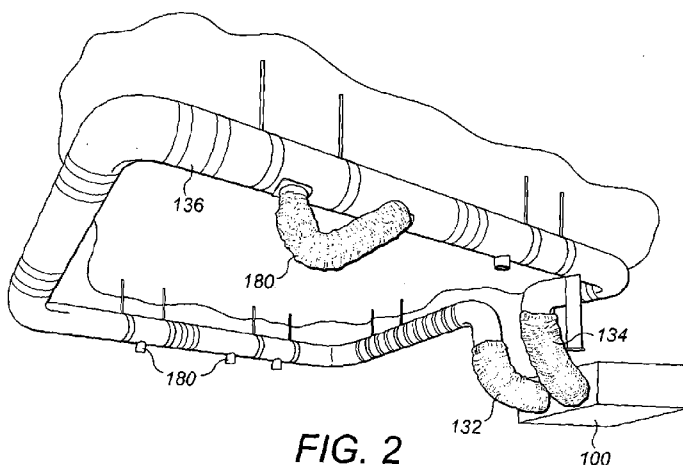


FIG. 2

(57) **Abstract:** An improved ducted unit is provided. The ducted unit has first and second outlets wherein the first and second outlets are connected to each other by outlet ducting to form a closed loop, the outlet ducting having at least two spaced apertures for ejecting air within the outlet ducting at substantially constant pressure. Consequently, the air pressure within the closed loop outlet ducting is substantially equalised meaning that the outlets operate at a substantially constant pressure. Operating noise is therefore reduced.

WO 2013/014443 A1

AIR CONDITIONING UNIT, SYSTEM AND METHOD OF COOLING OR HEATING

The present application relates to an improved air conditioning unit and in particular, although not exclusively, to an air conditioning unit suitable for recording studios, home cinemas and other noise sensitive areas.

5 There is a need for substantially silent air conditioning units, especially in the context of noise sensitive areas such as recording studios, sound recording booths or audio booths used for conducting hearing tests, home cinemas and the like. Such rooms are designed to block out as much external noise as possible and require any equipment within the room to work at minimal sound levels. For this reason, the walls of such audio booths are generally very thick and substantially soundproofed, meaning that they can get very hot, especially when the room is occupied for a long period of time. Such hot conditions may lead to extreme discomfort for the occupiers, and may furthermore cause excessive sweating which in itself leads to drips causing undesirable background noise which may interfere with the function of the sound-proofed room. Therefore some form of cooling within the sound-proofed room is essential.

10 At present, large and complex fan-assisted air conditioning systems are employed. Such air conditioning units comprise a refrigeration unit and a ducted unit. The refrigeration unit is typically mounted on the outside of a building and supplies refrigerant to the ducted unit in a closed loop. The ducted unit has an air inlet and an air outlet with a circulation fan to draw air over a radiator (heat is removed by the refrigerant). Conduits run from the ducted unit to disperse the cooled air into the room being cooled.

15 Fan based ducted units are standard equipment, which typically, during operation, emit a noise of around 32 decibels. However, by using silencers and increasing the size of the ducting from around 200 millimetres diameter to 600 millimetres diameter, specific units have been able to operate at a noise level of around 19 decibels. However, the noise needs to be below about 12 decibels to be placed inside a recording studio. Consequently, at the moment, to achieve the necessary noise level, the ducted units are placed outside the recording studio and combined with silencing baffles within extensive ducting between the fan and sound-proofed room, which necessarily requires at least four holes through the sound proof recording studio each of around 600 millimetres diameter. This is undesirable as it reduces the sound proofing of the recording studio and also requires significant destruction during installation of the air conditioning unit. Moreover, such air conditioning systems require a large amount of space for the ducting and corresponding air handling system to feed "silent air" into the booth due to the long path needed to overcome the significant sonic vibrations caused by the fan. Furthermore it is necessary to keep the fan as far away from the audio booth as possible. This all leads to an inefficient use of space and also energy inefficient air conditioning since chilled air passing through such a long path is likely to heat up before it reaches the sound-proofed room.

20 25 30 The outlet of a standard ducted unit is typically connected to two or more conduits for dispersing the cooled air around the sound-proofed room. Here, each ducting has a series of exit apertures and a closed end. The pressure of cooled air ejected from the apertures furthest from the ducting and nearest the closed end tends to be a lower pressure than the pressure of the cooled air ejected from apertures nearer the ducted unit and further from the closed end. This creates an uneven pressure across the apertures. Importantly, apertures ejecting the cooled air at higher pressures and therefore higher speeds operate at a higher noise level.

US 5 207 615, EP 0374527 and DE 2 649 279 all disclose ducted units in which conditioned air is ejected.

35 40 It is an aim of the present invention to attempt to overcome at least one of the above or other disadvantages. It is a further aim to provide a ducted unit able to operate at a noise level at or below the 12 decibel noise limit required by some noise sensitive areas.

According to the present invention there is provided an apparatus and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

45 According to one aspect there is provided an improved ducted unit comprising a sound-insulated housing having a sound absorption coefficient of at least 0.05 W/m^2 at 100 Hz and wherein the sound-insulated housing contains an air circulation unit to draw air through the ducted unit, wherein the air circulation unit is operated to spin between around 1000 and 750 revolutions per minute. Advantageously, it has been found that because the combination of sound-insulation and air circulation speed reduce the mechanical noise of the ducting unit, it is possible for the ducted unit to operate at a noise level of less than 10 decibels. Consequently, the ducted unit can be placed

within a sound-proofed room. This is advantageous because it reduces the distance the air ejected from the outlet has to travel from the ducted unit to the room, which increases the efficiency when the ducted unit is used in an air conditioning system. Moreover, it is not necessary to form holes through the sound-proofed room for ducting to penetrate. Rather, when the ducted unit is used in an air-conditioning system, only in and out fluid pipes connecting a radiator element in the ducted unit to an external refrigeration unit are required. These pipes are significantly smaller than air ducting so requiring less disruption and sound leakage.

Sound absorption is defined as a co-efficient, ranging from 0.0 for total reflection, to 1.0 for total absorption. The sound absorptive properties of a material are defined in BS EN ISO 11654:1997, which gives three relevant properties: Sound Absorption Coefficient (α_s), which are Individual sound absorption figures quoted in third octave frequency bands; Practical Sound Absorption Coefficient (α_p), which are sound absorption figures quoted in single octave frequency bands; and Sound Absorption Rating (α_w), which is a single figure rating based upon the values of (α_p), compared to a reference weighting curve. It has been found that by lining the inside walls of the housing with a sound absorbing material, a sound-insulated housing is achieved which gives surprisingly suppressed noise. It is important that the using the third octave frequency band data, the sound insulating has a sound absorption coefficient of at least 0.05 W/m^2 at 100 Hz.

In one exemplary embodiment, the sound absorbing material has open cells or voids, through which the noise travels and is dissipated. However, in one exemplary embodiment, the inner most surface of the sound insulating over which the air travels is substantially continuous and flat. That is, the open cells or voids are closed, for instance with a silicone layer. This is beneficial as turbulence is not introduced in to the air flowing over the sound insulation, which would otherwise increase the noise of the air, whereas the noise energy in the air still permeates through the smooth layer and into the underlying voids for dissipation.

In the exemplary embodiments the sound-insulated housing provides an enclosure for the air circulation unit to be arranged between an inlet and an outlet, wherein operation of the air circulation unit causes air to be drawn through the inlet and expelled through the outlet. In one exemplary embodiment, the ducted unit is suitable for use in an air-conditioning system. Here, the sound-insulated housing comprises an enclosure suitable to arrange a radiator in the air flow. Consequently, by running refrigerant through the radiator, the air expelled from the outlet of the ducted unit can be cooled with respect to the inlet. Here, the ducted units are typically rated for their ability to extract heat. Although the combination of fan speed and insulation rating provide beneficial results for larger ducted units, they are particularly effective for 5 kW ducted units.

In the exemplary embodiments the air-circulation unit is suitably a fan having a rotating blade or blades.

In one exemplary embodiment, the ducted unit has a plurality of inlets. The ducted unit may also have a plurality of outlets. However, it is preferable if the ducted unit has more inlets than outlets as this reduced the air circulation noise. For instance in one particular exemplary embodiment, the ducted unit has three inlets and two outlets. The increase in area of the inlet as opposed to the area of the outlet means that the ducted unit has to work less hard to pull air into the unit, which reduces the sound generated by the air being sucked through the inlet(s). This goes against conventional wisdom that suggests that the area of the inlet should equal the area of the outlet so as to balance the system.

The ducting unit may be connected to inlet and outlet ducting, each having one or more inlets and outlets to a room, such as a sound-proofed room. Here, the inlet and outlet ducting lengthens the distance from the inlet and outlet of the ducted unit before the air is expelled into the room. In one exemplary embodiment, the ducted unit inlet and outlet ducting are provided as a single unit housed on a common frame. Consequently, the single unit needs limited installation other than being connected to the refrigerant (if used as part of an air-conditioning system).

In an alternative exemplary embodiment, the ducted unit comprises at least one pair of outlets. Here each outlet is connected to an outlet ducting having a plurality of apertures, wherein the outlet ducting of each outlet in said pair is connected to the other to form a substantially closed loop. Consequently, the air pressure within the closed loop outlet ducting is substantially equalised meaning that the outlets operate at a substantially constant pressure. It will be appreciated that the closed loop outlet ducting provides advantages when used independent to the exemplary ducted units and so according to a second aspect there is provided an improved ducted unit having first and second

outlets of air wherein the first and second outlets are connected to each other by ducting to form a closed loop, the ducting having at least two spaced apertures for ejecting air within the ducting at substantially constant pressure.

In the exemplary embodiments, the outlet ducting has a substantially constant cross-section. The apertures are spaced along the closed loop outlet ducting so that apertures are spaced at varying distances from each outlet of the ducted unit. A particularly suitable ducting comprises 250mm diameter ducting.

