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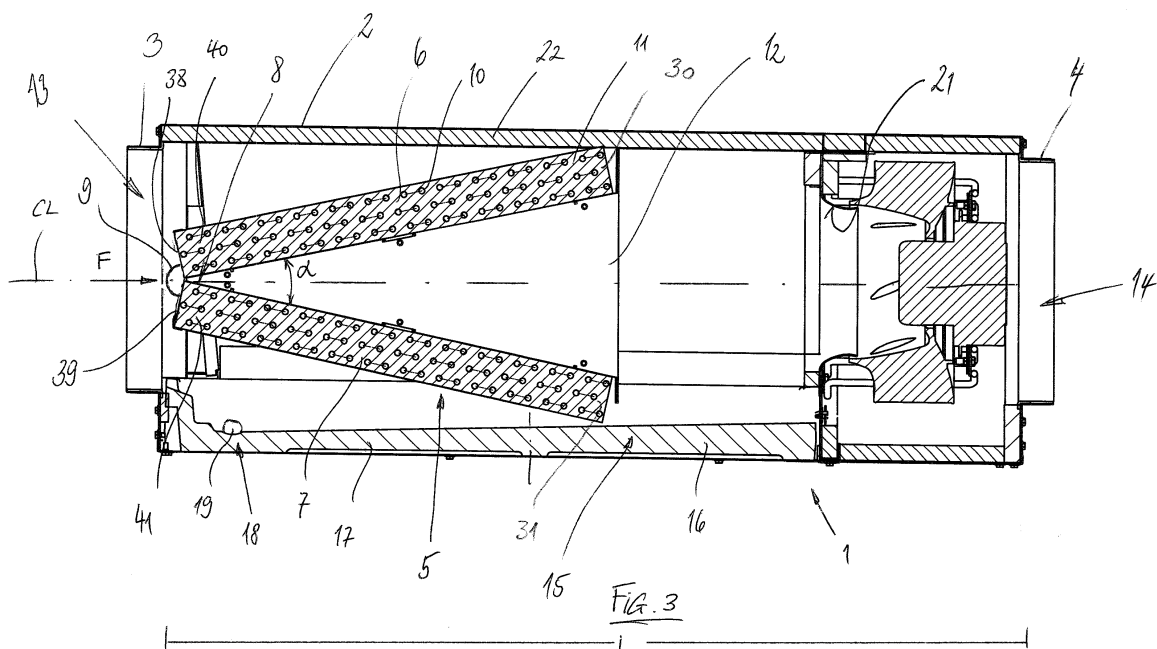
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(54) **HEAT EXCHANGER UNIT**

(57) Heat exchanger unit comprising: a casing (2) having a duct to be flown through by a fluid, a fan (20) disposed in the casing and configured to induce a flow of the fluid through the duct in a flow direction (F), a heat exchanger (5) being V-shaped in side view with an apex (8) at one end and an opening (12) at the opposite end,

the heat exchanger being disposed in the duct with the apex directed towards the flow direction, wherein a line (CL) of the V-shaped heat exchanger in the side view and passing the apex extends horizontally, wherein the fan is disposed downstream of the heat exchanger in the flow direction.

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Description

Technical Field

[0001] The present invention relates to a heat exchanger unit for an air conditioner. In particular, the heat exchanger unit is of a kind that may be installed at, e.g. hidden behind, a ceiling of a building or any other location providing for a limited installation space, particularly a limited height. Heat exchanger units of this type are often also called duct-type heat exchanger units, which are connected to and form part of an air duct of an air conditioner.

Background

[0002] An example of such heat exchanger unit is known from EP 2 108 897 A1 disclosing a heat exchanger unit having an L-shaped heat exchanger laying on its side, wherein air is flown through both legs of the "L". Such a heat exchanger, however, provides for a relatively small heat exchange surface in combination with a relatively uneven distribution of air flowing through the heat exchanger (uneven air distribution). In addition, the height of the heat exchanger unit is relatively large, because the legs of the "L" shaped heat exchanger are arranged with their width oriented vertically.

[0003] A heat exchanger unit providing for a larger heat exchange surface and a lower height is disclosed in EP 2 402 669 A2. This heat exchanger unit implements a V-shaped heat exchanger with a central axis of the "V" oriented horizontally. Thereby, the height of the heat exchanger can be reduced at the same time increasing the heat exchange surface. Yet, the air distribution of air flowing through the heat exchanger is still relatively uneven, because the air is blown by a fan towards the apex of the "V" leading to reduced heat exchange efficiency.

Brief description of the invention

[0004] In view of the aforesaid, it is the object of the present invention to provide a heat exchanger unit being improved with respect to its heat exchange efficiency.

[0005] This object is solved by a heat exchanger unit as defined in claim 1. Embodiments of the invention are named in the dependent claims, the following description and the accompanying drawings.

[0006] According to one aspect, a heat exchange unit is suggested comprising a casing having a duct to be flown through by a fluid, particularly air (in the following reference is made primarily to air only, but it is to be understood that other fluids may as well be used). The casing is particularly configured to be connected to a fluid path, particularly an air duct, e.g. connecting to a space to be conditioned or a heat source, particularly outside air. As such, the casing will be part of the fluid path.

