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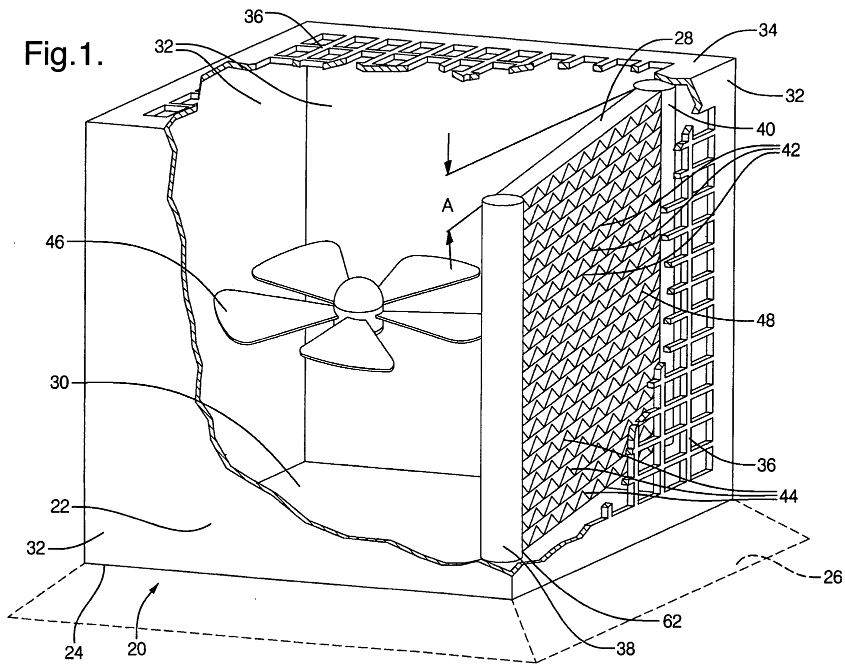
(54) **Heat exchanger unit**

(57) A heat exchanger unit (20) includes a support assembly (22) having a support surface (24) extending in a first plane (26) and a heat exchanger (28) coupled to the support surface (24) and fixed relative to the first plane (26). The heat exchanger (28) includes a first manifold (38) and a second manifold (40) extending in spaced relationship with one another and a plurality of tubes (42) spaced from one another and extending between and engaging the first manifold (38) and the second manifold (40). The tubes (42) communicate fluid between the manifolds (38, 40). At least a portion of each of the tubes (42) extend angularly relative to the first plane (26) for draining condensate along the tubes (42) toward a common drainage point (62) to remove the condensate from the tubes (42) and focus the condensate to the common drainage point (62). The drainage of the condensate from the tubes (42) prevents the freezing of the condensate on the tubes (42) to prevent the blockage of air movement over the tubes (42) by frozen condensate.

Fig.1.



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Description

Technical field

[0001] The present invention relates to a heat exchanger unit including a heat exchanger.

Background of the Invention

[0002] Heat exchanger units are used in a variety of applications that require the transfer of heat from one space to another space. Specifically, the heat exchanger unit includes a heat exchanger and a support assembly for supporting the heat exchanger. Heat transfers from ambient air surrounding the heat exchanger to fluid, i.e. refrigerant, in the heat exchanger. Specifically, the heat exchanger includes a plurality of tubes. The fluid passes through the tubes and heat is transferred from the air surrounding the tubes to the fluid. Fins are generally disposed on the tubes to increase the surface area to the tubes to increase heat transfer from the air surrounding the tubes.

[0003] For example, such a heat exchanger unit is included in a non-mobile heat exchanger system such as a heat pump system. The heat pump system transfers heat from an exterior of a building to an interior of the building. Specifically, in such a configuration, the heat exchanger unit is disposed in the exterior of the building and heat is transferred from the heat exchanger unit to an interior unit disposed in the interior of the building. The heat is dispersed from the interior unit to air in the interior of the building to heat the interior of the building.

[0004] The tubes of the heat exchanger may extend vertically such that the refrigerant flows vertically. Alternatively, the tubes of the heat exchanger extend horizontally such that the refrigerant flows horizontally. The heat exchanger configured with horizontal tubes is advantageous in the non-mobile heat exchanger unit due to packaging and size restraints. The tubes extend between a pair of manifolds.

[0005] Two common configurations exist for the heat exchanger, namely, a round tube and plate fin construction and a brazed construction. With respect to the tube-fin construction, typically each tube has a circular-shaped cross-section. With respect to the brazed construction, typically each tube has a hyper-ellipse-shaped cross-section, i.e. the cross-section is generally rectangular with rounded corners.

[0006] The round tube and plate fin construction is conventionally used in the non-mobile heat exchanger unit. Because the refrigerant is colder than the ambient air flowing around the tubes, condensate forms on the tubes and fins. Because the tubes have the circular-shaped cross-section, the condensate drains from the tubes in response to gravitational force. However, the condensate drains from the tubes along the entire length of the tubes. A large pan is required to collect the drained condensate and to prevent the condensate from draining on water-sensitive components of the heat exchanger unit.