In the exemplary embodiments, at least 12 or at least 18 apertures are provided dependent on the specific design of the sound-proofed room. However, preferably the closed loop outlet ducting has at least 2 outlets apertures per kW that the ducted unit is rated to, which has been found to provide a particularly quite air distribution. In particular, for a 5kW ducted unit, it is particularly suitable to provide 12 outlets or more. In the exemplary embodiments, the apertures are formed on nozzles or extensions to the closed loop outlet ducting. For instance, solid or flexible tubing may be arranged to extend from the closed loop outlet ducting in order to change the direction of airflow from one plane, for instance along a roof, to a second plane, for instance substantially downwardly. The apertures are suitably 80mm diameter rings. The tubing extending from the outlet ducting may be substantially similarly sized. However, again it will be appreciated that the exact sizing will be dependent on the application. It has been found though that particularly low noise levels can be achieved using apertures having an area approximately 10% of the cross sectional area of the closed loop outlet ducting, though between 9% and 11% or 8% and 12% have also been found to be beneficial.

According to a further aspect, a first ducted unit is used in an air-conditioning system and a second ducted unit is used to supply fresh air. Particularly suitably, one or both of the first and second ducted units may be connected to a closed loop outlet ducting in accordance with previous aspects. Moreover, one or both of the ducted units may be located in a soundproofed room, wherein the ducted units are in accordance with previous aspects.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

- Figure 1 is a schematic view of a ducted unit according to a first exemplary embodiment;
- Figure 2 is a perspective view of an exemplary ducting arrangement for use with a ducted unit;
- Figure 3 is a perspective view of a first embodiment of an exit aperture for use with a ducting arrangement;
- Figure 4 is a perspective view of a second embodiment of an exit aperture for use with a ducting arrangement;
- Figure 5 is a schematic front view of a ducting unit of a second exemplary embodiment;
- Figure 6 is a schematic plan view of an air conditioning installation of an exemplary embodiment;
- Figure 7 is an end view through a ducting arrangement for use in Figure 6;
- Figure 8 is a schematic plan view of an air conditioning installation of a further exemplary embodiment;
- Figure 9 is an end view through a ducting arrangement for use in Figure 7;
- Figure 10 is a cross section through an inlet ducting of a further exemplary embodiment;
- Figures 11, 12 and 13 are further exemplary embodiments of alternative arrangements of ducting for use with a ducted unit;
- Figure 14 is a schematic plan view of an air conditioning installation of a further exemplary embodiment;
- Figure 15 is a perspective view of a section of ducting according to a further embodiment;
- Figure 16 is a perspective schematic view of an overhead air conditioning unit according to a further embodiment;
- Figure 17 is a perspective view of a section used in Figure 16, and
- Figure 18 is a side view showing how the section of Figure 16 is supported.

Referring to Figure 1, an exemplary ducted unit 100 is shown. The ducted unit 100 houses an air circulation unit 200 within a sealed housing 110. The air circulation unit 200 suitably comprises a rotating blade arranged to pull air from an inlet 120 and to push air towards an outlet 130. In Figure 1, air movement is depicted by the arrows. The air circulation unit is arranged to rotate at a between 1200 and 900 revolutions per minute. However, a fast speed of around 1191 and a slow speed of around 990 revolutions per minute are particularly suitable. It has been found that when combining the reduced air circulation unit with a sound insulated housing a ducted unit having an external operating noise of less than 10 decibels is achieved. These results are achieved using an off the shelf 5kW ducted unit adapted to include sound insulation on the inside of the housing. Here, it has been found that it is necessary for

the sound insulation to have a sound absorption coefficient of at least 0.05 W/m^2 at 100 Hz. Advantageously, the combined result of a sub 10 decibel ducted unit allows the ducted unit to be provided within a sound sensitive area such as a sound-proofed room.

5 Typically, the housing 110 is formed from a box-like structure having a geometric shape for low cost manufacture. Here, sheet materials are welded to seal the seams of the housing. In Figure 1, the inlet in the housing is shown as being three apertures, each linked to an inlet ducting 122, 124, 126. Here, each inlet ducting has a substantially tubular form. However, although three inlet apertures are shown in the specific embodiment, one or more inlet apertures are sufficient. It is though advantageous to provide greater inlet capacity (e.g. inlet area) to outlet capacity (e.g. outlet area) and it will be appreciated that this can be achieved with larger apertures or a greater number of apertures. In Figure 1, the outlet 130 is shown as being two apertures, each linked to an outlet ducting 132, 134. Here, each outlet ducting has a substantially tubular form. Again, only one or more outlet apertures are required, however, as herein described it is advantageous if the outlet apertures are grouped in pairs. In Figure 1, the inlet and outlet ducting is shown on the outside of the ducted unit housing 110. However, as shown in Figure 5, the ducted unit housing 110 may extend to incorporate the inlet and outlet ducting. In any event, the inlet and outlet ducting may also be lined with the sound insulation material.

Optionally, and in accordance with a further exemplary embodiment, the ducted unit is suitably used within an air-conditioning system. Here the air-conditioning system includes a refrigerant supply 300, typically from an external refrigeration unit (not shown). Referring to Figure 1, the refrigerant supply is fed to the ducted unit 100 by inlet and outlet pipes 302, 304 respectively. In this embodiment, a radiator 310 is also housed within the ducted unit housing 110. The radiator 310 is arranged in the airflow pathway through the housing so that a heat transfer process can take place between the refrigerant flowing within the radiator 310 and the air being driven through the ducted unit. Consequently, the air expelled from the outlet 130 is cooler than that pulled through the inlet 120.

Referring to Figure 5, a further exemplary embodiment is shown. Here an assembly 400 is shown, wherein the assembly 400 is a stand alone unit that requires no installation other than the connection of a refrigerant supply (not shown), but only when used as part of an air-conditioning system. The advantage of providing a stand alone assembly is that in the case of malfunction or maintenance, the assembly can be simply swapped out and the work undertaken elsewhere. This is particularly important as sound proofed rooms are often expensive and therefore have a high premium on working time. Significant savings can therefore be made by reducing downtime necessary to repair or maintain an assembly within the sound-proofed room. In Figure 5, the ducted unit 100 previously described is incorporated in a single housing that also includes inlet ducts and outlet ducts. Suitably, the ends of the inlet and outlet ducts may be bent at elbows to extend through a grill 114, 116 on the front face of the assembly 400. Suitably the inlet ducting may draw air from a lower area of the assembly and the outlet ducting ejects air from an upper area of the assembly. In figure 5, inlet and outlet ducting 122,124,126, 132, 134 are shown. However, the inlet and outlet ducting may be a substantially open to the housing or channels may be provided within the housing rather than the use of ducting. In this case the panels used to define the channels may also include sound insulation. Furthermore, referring to Figure 10, and in accordance with a further exemplary embodiment, rather than being straight, the inlet and outlet ducting may include one or more bends in order to compact the size of the silencer.

Referring to Figure 2, a further exemplary ducted unit 200 is shown. Here, the ducted unit is substantially as herein described. However, rather than the outlet ducting being substantially straight ducting to expel air in to a specific locality, the outlet ducting is substantially elongate and arranged to expel the air from the air circulation unit 200 about a large area. Importantly, in this exemplary embodiment, the outlet ducting forms a closed loop. That is, the outlet duct 132 is connected at its distal end to outlet duct 132 to form a closed loop. Here apertures 180 are arranged along the closed loop outlet ducting 136 to supply air to the soundproofed room at spaced locations. Since the apertures 180 are spaced along the closed loop ducting, the air path from the air circulation unit to one aperture is longer than the air path to another. However, because the ducting is arranged in a closed loop, the air-pressure within the closed loop ducting is substantially equalised, meaning that the air exiting each aperture does so at a consistent pressure and therefore speed across all the apertures.

Figure 3 shows a particularly suitable aperture 180. Here an exit aperture 182 is connected to a nozzle 184. The nozzle 184 is shown as a substantially rigid tube. Suitably, the exit aperture 182 may be adapted to fit

conveniently in a false ceiling. The nozzle 184 extends from the closed loop ducting 136. Here the nozzle forms an elbow with the ducting to change the direction of the air flow from one plane to another. The closed loop ducting is suitably arranged parallel to a plane of the ceiling and the nozzle therefore enabling the nozzle to extend downwardly. Consequently, for a traditional box-shaped sound proofed room, the planes are shown as being perpendicular in the Figure. Figure 4 shows an alternative embodiment, wherein the nozzle is formed from a pliant or flexible tubing. This is advantageous as the nozzle is provided with greater flexibility for locating the position of the exit aperture 182. In either embodiment, the closed loop ducting may be above or hidden behind a ceiling or wall and the nozzles protrude there through.

5 The cross sectional area of the exit aperture 182 and nozzle tubing 184 is shown as being substantially
10 consistent. It has been found that when using a closed loop ducting 136 of around 0.25 meter diameter, it is particularly efficient to provide the exit aperture with a 0.08 meter diameter cross sectional area. Consequently, it is preferable for the exit aperture to have an area approximately 10% of the closed loop ducting. However, good results have also been achieved using areas of between 8% and 12% of the cross sectional area.

15 The apertures 180 may be spaced equally or unequally depending on the specific structure and use of the soundproofed room. However, it has been found that when using apertures as described above, a density of 2 or more apertures per kW that the ducted unit is rated is particularly suitable for achieving reduced airflow noise below the 10 decibel limit.

20 Preferably, and because it has been found to provide a particularly efficient cooling of the soundproofed room, the outlet ducting is arranged to expel air around a periphery of a room (see figure 2). Typically it has been found that in order to cool the fabric of the soundproofed room it is advantageous to mount each aperture with around 0.152 meters of the soundproofed room's walls. However, between around 0.14 and 0.16 metres is also suitable. Figure 11 shows an alternative exemplary arrangement of the ducting 136, wherein rather than being arranged in a loop shape, two sides, 138, 139 of the closed loop ducting are provided substantially side-by-side. Here a 90° bend 137 is provided at the end of two parallel ducts 138, 139 and opposed to the ducted unit 100. However, dependant on the requirements of the system, more than one ducted unit may be configured in the same ducted loop. For example, and referring to an exemplary embodiment depicted in Figure 12, two opposed ducted units 100, 100' may be connected so that a closed loop is formed by ducting 138 between one outlet on ducted unit 100 and an opposed outlet on ducted unit 100' and a second closed loop is formed by ducting 139 between a second outlet on ducted unit 100 and a second outlet on ducted unit 100'. Alternatively, and as shown in Figure 13, first, second and third ducted units are connected in series so that each outlet is connected to ducting to an outlet of another ducted unit. In yet a further exemplary embodiment, two or more outlets of one ducted unit are connected to one end of a closed loop ducting 136 and two or more outlets of a second ducted unit 100' are connected to the opposed end of the closed loop ducting.