[0007] Further, a fan is disposed in the casing. Certainly, more than one fan may be provided. In this in-

stance, it is desirable that the center axes of the fans are aligned and positioned on a horizontal line. The fan or fans are configured to induce a flow of the fluid through the duct in a flow direction.

5 [0008] Moreover, a heat exchanger is provided within the duct and to be flown through by the fluid flowing through the duct by means of the fan/-s. Preferably, the heat exchanger is disposed in the duct so that no air may bypass the heat exchanger. In other words, the heat exchanger is disposed in the air duct so that the entire amount or at least a major part of air flowing through the duct also passes through the heat exchanger. The heat exchanger is V-shaped in a side or cross-sectional view with an apex at one end and an opening at the opposite end. The angle of the "V" may be adjusted as needed. The larger the angle, the better for achieving even air distribution and good efficiency. The smaller the angle, the better for obtaining a low height. According to one example, the heat exchanger may comprise two planar or plate shaped heat exchange elements which are positioned so as to form the "V". These elements may be fluidly connected by refrigerant piping to be flown through by refrigerant preferably in parallel. Further, these elements may be defined as an upper heat exchange element and a lower heat exchange element. The terms "upper" and "lower" in this context refer to a line passing the apex and extending horizontally in use. In certain embodiments, this line may be a centerline or a line of symmetry of the heat exchanger when seen in the side view. In this particular embodiment, the heat exchanger is disposed in the duct with the apex of the "V" being directed towards the flow direction.

[0009] Furthermore, the fan or fans is/are disposed downstream of the heat exchanger in the flow direction. To put it differently, the fan is disposed further away from the apex than the opening of the heat exchanger or is disposed on a side of the opening of the "V" of the heat exchanger.

[0010] Because the fan is disposed downstream of the heat exchanger in the flow direction, it can be ensured that fluid is passing the whole or at least a major part of the heat exchanger at a relatively even amount distributed over the heat exchange surface of the heat exchanger (air distribution). In particular, the fan establishes a lower pressure on the side downstream of the heat exchanger. Therefore, air is sucked into the duct from an upstream side of the heat exchanger flowing into an inlet opening of the duct and hence through the heat exchanger more evenly. As a result the amount of air is not as concentrated on a particular portion of the heat exchanger as in the prior art. Hence, a more even air distribution and thus higher efficiency may be achieved.

[0011] According to one embodiment the heat exchanger is symmetric in the side view. In particular, it is desired that a line of symmetry of the heat exchanger in the side view extends horizontally. In this context, the upper and lower heat exchange elements are preferably identical or at least substantially identical. All these meas-

ures assist in obtaining an even air distribution.

[0012] In this context it is also desired that the center axis of the fan or fans, particularly their suction opening/s is located on a line parallel with the line of the V-shaped heat exchanger particularly its centerline or line of symmetry. According to a preferred embodiment, the center axis of the fan or fans, particularly their suction opening/s is located on a common line with the line of the V-shaped heat exchanger particularly its centerline or line of symmetry in the side view.

[0013] According to an aspect, the fan or fans is/are a backward curved centrifugal fan. As previously described, the heat exchanger unit is disposed in a fluid path (air duct). The heat exchanger unit is further preferably used as part of a heat source unit (also known as outdoor unit even if disposed indoors) and may be combined with a compressor or a separate compressor unit to constitute the "outdoor unit". In these appliances, a relatively large pressure drop has to be overcome because of fences and filters. Therefore a relatively high ESP (external static pressure) is required. In addition a relatively high airflow is required so as to enable the use in an air conditioner supplying a plurality of indoor units disposed in the spaces to be conditioned. In this context, normal outdoor units provide for an air flow of 120 m³ per minute, whereas common indoor units provide for an air flow of 30 m³ per minute. The appliance of the heat exchanger unit as described above only requires a lower flow rate as compared to normal outdoor units but a higher flow rate as compared to usual indoor units. The use of a backward curved centrifugal fan is desirable to achieve a relatively high ESP and air flow rate with high-efficiency. An additional requirement for the heat exchanger unit to be placed in the ceiling is that the whole unit and also the fans have to be restricted in regard of weight and size. In addition, the fluid flow rate needs to be adjustable. Also these requirements can be met by the use of a backward curved centrifugal fan.

[0014] In one embodiment, the flow rate to be induced by the fans resides between about 60 m³ per minute and 100 m³ per minute and preferably about 60 m³ per minute and 85 m³ per minute. This may efficiently be obtained with one or more backward curved centrifugal fans. In addition, the flow rate should also be adjustable in the aforesaid ranges.

[0015] The use of a plurality of backward curved centrifugal fans further provides for a reduced overall fluid speed in the high velocity zones of the fans. Accordingly, the fans may be positioned closer to the heat exchanger without condensation water formed on the outer surface of the heat exchanger being drawn into the fans. By positioning the fans closer to the heat exchanger, a more compact heat exchanger unit as regards its length may be achieved. In particular embodiments, the heat exchanger, i.e. the opening of the heat exchanger must stay away from the fan between 20 and 30 cm to avoid water from being sucked into the fan at a flow rate of 85 m³ per minute when two backward curved centrifugal

fans are used. In addition, the use of a plurality of fans leads to less noise because each fan may be driven at a lower RPM to reach a certain air flow rate as compared to the use of fewer fans to reach the same air flow rate.

[0016] According to an even further aspect, the heat exchanger comprises baffle plate disposed at the apex of the heat exchanger and directed towards the flow direction, i.e. facing the fluid flow (airflow). The baffle plate provides for the advantage that a certain amount of fluid is deflected at the baffle plate so as to ensure that not all of the fluid passes the heat exchanger through the apex but is evenly distributed over the heat exchanging surface along the legs of the "V". Thereby an improved distribution of air flowing through the heat exchanger can be achieved. If the baffle plate covers the entire surface of the heat exchanger at the apex, that is the front faces of the heat exchanger elements at the apex, no air flows through the apex. If the baffle plate only covers a part of the surface of the heat exchanger at the apex or front to surfaces of the heat exchanger element, some passes through the apex and a more even air flow through the heat exchanger at the apex may be obtained. The baffle plate may be air impermeable, but it is also conceivable that the baffle plate is perforated to allow a certain amount of air to pass the baffle plate. Further, the baffle plate may be made of sheet-metal or EPS.

[0017] In order to equalize the air flow between the upper and a lower leg of the "V", i.e. the upper and lower heat exchanger element, it is beneficial that the baffle plate is symmetrical relative to the line, particularly the centerline or the line of symmetry, of the heat exchanger.

[0018] It has also been shown beneficial that the baffle plate has, in the cross section or side view an equiangular triangular shape. Thereby, a relatively large surface of the baffle plate may be obtained with low turbulences as described above at the same time equalizing the flow of fluid along the top and the bottom of the heat exchanger.

[0019] To further improve the baffle plate so as to achieve these effects, the legs of the equiangular triangular shape directed towards the flow direction are convex.

[0020] According to an alternative embodiment, the baffle plate may have in cross section or side view a rounded shape, particularly a partial circular shape. The rounded shape provides for a larger amount of deflection as compared to the previously described shape.

[0021] In order to collect condensation water formed on of the outer surfaces of the heat exchanger, the heat exchanger unit according to an aspect further comprises a drain pan. The drain pan may be a drain pan which needs to be manually removed and emptied or drain pan that is connected to drainage.

[0022] It is preferred that the drain pan has a lowest position. If the drain pan is connected to drainage, a drain opening is disposed at the lowest position. According to an aspect it is preferred that the lowest position and if present the drain opening is disposed in that half of the drain pan away from the fan seen in the flow direction.

In particular, the drain pan extends in a direction away from the fan. If the drain pan in this extension direction is separated into halves, the lowest position is positioned in that half that is further away from the fan than the other half. Furthermore, the drain pan is particularly designed so as to guide water accumulated in the drain pan away from the fan to its lowest position and if present the drain opening.

[0023] According to a further aspect, the heat exchanger unit further comprises an insulation (thermal and/or sound) disposed on an opposite side of the heat exchanger relative to the drain pan. In order to obtain a duct which is as symmetric as possible in order to obtain an as even as possible air distribution through the heat exchanger, it is preferred that the surfaces of the insulation and the drain pan directed toward the heat exchanger have approximated, preferably identical shapes. As a result, the pressure within the "V" may be balanced with the result of a more even fluid flow distribution.

[0024] Furthermore and in order to further prevent water from dropping from the heat exchanger close to the fan it is preferred to use waffled fins for the heat exchanger or at least one of the upper and lower portion (element) of the heat exchanger. In this context, the heat exchanger or heat exchanger elements each comprise loops of tubing with fins being interposed between the tubing. These fins are preferably waffled fins without any openings formed in the fins itself.

[0025] Further features and effects of the heat exchanger unit may be obtained from the following description of embodiments. In the description of these embodiments reference is made to the accompanying drawings.

Brief description of drawings

[0026]

Figure 1 shows a perspective view of a heat exchanger unit from one side;

Figure 2 shows a perspective view of the heat exchanger unit of figure 1 from the opposite side;

Figure 3 shows a longitudinal section through the heat exchanger unit along a line cutting a center of one of the fans; and

Figure 4 shows a simulation of air distribution over the heat exchanger in a) a heat exchanger with a baffle plate having an equiangular triangular shape, b) a heat exchanger with a rounded baffle plate covering the entire apex and c) a heat exchanger with a rounded baffle plate covering only a small portion of the apex.

Description of embodiments

[0027] Figures 1 and 2 show a heat exchanger unit 1

in accordance with one embodiment.

[0028] The heat exchanger unit 1 comprises a casing 2 being configured for connection to an air duct of an air conditioner. In particular, the heat exchanger unit is configured as an "outdoor" unit of an air conditioner which is however disposed inside particularly within ceiling of a building. Hence a first connection 3 is provided at the casing 2 for connection to an air duct communicating the heat exchanger unit 1 with the outside of the building and so as to enable sucking of outdoor air into the casing 2. A connection 4 provided for the connection of the heat exchanger unit 1 to the air duct again leading to the outside of the building and to enable blowing out of air having passed the heat exchanger 5 to the outside is disposed at the opposite end of the casing 2.