25 Referring to Figure 6, an exemplary application of the ducted unit 100 herein described is shown. The ducted unit housing the air circulation unit 200 is provided to supply air along the two outlet ducts 132, 134 and subsequently
30 along side units 602, 604 before being expelled downwards through exit apertures 182. Return air is collected through the side units 602, 604 and returned to the ducted unit housing via inlet ducts 122, 124. The side units 602, 604 may be connected across a rear wall to provide a closed loop for the supply air. Furthermore, the side units may be used for existing ducted units with conduits linking the side units within the room to the ducted unit outside thereof.

35 Referring to Figure 7, a cross section through the side unit 602, 604 is shown. Suitably, the supply air from the air circulation unit is sealed within a first chamber 606 that travels the length of the side unit. Downward nozzles are provided by sub chambers 608 that are spaced along the side unit appropriately. A further chamber 610 is provided along the length of the side units for receiving air from the room and returning it back to the air circulation unit.

40 Referring to Figure 8, a further exemplary application of the ducted unit 200 herein described is shown. Here, a first ducted unit housing 110 and a second ducted housing unit 110' is provided. One of the ducted unit housing's includes a radiator and is incorporated in an air conditioning system. In contrast the other ducted unit housing comprises a fresh air supply. Here, fresh air is supplied from outside the soundproofed room in order to replenish oxygen. Consequently, one ducted unit supplies cooled air and the other fresh air. However, since both function

using the advantageous ducted unit herein described, both units can be provided within the soundproofed room due to the advantageously low operating sound.

Figure 9 shows an adapted side unit 602, 604, wherein a further chamber 612 is provided along the length of the side unit. The chamber 612 provides a sealed passageway for the fresh air supply from the air circulation unit 200. Slots or apertures 615 are formed between the nozzles 608 for expelling the fresh air from the side unit.

Figure 15 shows a further exemplary embodiment for a section of the ducting, which may be a closed loop ducting, or otherwise. The section of ducting is generally referenced at numeral 800. The ducting section 800 has at least one 802, but preferably two 802, 804 chambers defined by ducting housing 806. Importantly, the ducting housing 806 includes a step 810, 811 on each outer side. This is advantageous as it enables the main bulk of the ducting to be located above a ceiling or within a wall, with only a lower section protruding into the room. Moreover, the step provides a convenient fixing location. Outlet apertures are provided on the lower side of each step section. The apertures may suitably as herein described, but also, although circular apertures have been described herein, these may be replaced with slots or elongate shapes with a similar area. This is particularly useful in reducing the height of the lower side wall of the step area that protrudes into the room. Suitably, the apertures are shown on the lower side wall of the step and are therefore arranged to direct the air parallel to a mounting surface such as a ceiling or wall.

Figures 16 to 18 show a modified air conditioning unit.

An air circulation unit 900 is provided at one end of the unit as shown in Figure 18. The unit 900 may be as previously described in any of the embodiments. Air is provided through an inlet 920 which may draw in air from above and is pushed towards an outlet 930. The outlet supplies cooled or heated air to the lower portion of a wing 932. Air is discharged from the lower portion of the wing through outlets 934 and through outlets 936 towards the outside of the wing.

The wing is divided by a plate 938. As shown in Figure 17 air is fed in the direction shown by arrow 942 and is returned to the air conditioning unit above the plate in the direction shown by arrow 944.

A plurality of wings may be provided which may be clipped together such as by sliding the end of one wing over a projecting connector 946 of another wing.

One wing, which may be the end wing in a series of wings, may have a gap at the end of the plate to allow the air to change direction back towards the air conditioning unit in the direction of arrow 944.

The or each wing may be supported by a box 948, for instance by a downwardly projecting flange 950 extending into an upwardly projecting flange 952 on the side of the box 948.

The box 948 may be supported from above such as by wires extending from the ceiling.

Sections of a building, which may be a substantially enclosed building which may have an open side or top or a partially open side or top, may be cooled or heated to a greater extent than other sections. For instance an air conditioning unit may be suspended above the aisles of a supermarket to cool the aisles but to leave the shelves between the aisles largely uncooled. The system may maintain the aisles to within plus or minus 1°C. Accordingly the energy required to cool the supermarket is significantly less than that normally required to cool the supermarket when the whole area of the supermarket is cooled, it may also be possible to cool a marquee for instance by suspending a unit from the cross members of the marquee. Different sections may be cooled to different extents.

The air conditioning unit with the closed circuit may be used to cool the building. Alternatively or additionally different sections may be cooled without the closed circuit of a building. For instance the wings 932 may be suspended over the aisles of a supermarket without there being any return of the air to the air conditioning unit.

In a building, for instance, a supermarket, the length to be cooled may be such that two or more air conditioning units may be aligned above the aisle to adequately cool the aisle.

Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

- 5 The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An improved ducted unit having first and second outlets wherein the first and second outlets are connected to each other by outlet ducting to form a closed loop, the outlet ducting having at least two spaced apertures for ejecting air within the outlet ducting at substantially constant pressure.
2. The ducted unit of claim 1, wherein the closed loop outlet ducting comprises at least one section of ducting connected at each end to an outlet of a ducted unit.
3. The ducted unit of claim 1 or 2 wherein the closed loop outlet ducting has at least 2 outlet apertures per kW that the ducted unit is rated to.
4. The ducted unit of any of claims 1 to 3, wherein solid or flexible tubing is arranged to extend from the closed loop outlet ducting in order to change the direction of airflow from one plane to a second plane.
5. The ducted unit of any preceding claim, where each aperture has an area that is between 8% and 12% of the cross-sectional area of the closed loop outlet ducting.
6. The ducted unit of any preceding claim, wherein the ducted unit comprises a sound-insulated housing having a sound absorption coefficient of at least 0.05 W/m^2 at 100 Hz and wherein the sound-insulated housing contains an air circulation unit to draw air through the ducted unit, wherein the air circulation unit is operated to spin between around 1000 and 750 revolutions per minute.
7. The ducted unit of claim 6, wherein the sound absorbing material has open cells or voids, through which the noise travels and is dissipated, with the inner most surface of the sound insulating over which the air travels being substantially continuous and flat.
8. The ducted unit of any preceding claim including a housing that provides an enclosure for an air circulation unit to be arranged between an inlet and an outlet, wherein operation of the air circulation unit causes air to be drawn through the inlet and expelled through the outlet.
9. The ducted unit of any preceding claim suitable for use in an air-conditioning system, wherein the housing comprises an enclosure suitable to arrange a radiator in the air flow.
10. The ducted unit of claim 8 or 9 wherein the ducted unit has a plurality of inlets, and a plurality of outlets, the ducted unit having more inlets than outlets.
11. The ducted unit of any preceding claim, wherein the outlet ducting of two or more ducted units are connected together, the closed loop outlet ducting therefore being formed by a plurality of outlet ducting sections, with each outlet ducting section being directly connected at one end to one outlet and the other end to a different outlet.
12. The ducted unit of any preceding claim, wherein the outlet ducting is formed from a section having a first chamber for supply air and a second chamber for return air.
13. The ducted unit of any preceding claim, wherein the outlet ducting is formed from a section having a first chamber for supply air, wherein the section has a step formed on each outer side, wherein the side face of each step includes said apertures.
14. The ducted unit of claim 13, wherein the outlet ducting includes a second, separate chamber for supply air, wherein the first and second chambers are arranged parallel to each other and the apertures on one side face are connected to one chamber and the apertures on the other side face are connected with the other chamber.
15. An air conditioning system including a first ducted unit adapted to cool re-circulated air and a second ducted unit adapted to supply fresh air, wherein one or both of the first and second ducted units are as claimed in any of claims 1 to 14.
16. A system as claimed in claim 15 including a plurality of spaced units arranged to cool or heat only some regions of a building.
17. A system as claimed in claim 16 in which the regions to be cooled or heated comprise the aisles of supermarkets.
18. A system as claimed in claim 16 or 17 in which spaced units are arranged to be suspended from a building.

20. An air conditioning system for a substantially enclosed building, the system comprising a plurality of air outlets arranged to emit conditioned air to cool or heat one section of a room included in the building to a different extent to another section of the room.
21. A system as claimed in claim 20 in which the outlets are provided on ducting suspended from above.
- 5 22. A system as claimed in claim 21 in which the conditioned air is arranged to heat or cool the aisle or aisles or a room of a building.
23. a system as claimed in claim 22 in which the aisle or aisles comprise part of a supermarket.
24. A system as claimed in any of claims 21 to 23 in which the ducting is elongate with the ducting including a lower passage and in which conditioned air is arranged to be emitted at least partially downwardly from the lower passage.
- 10 25. A system as claimed in claim 24 in which the ducting includes an upper passage and in which air is returned to the air conditioning unit via the upper passage.
26. A system as claimed in claim 24 or 25 in which the elongate ducting includes a plurality of ducting units that are connected together to comprise the elongate lower passage.
- 15 27. A system as claimed in claim 26 in which the units are connected together by a push fit.
28. A system as claimed in claim 26 or 27 when dependent on claim 25 in which each unit includes an upper and a lower passage.
29. A system as claimed in claim 28 in which an end unit has a flow passage connecting the upper and lower passages and in which conditioned air is arranged to flow from the air conditioning unit into and along the power passage and then back to the air conditioning unit via the upper passage.
- 20 30. A system as claimed in any of claims 24 to 29 in which the ducting includes two side by side ducts.
31. A system as claimed in claim 30 in which the side by side ducts are arranged to be supplied with conditioned air from the same air conditioning unit.
32. A system as claimed in any of claims 24 to 29 in which the ducting comprises a plurality of ducts each extending over a different elongate extent and each being supplied with conditioned air from a different source.
- 25 33. A system as claimed in any of claims 21 to 32 in which the ducting is arranged to be connected to supporting member which is suspended from above.
34. A system as claimed in any of claims 20 to 33 in which the conditioned air is arranged to be supplied by a ducting unit as claimed in any of claims 1 to 18.
- 30 35. An air conditioning system as claimed in any of claims 20 to 34 when installed in a building.
36. A method of cooling or heating at least one section of a room of a substantially enclosed building to a different extent to another section of the room comprising emitting air from a plurality of outlets to heat or cool that section.
- 35 37. A method as claimed in claim 36 comprising cooling or heating a section of a supermarket comprising an aisle of the supermarket by directing air downwardly towards the aisle through a plurality of outlets along substantially the complete extent of the aisle.
38. A method as claimed in claim 37 comprising heating or cooling different aisles to different temperatures.
39. A method as claimed in any of claims 36 to 38 when using an air conditioning system as claimed in any of claims 20 to 35.