[0029] The casing is substantially rectangular and flat, meaning that the height H is a smaller than the width W and the length L. In one embodiment the height H is not more than 500 mm, preferably not more than 450 mm, more preferably not more than 400 mm and most preferred not more than 350 mm.

[0030] The heat exchanger unit 1 further comprises a heat exchanger 5 which is also visible in figure 1. However, the configuration of heat exchanger 5 can be best seen from figure 3. Figure 3 also represent a side view of the heat exchanger 5.

[0031] The heat exchanger 5 comprises an upper heat exchanger element 6 and a lower heat exchanger element 7. Both, the upper and lower heat exchanger elements 6, 7 are flat or planar shaped and are positioned with an angle α enclosed between them. Hence the heat exchanger 5 has a V-shape wherein the "V" is oriented horizontally. A line CL passing the apex 8 of the "V" is oriented horizontally, that is along the length L extension of the heat exchanger unit 1. The line CL is also the centerline of the heat exchanger 5 or to put it differently a line of symmetry of thereof as regards the heat exchanger elements 6, 7.

[0032] Heat exchanger 5 is arranged within the air duct formed by the casing 2 so that all air sucked in through the opening at the connection 3 has to flow through the heat exchanger 5 without any air bypassing the heat exchanger 5 at the top or the bottom or the sides of the heat exchanger 5 in the width direction W. further, the apex 8 is directed towards the connection 3 and, hence, the flow of air introduced into the duct formed by the casing 2 and flowing there through.

[0033] The upper and lower heat exchanger elements 6, 7 are connected to each other at the apex 8. The baffle plate 9 may be used for connecting the heat exchanger elements 6, 7 at the apex. The baffle plate 9 is impermeable to air and as mentioned before can also be used to mechanically or physically connect the upper and lower heat exchanger elements 6, 7. The baffle plate 9 serves for guiding the flow of air introduced through the connection 3 into the duct of the casing 2 along the upper and lower heat exchanger elements 6, 7 so as to obtain an as even as possible air distribution through the heat ex-

changer elements 6, 7. This effect is particularly described with respect to figure 4.

[0034] Each of the heat exchanger elements 6, 7 comprises heat exchanger coils 10 (loops of tubing) and fins 11 disposed there between. The heat exchanger of the present embodiment is particularly applied for outdoor applications, i.e. as part of the heat source unit of an air conditioner. In this case, the fins of the upper and lower heat exchanger element 6, 7 are preferably waffled fins. In case the heat exchanger is, however, used for indoor applications (when indoor air passes the heat exchanger), that is as indoor unit of an air conditioner, or used as cooling only outdoor unit, louvered fins may be used. Louvered fins are preferably for a good air flow through the heat exchanger as several holes are provided to allow the air to flow through the fins. However, condensation water may accumulate in these holes and may lead to problems regarding the formation of frost during heating operation if used as outdoor application (i.e. when outdoor air passes the heat exchanger), when the ambient temperature is lower than about 7°C. To prevent these problems it is in these cases preferred to use waffled fins.

[0035] Two backward curved centrifugal fans 20 are provided inside the casing. These backward curved centrifugal fans 20 each have a suction opening 21. In the side view (figure 3), the center axis of the suction opening 21 and hence the fans 20 is substantially congruent or aligned with the center line CL of the heat exchanger 5. In some appliances, it may however be sufficient as in the depicted embodiment that the center axis of the suction opening 21 and the centerline CL of the heat exchanger 5 are parallel but displaced relative to each other in a horizontal direction.

[0036] In use, the fans 20 create a suction force at the suction opening 21 so as to induce a fluid flow (airflow) in the direction F. Thus air, particularly outside air is drawn in through the connection 3 toward the apex 8 of the heat exchanger 5, passes through the upper and lower heat exchanger elements 6, 7 and is sucked through the suction opening 21 to be flown out through the connection 4. As such the casing 2 defines a duct from the connection 3 via the heat exchanger 5 and the fan 20 to the connection 4. In this context, the connection 3 and the connection 4 define an inlet opening 13 and an outlet opening 14.

[0037] Furthermore, a drain pan 15 is provided within the casing. The drain pan 15 is separated into two halves 16, 17 along the length L of the casing 2 in the side view. In figure 3, the two halves 16, 17 are identified by the dotted line with one half being located on the left side and one half being located on the right side of the dotted line. The drain pan 15 has a lowest position 18 at which a drain opening 19 is provided. The bottom of the drain pan 15 slants toward the drain opening 19 and hence the lowest position 18. Thus water dropping from any component into the drain pan is directly guided to the drain opening 19 and the lowest position 18 which is furthest away from the fan 20. Thereby it is prevented that water

accumulated within the drain pan may be sucked into the fan 20 and hence through the opening 14 into the duct. The drain opening 19 is directly connected to drainage so that water is directly drained.

[0038] Moreover, a sound and/or thermal insulation 22 are provided within the casing 2 at the side opposite to the drain pan 15 with respect to the line CL. In the cross section and hence a side view (figure 3), the inner surfaces of the drain pan 15 and the insulation 22 respectively directed to the heat exchanger 15 should be approximated so that the duct created within the casing 2 is as symmetric as possible.