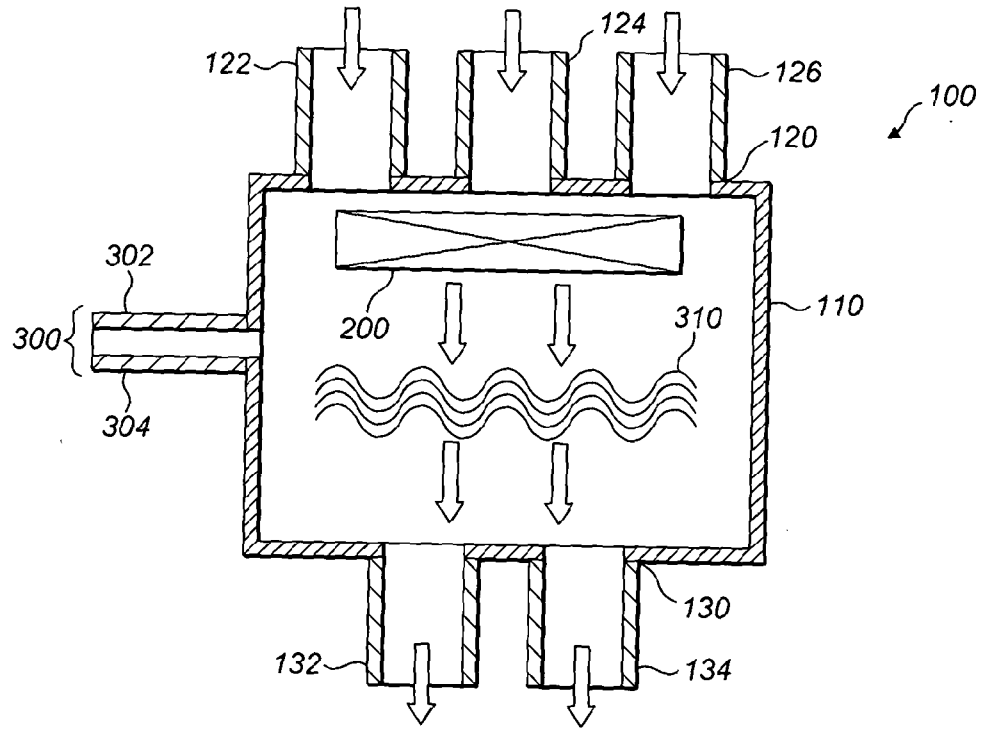


FIG. 1

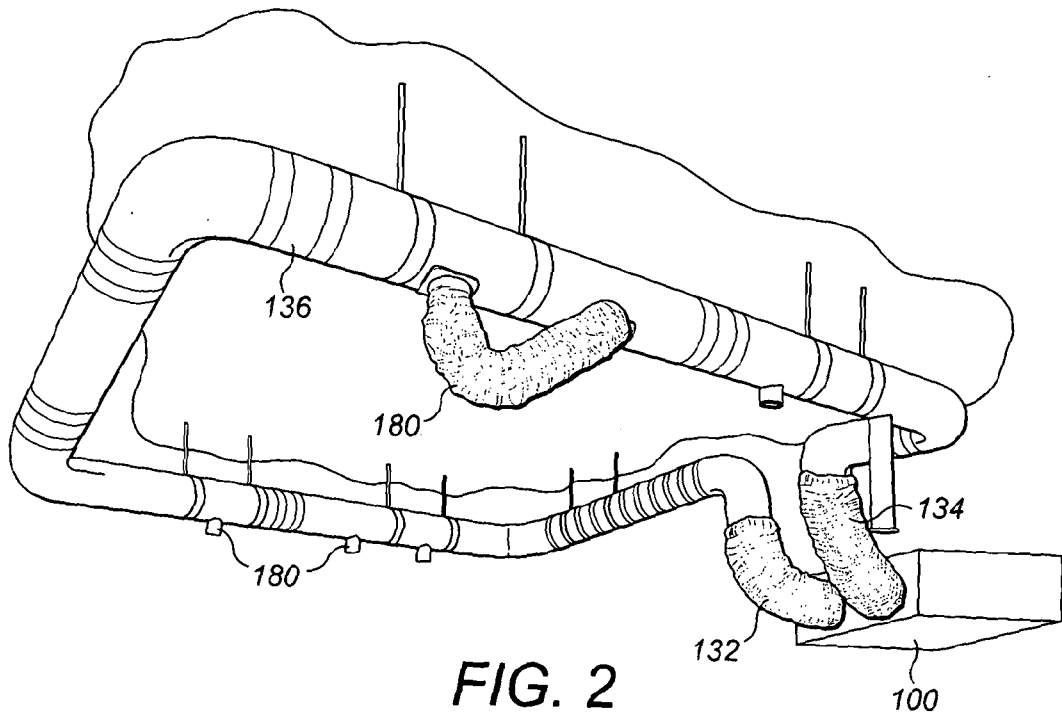


FIG. 2

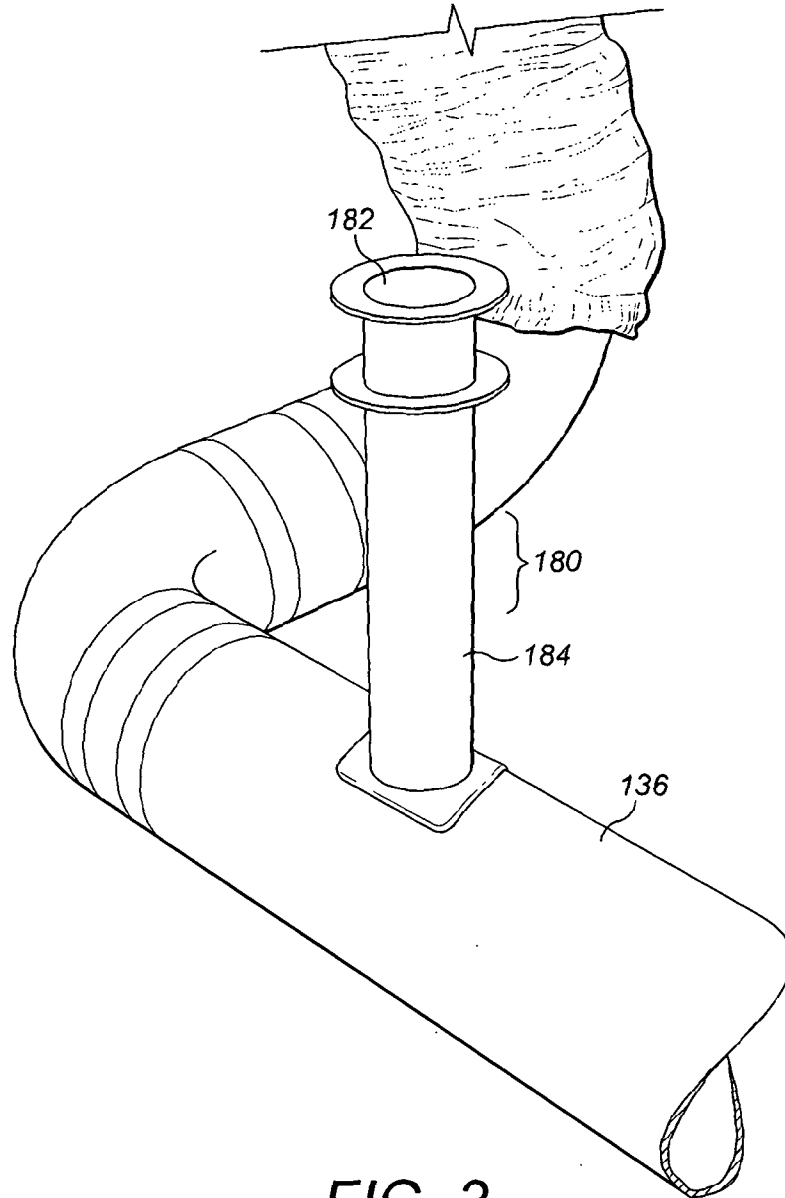


FIG. 3

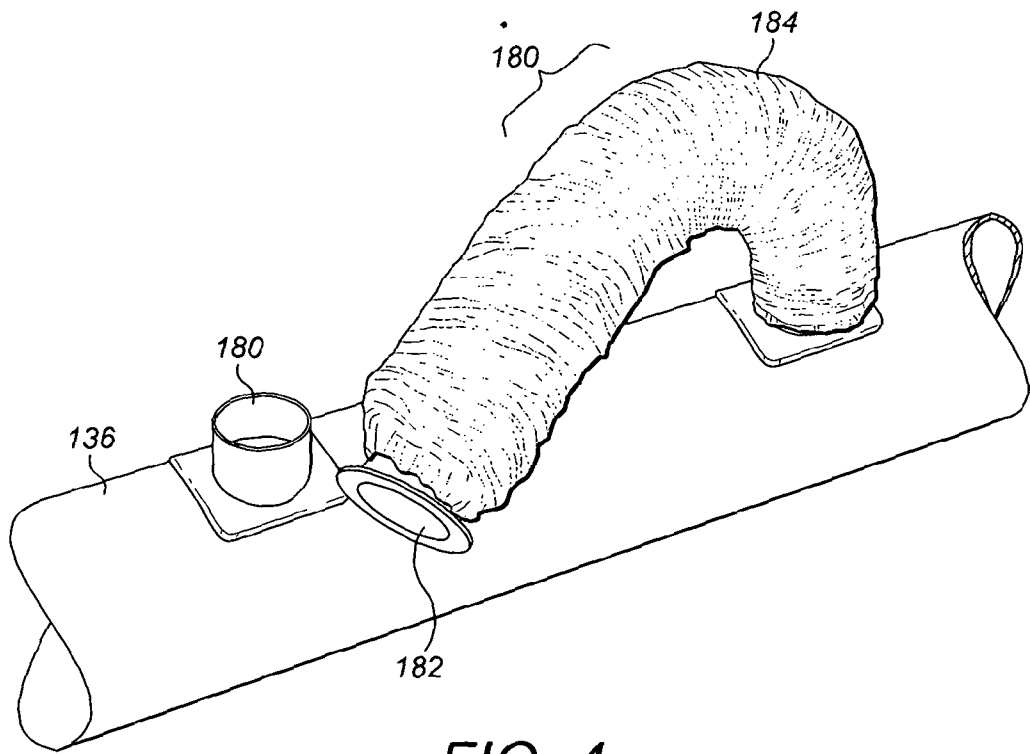


FIG. 4

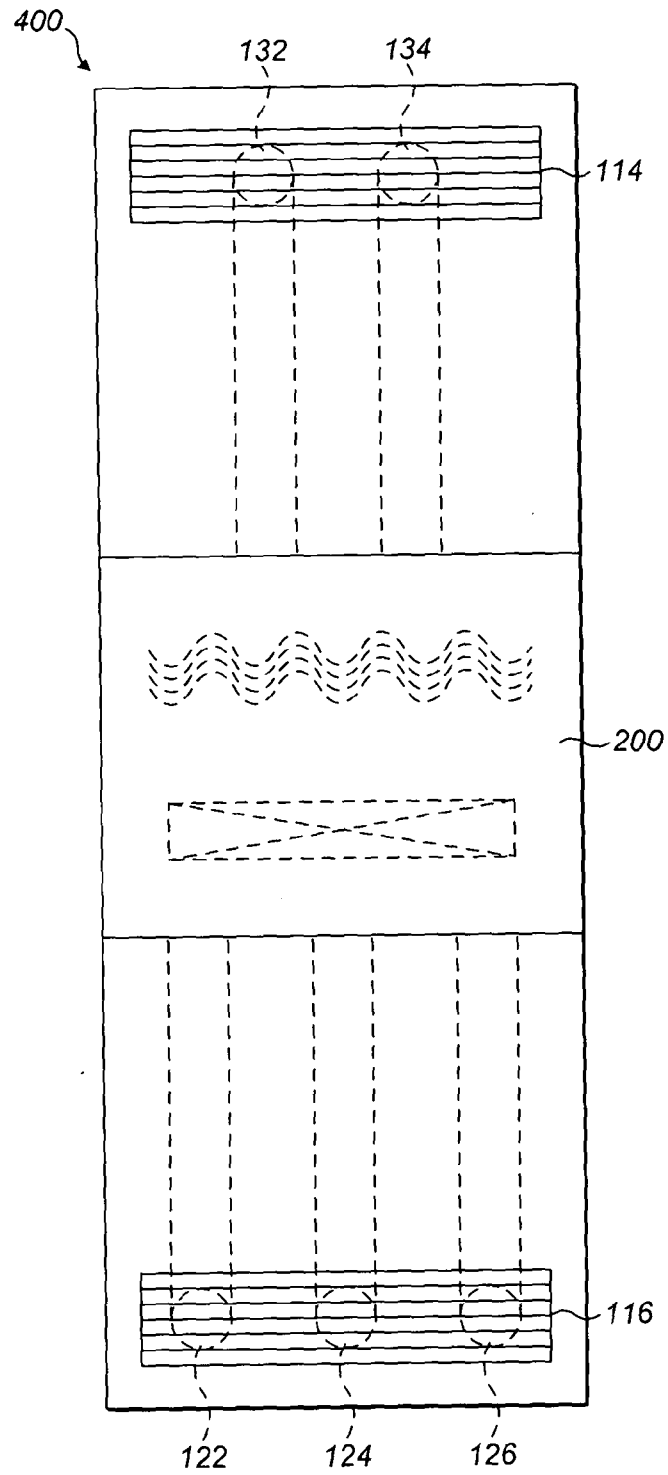


FIG. 5

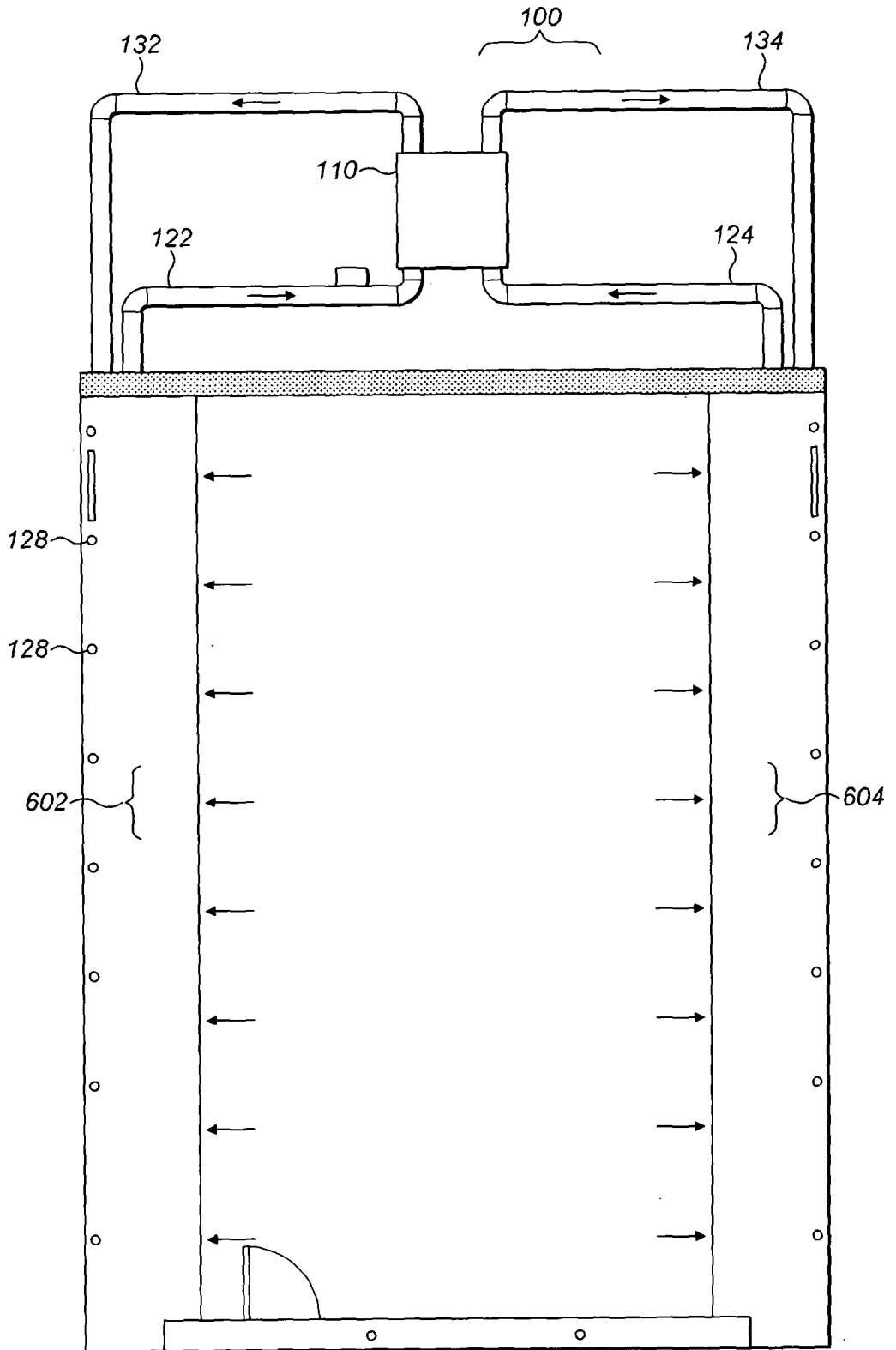


FIG. 6

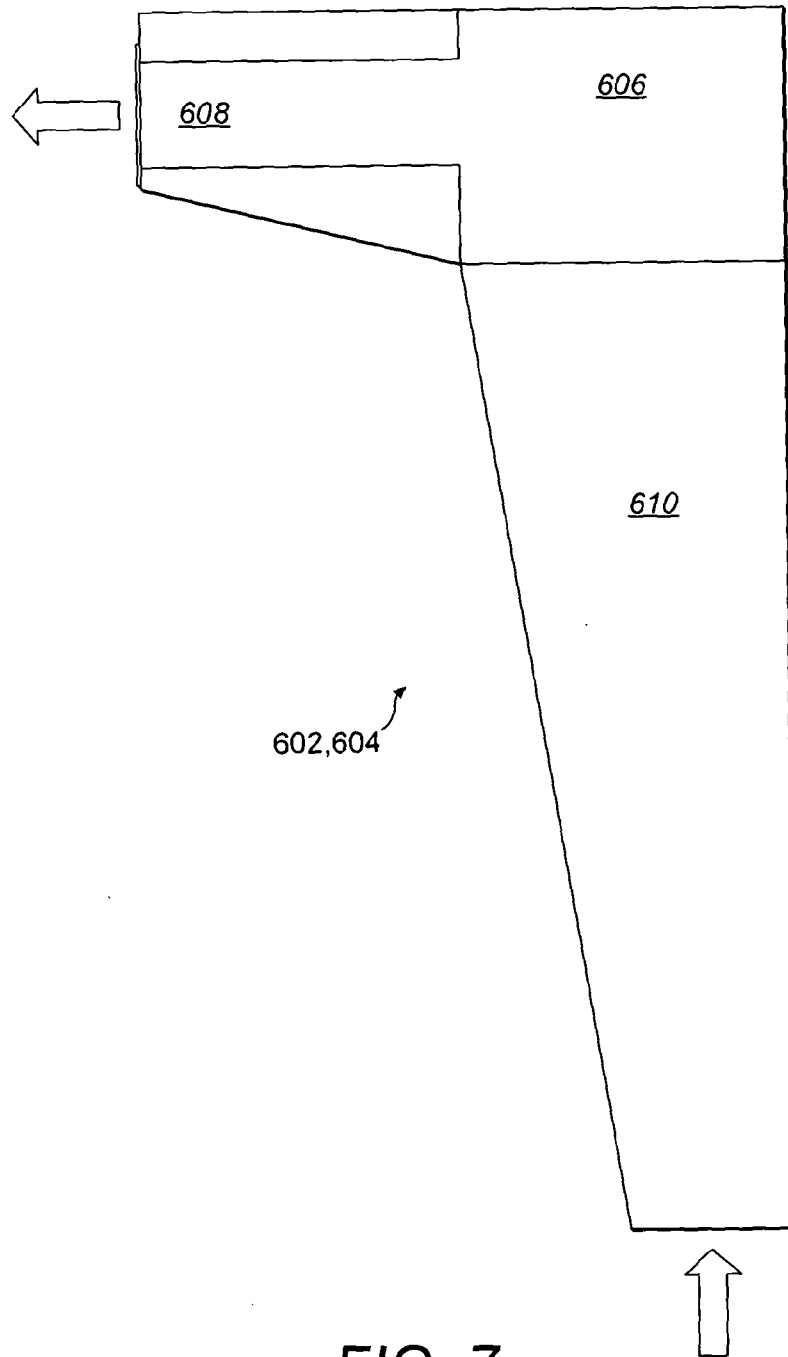


FIG. 7