[0039] Further, the distance between the ends 30, 31 of the upper and lower heat exchanger elements 6, 7 away from the apex 8 and the entry of the suction opening 21 should be as short as possible to reduce the length. In particular, the high velocity zone of the fans should in the side view not overlap with the heat exchanger 5 and/or the drain pan 15.

[0040] Figure 4 shows simulations of the air distribution through the heat exchanger 5.

[0041] The baffle plates 9 shown in figure 4 are all air impermeable. The baffle plate 9 in figure 4a) covers a part of the area of the apex 8 as seen in a direction perpendicular to the flow of air F. In the shown cross-section or side view, the shape of the baffle plate 9 is that of an equiangular triangle. The legs 34, 35 of the triangle are convex. In addition, the apex 36 of the triangle is located on the centerline CL of the heat exchanger 5 and directed towards the air flow F. The simulation in figure 4a) visualizes that the selected shape of the baffle plate 9 avoids turbulences in an area 37 upstream of the baffle plate 9 as compared to a baffle plate 9 as shown in figure 4c).

[0042] Similar may also be achieved when using a baffle plate 9 as shown in figure 4b). The baffle plate 9 in figure 4b) has a rounded shape and particularly that of a partial circle. The center of the circle is again located on the centerline CL of the heat exchanger 5. Further apparent from the drawing, the baffle plate 9 covers the entire area of the apex 8 of the heat exchanger so that substantially no air is introduced into the heat exchanger 5 at the front facing the air flow F.

[0043] On the baffle plate 9 in figure 4c) is much smaller than those in figure 4a) and figure 4b) above and covers only a minor portion of the area of the apex 8. The shape of the baffle plate 9 is again rounded or curved, preferably as part of a circle with the center of the circle being located on the centerline CL of the heat exchanger 5. Because of the smaller size of the baffle plate 9 front faces 38 and 39 of the heat exchanger elements 6, 7 allow the entry of air into the heat exchanger elements 6, 7 so that the air distribution of air flowing through the portions of the heat exchanger elements 6, 7 referred to as 40 and 41 in figure 4c) can be increased with the effect of more even air distribution through the heat exchanger elements 6, 7 as compared to the previous embodiments in figure 4a) and 4b). However, the area 37 upstream of the baffle plate 9 has more turbulences as compared to the

previous embodiments.

mated shapes.

Claims

1. Heat exchanger unit comprising:

a casing (2) having a duct to be flown through by a fluid,
 a fan (20) disposed in the casing and configured to induce a flow of the fluid through the duct in a flow direction (F),
 a heat exchanger (5) being V-shaped in side view with an apex (8) at one end and an opening (12) at the opposite end, the heat exchanger being disposed in the duct with the apex directed towards the flow direction, wherein a line (CL) of the V-shaped heat exchanger in the side view and passing the apex extends horizontally,
characterized in that
 the fan is disposed downstream of the heat exchanger in the flow direction.

2. Heat exchanger unit according to claim 1, wherein the flow direction (F) and the line (CL) of the V-shaped heat exchanger (5) are parallel in the side view.

3. Heat exchanger unit according to claim 1 or 2, wherein the fan (20) is a backward curved centrifugal fan.

4. Heat exchanger unit according to any one of the preceding claims, further comprising a baffle plate (9) disposed at the apex (8) of the heat exchanger (5) and directed towards the flow direction (F).

5. Heat exchanger unit according to claim 4, wherein the baffle plate (9) is symmetrical relative to the line (CL) of the heat exchanger (5).