7 / 14

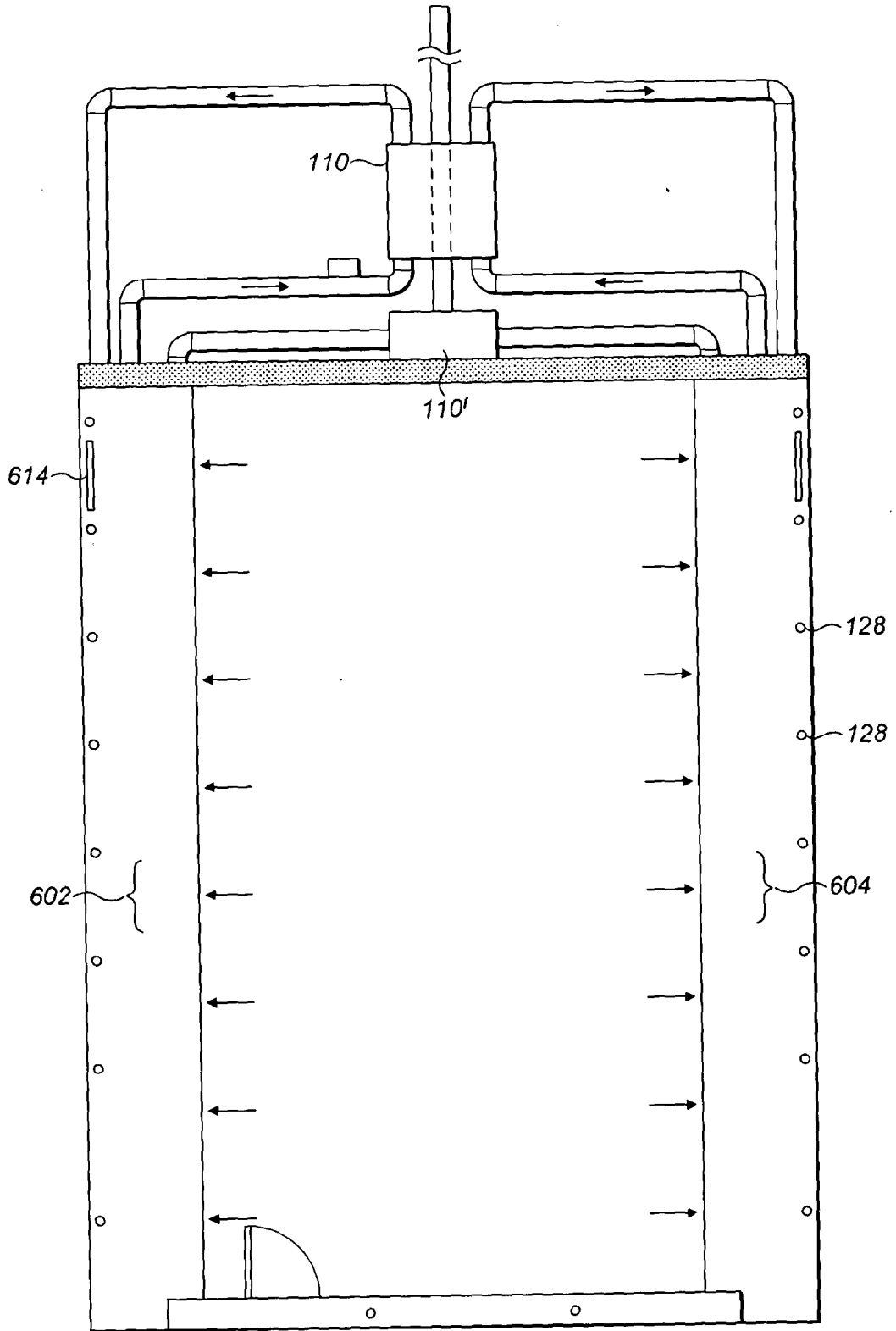
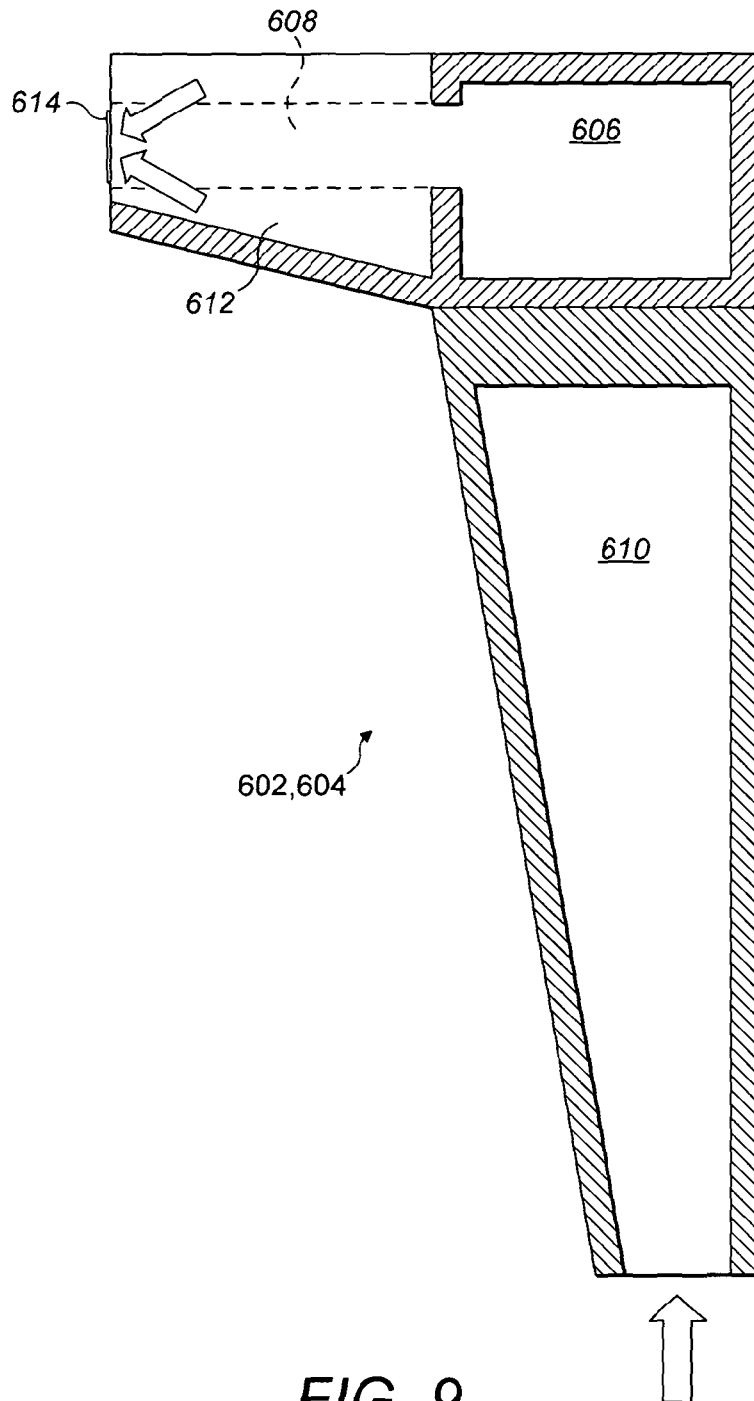
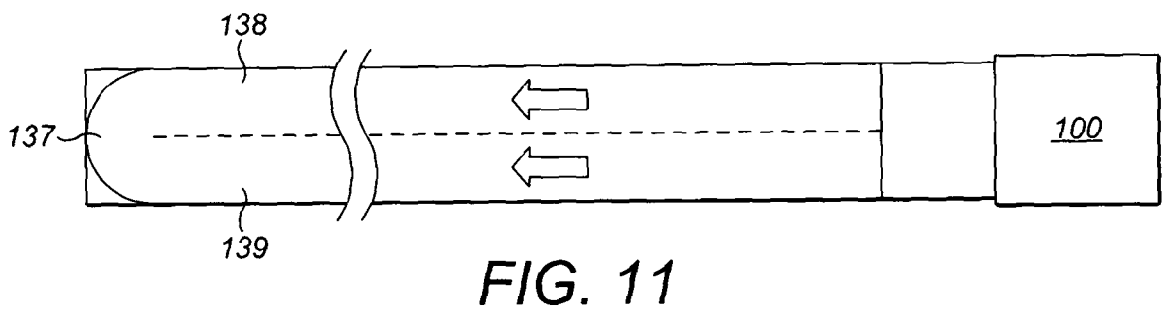
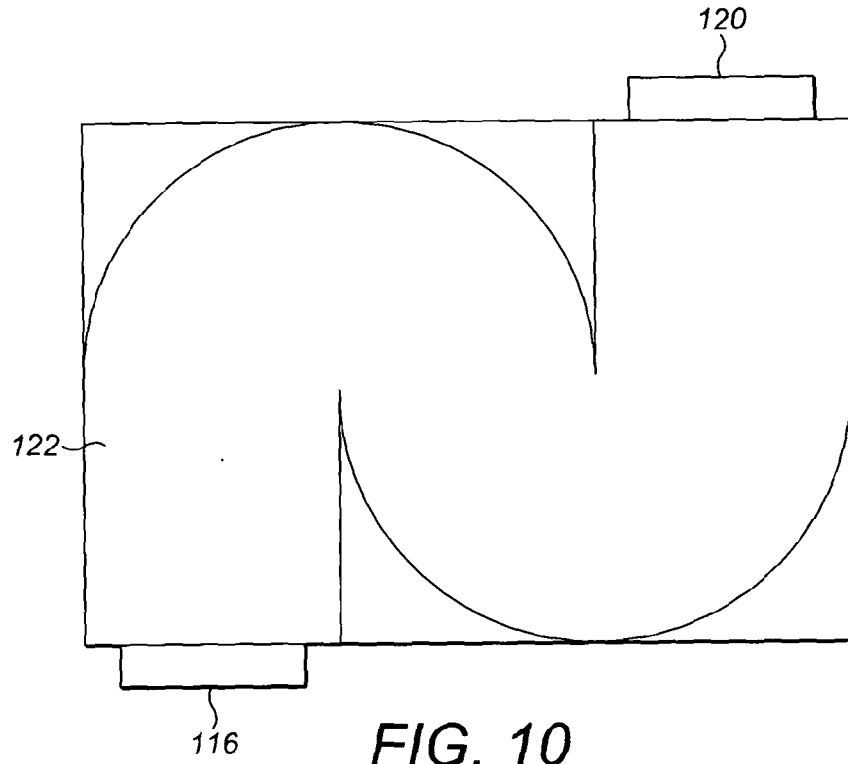