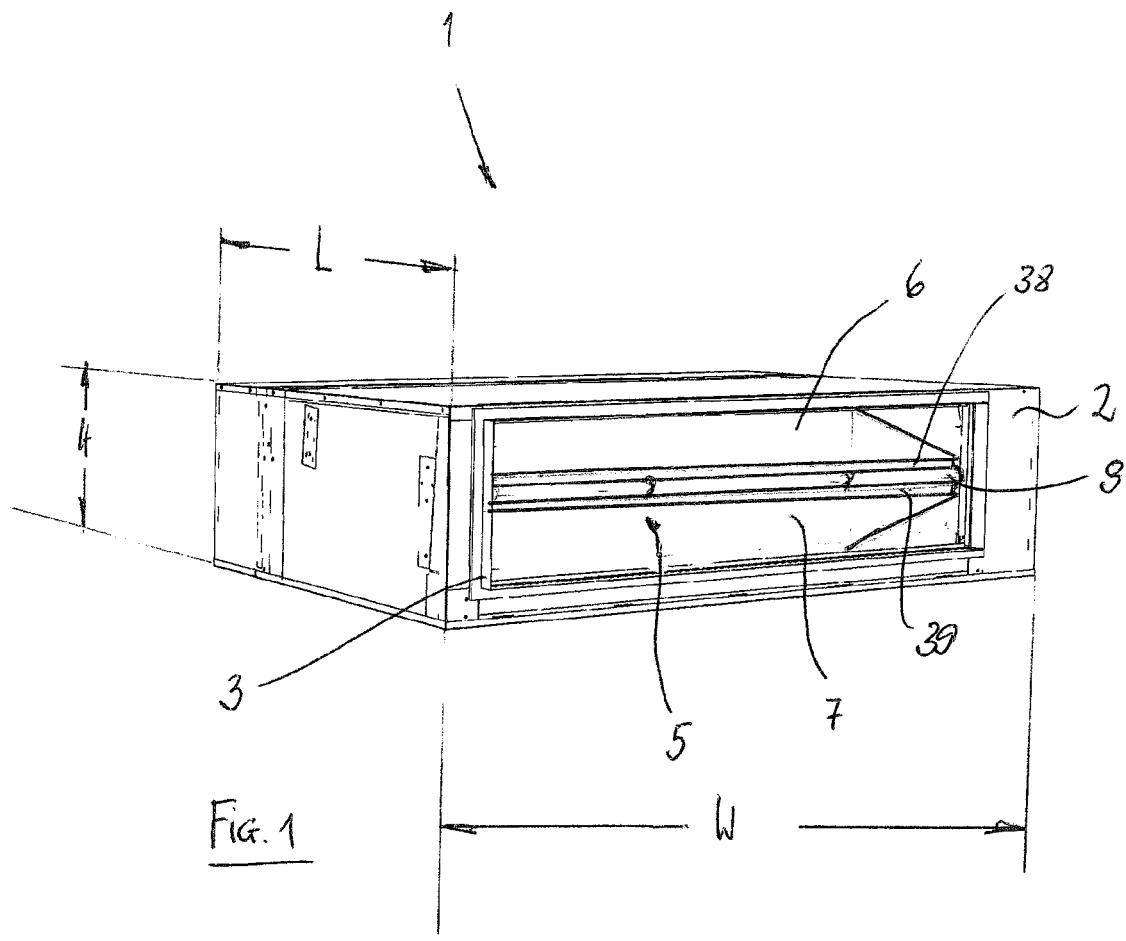
6. Heat exchanger unit according to claim 4 or 5, wherein the baffle plate (9) has, in cross section, an equiangular triangular shape.

7. Heat exchanger unit according to claim 6, wherein the legs (34, 35) of the equiangular triangular shape directed towards the flow direction (F) are convex.

8. Heat exchanger unit according to claim 4 or 5, wherein the baffle plate (9) has a rounded shape in cross section.

9. Heat exchanger unit according to any one of the preceding claims, further comprising a drain pan (15) and an insulation (22) disposed on an opposite side of the heat (5) exchanger relative to the drain pan, wherein surfaces of the insulation and the drain pan directed toward the heat exchanger have approxi-