FIG. 8





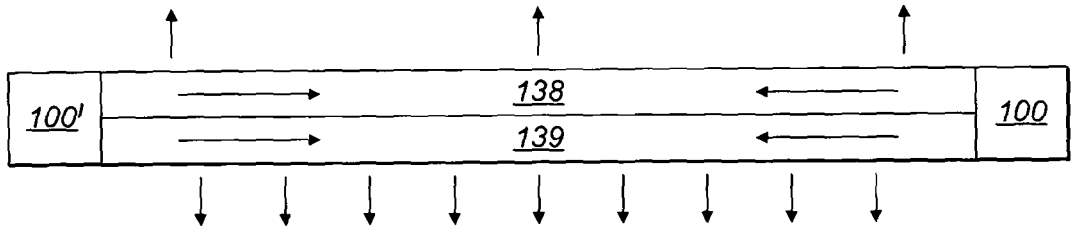


FIG. 12

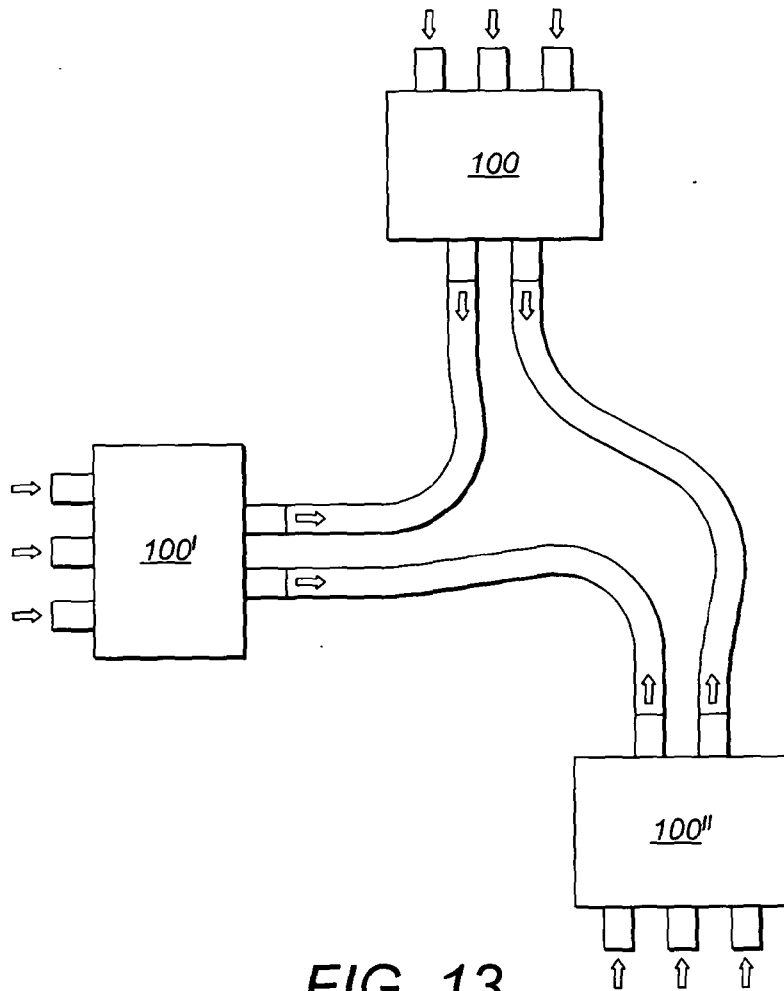


FIG. 13

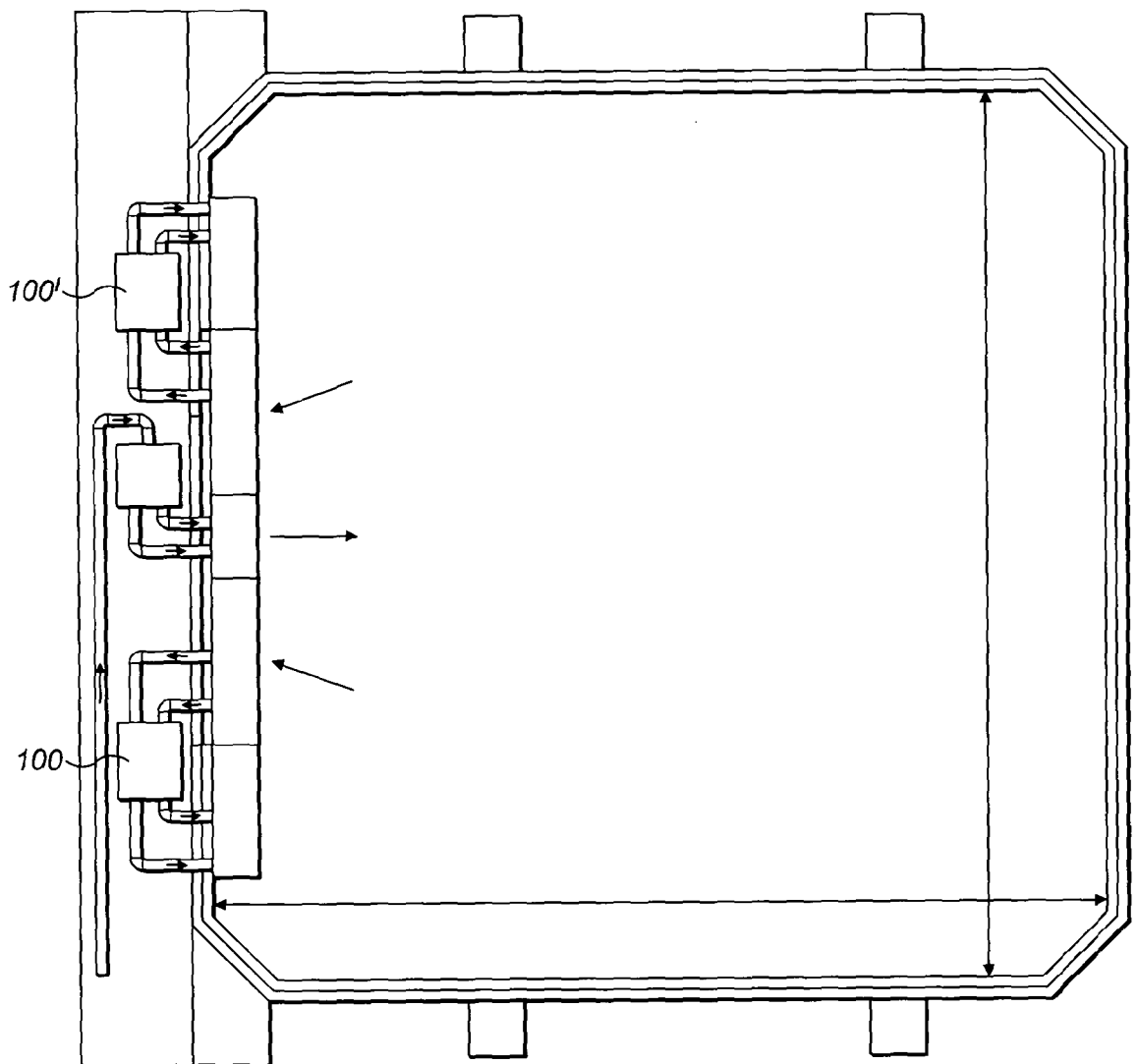


FIG. 14

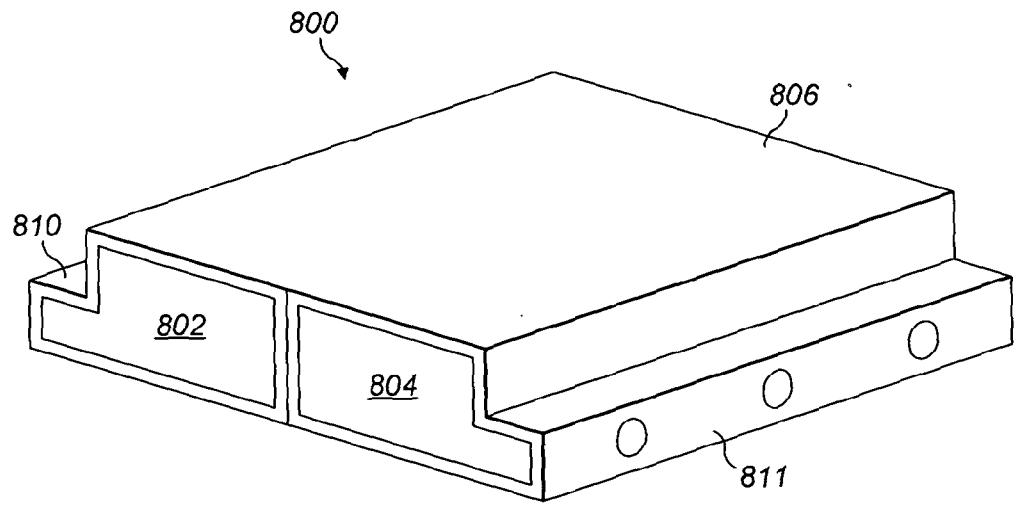


FIG. 15

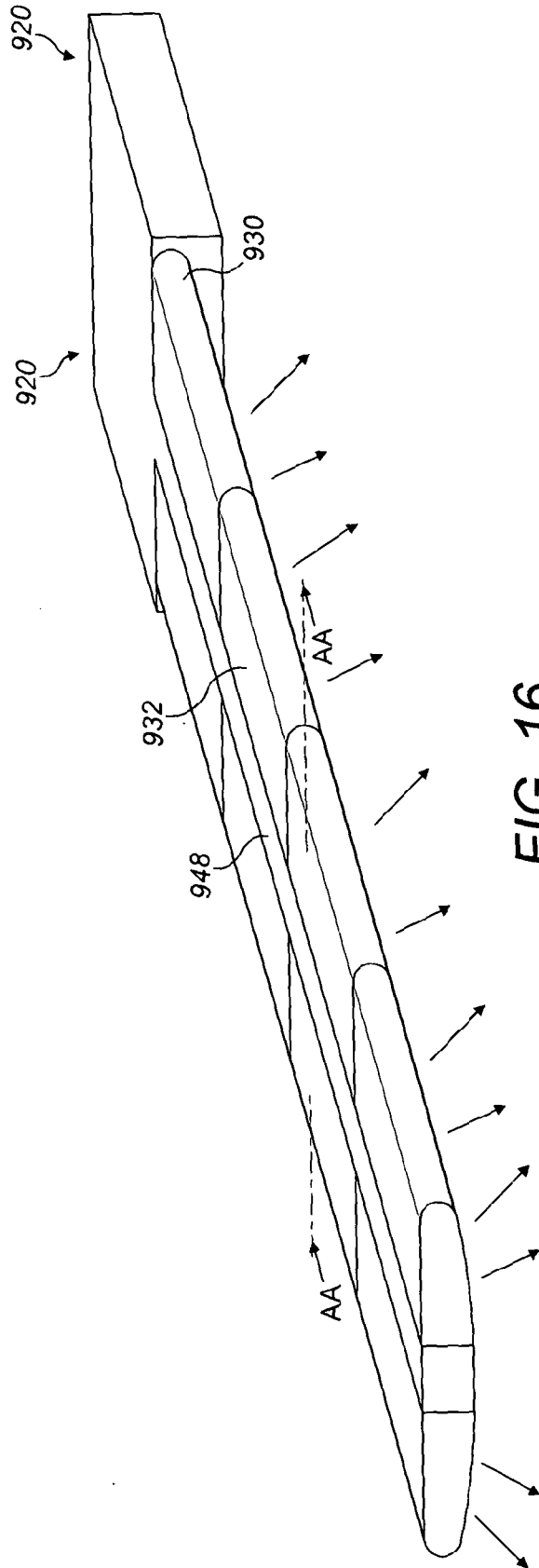
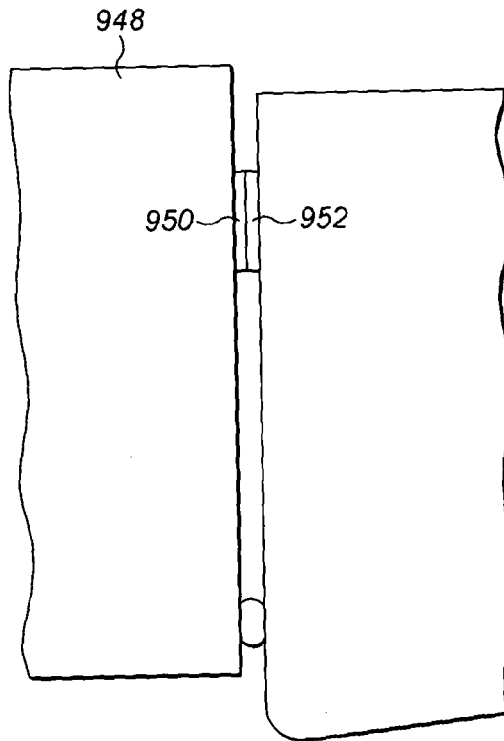
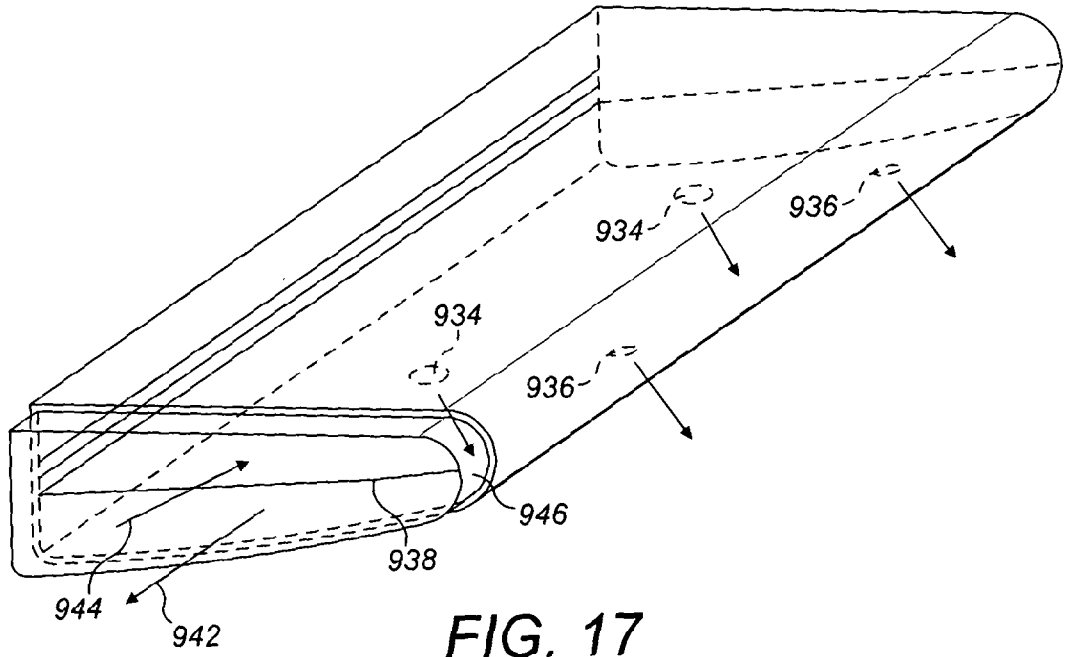


FIG. 16



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/051774

A. CLASSIFICATION OF SUBJECT MATTER
INV. F24F1/00 F24F7/06
ADD.
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)
F24F

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)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/061104 A1 (JUNGERS JON W [US]) 23 March 2006 (2006-03-23)	1,2,4
Y	paragraph [0028]; figure 1	3,5-18
Y	----- US 3 289 566 A (TODD JOHN S) 6 December 1966 (1966-12-06)	3,5-18
Y	column 3; figure 1 ----- WO 01/61253 A1 (SOFT INNEKLIMAT AB [SE]; SELLOE BENGT [SE]) 23 August 2001 (2001-08-23)	3,5-18
A	figure 1 ----- DE 10 2009 016609 A1 (EGER CHRISTIAN [DE]; TARTSCH HENNING [DE]) 21 January 2010 (2010-01-21)	1-18
	the whole document ----- -/--	

Further documents are listed in the continuation of Box C.

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
- "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

14 November 2012

Date of mailing of the international search report

21/11/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer

Decking, Oliver

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/051774

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CH 91 784 A (TOBLER VICTOR [CH]) 16 March 1922 (1922-03-16) the whole document -----	1-18
X	WO 98/49499 A1 (FLAEKT OY [FI]; HAKALA INTO [FI]; SALORANTA MARKKU [FI]; POHJA JUKKA []) 5 November 1998 (1998-11-05) abstract; figures 1,6-10 -----	20-24, 30-39
Y	-----	26-28
A	-----	25,29
Y	DE 299 17 486 U1 (TROX GMBH GEB [DE]) 9 December 1999 (1999-12-09) page 7, last paragraph; figure 4 -----	26-28
A	EP 2 088 380 A2 (POULSEN RICHARD [DK]) 12 August 2009 (2009-08-12) abstract; figure all -----	20-29

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2012/051774

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:

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 additional sheet

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 an 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.:

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-18

ducted in having first and second outlets connected by outlet ducting to form a closed loop

2. claims: 20-39

air conditioning system comprising a plurality of air outlets to emit conditioned air different sections to a different extend.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2012/051774

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