10. Heat exchanger unit according to one of the preceding claims, wherein the heat exchanger (5) comprises waffled fins.



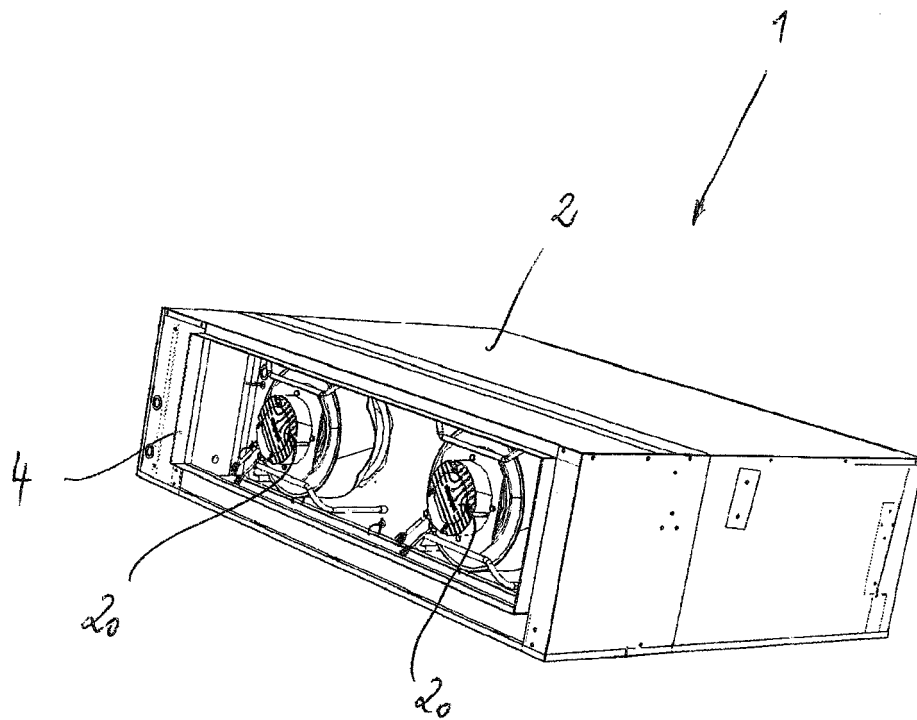
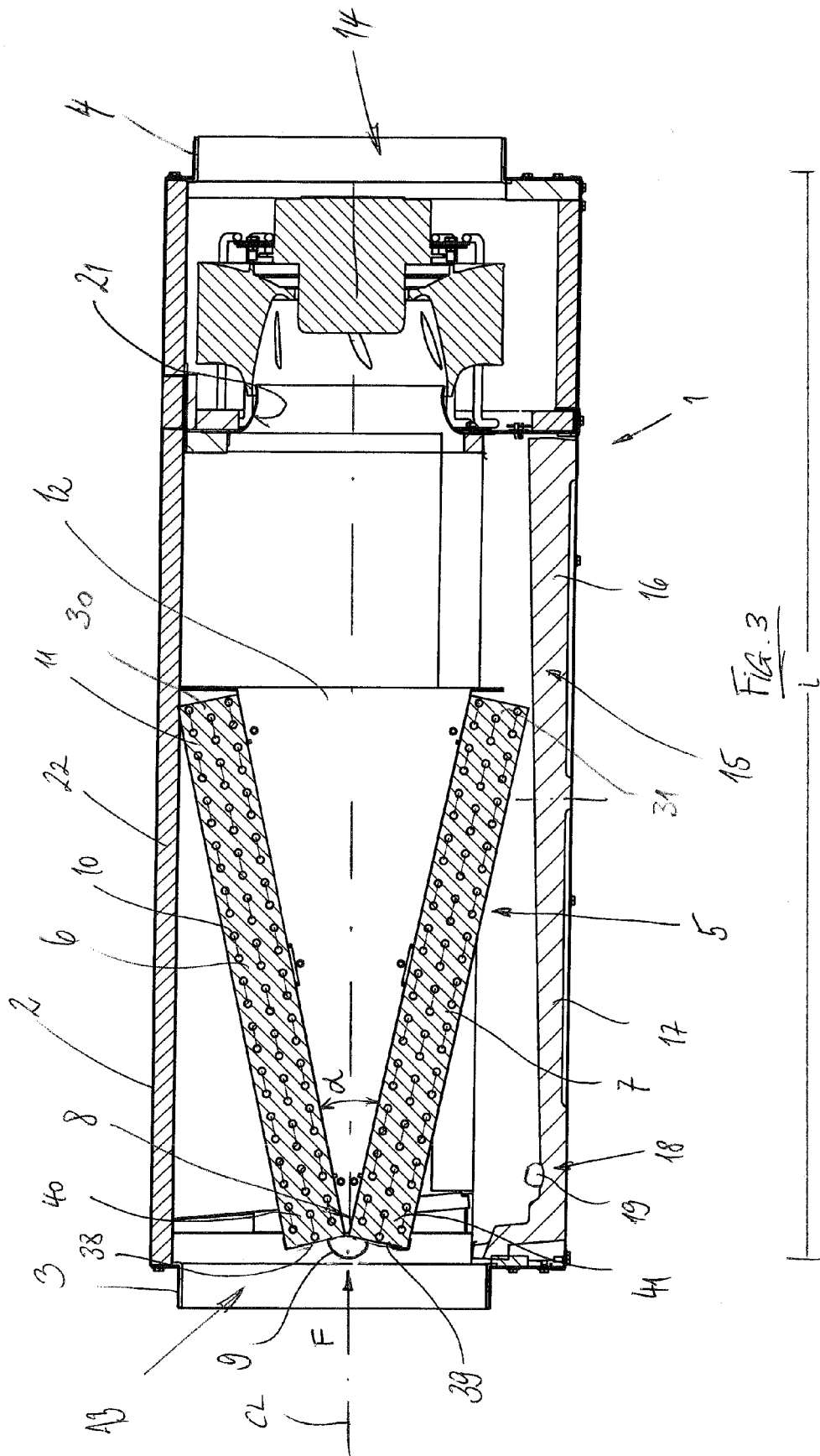
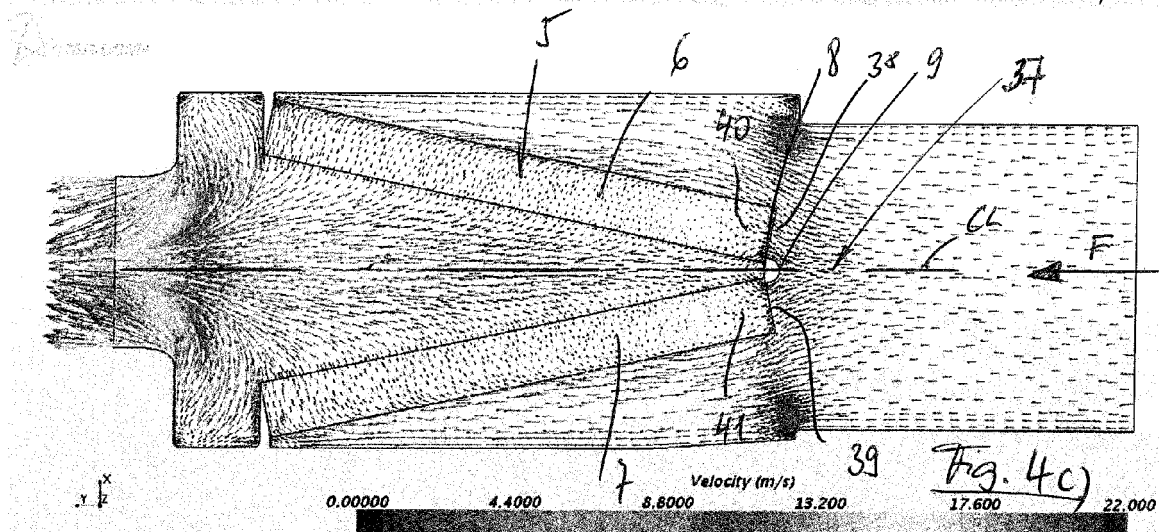
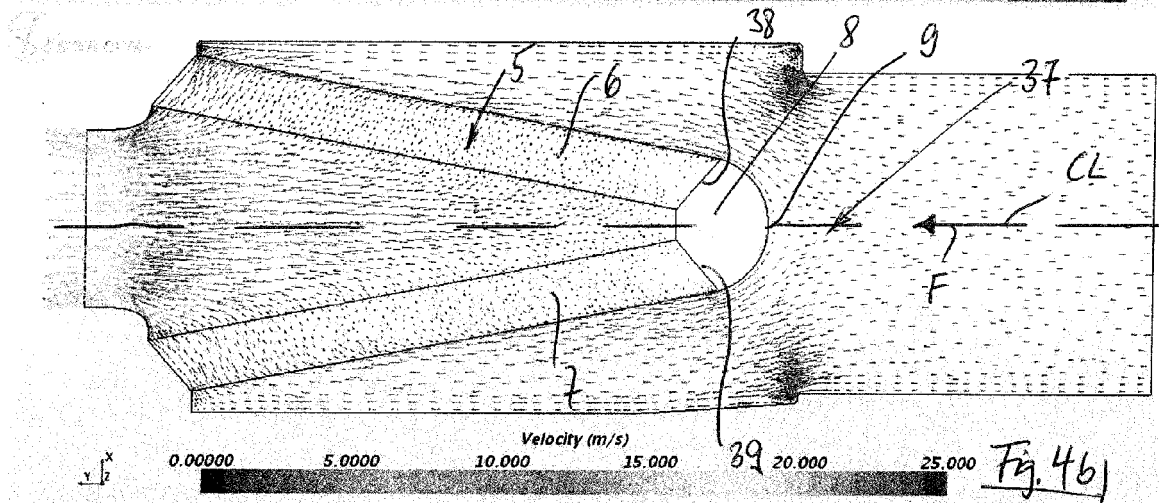
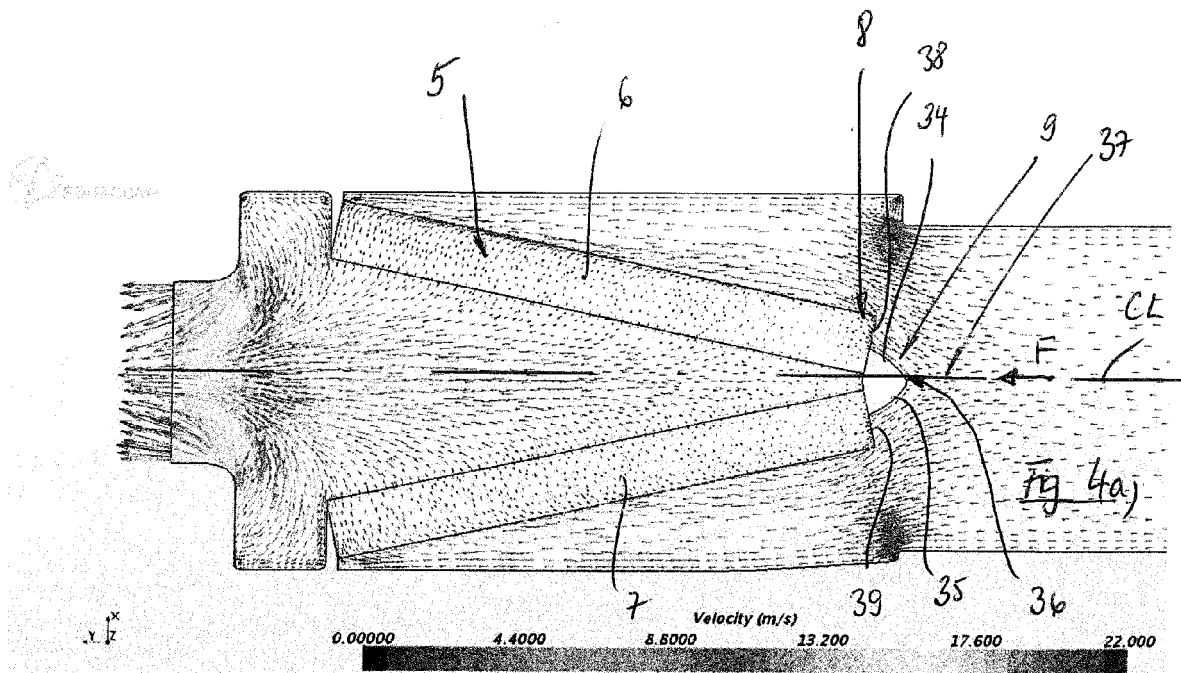


FIG. 2







EUROPEAN SEARCH REPORT

Application Number
EP 15 16 4037

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Place of search Munich		Date of completion of the search 7 October 2015	Examiner Valenza, Davide
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