[0007] The brazed construction has better heat transfer properties than the round tube and plate fin construction because brazing improves the thermal contact between the tubes and the fins and the hyper-ellipse-shaped cross-section of the tube creates less air flow resistance than do the round tubes. However, because the tubes have the hyper-ellipse-shaped cross-section, condensate does not drain from the tubes in response to gravitational force. In other words, condensate that forms on a top surface of the hyper-ellipse-shaped cross-section does not drain from the tubes in response to gravitational force. The condensate accumulates on the tubes and is subject to freezing on the tubes and fins. Water further accumulates on the tubes and fins in the form of frost. As more condensate forms and freezes on the tubes and fins, the frozen condensate and the frost increases the air flow resistance of the tubes and fins, which leads to a decrease in air flow and heat transfer.

[0008] Accordingly, it would be desirable to manufacture a heat exchanger unit including a heat exchanger with tubes wherein condensate is drained from the tubes to prevent the accumulation of the condensate on the tubes. In addition, it would be desirable to manufacture a heat exchanger unit whereby drained condensate is directed toward a common drainage point to manage the removal of the drained condensate.

Summary of the Invention

[0009] The present invention is a heat exchanger unit comprising a support assembly and a heat exchanger. The support assembly has at least one support surface extending in a first plane. The heat exchanger is coupled to the support surface and fixed relative to the first plane. The heat exchanger includes a first manifold and a second manifold extending in spaced relationship with one another and a plurality of tubes spaced from one another and extending between and engaging the first manifold and the second manifold. The tubes communicate fluid between the first manifold and the second manifold. At least a portion of each of the tubes extend angularly relative to the first plane for draining condensate along the tubes toward a common drainage point to remove the condensate from the tubes and focus the condensate to the common drainage point.

[0010] Accordingly, because the condensate is drained from the tubes, the condensate does not accumulate on the tubes and the fins. The prevention of the condensate from freezing maintains the free movement of air around the tubes of the heat exchanger and maintains the heat transfer capabilities of the heat exchanger.

[0011] In addition, the drainage of the condensate toward the common drainage point provides for efficient management of condensate. In other words, the condensate is drained toward the common drainage point to prevent the splashing or dripping of condensate from the tubes to the support assembly along the length of the tubes. The condensate is focused toward the common drainage point and is easily removed from the heat exchanger unit from the common drainage point.

Description of the Drawings

[0012] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a partially cut-away perspective view of the heat exchanger unit including a support assembly presenting a support surface and a first embodiment of a heat exchanger coupled to the support surface;
Figure 2 is a front view of the first embodiment of the heat exchanger;
Figure 3 is a perspective view of a second embodiment of the heat exchanger;
Figure 4 is a perspective view of a third embodiment of the heat exchanger;
Figure 5 is a front view of a fourth embodiment of the heat exchanger;
Figure 6 is a perspective view of a fifth embodiment of the heat exchanger;
Figure 7 is a perspective view of a sixth embodiment of the heat exchanger;
Figure 8 is a perspective view of a seventh embodiment of the heat exchanger;
Figure 9 is a perspective view of an eight embodiment of the heat exchanger;
Figure 10 is a perspective view of a ninth embodiment of the heat exchanger; and
Figure 11 is a graph illustrating the effect on air flow resistance of an exemplary heat exchanger when tubes of the heat exchanger extend angularly relative to a first plane.

Description of the Preferred Embodiments

[0013] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, a heat exchanger unit is shown generally at 20. The heat exchanger unit 20 may be a component of a non-mobile heat exchanger system, such as a heat pump system for a building. In the heat pump system, the heat exchanger unit 20 may be of the type disposed in an exterior of the building. In such a configuration, heat is transferred from air of the exterior of the building to fluid, i.e. refrigerant, in the heat exchanger unit 20. The fluid may then be transferred to an interior unit disposed in an interior of the building where the heat is dispersed from the interior unit to air in the interior of the building to heat the interior of the building.

[0014] The heat exchanger unit 20 includes a support assembly 22 having at least one support surface 24 extending in a first plane 26. A heat exchanger 28 is coupled to the support surface 24 and is fixed relative to the first plane 26.

[0015] The support assembly 22 includes a base 30, side panels 32 extending upwardly from the base 30, and a top panel 34. The base 30 presents the support surface 24 extending in the first plane 26. At least one of the side 32 and the top 34 panels defines a screen 36. In other words, one of the side and the top panels 32, 34 or any combination of the side panels 32 and/or the top panel 34 defines at least one screen 36.

[0016] The base 30 of the support assembly 22 is configured to rest on a solid surface. For example, the base 30 may be disposed on outdoor ground, on a cement slab, or on flooring. It should be appreciated that the base 30 may be disposed on any type of solid surface. As shown in Figure 1, the base 30 of the support assembly 22 is planar. It should be appreciated that the base 30 may include legs. In such a configuration, the legs present the support surface 24 extending in the first plane 26. It should also be appreciated that the base 30 may include a window mount to be mounted to a window sill of the building. In such a configuration, the heat exchanger unit may be cantilevered from the window mount. It should be appreciated that the base 30 may also include a ceiling mount to be mounted to a ceiling of the building or a wall mount to be mounted to a wall of the building. As will be discussed below, preferably, the support assembly 22 is arranged such that the first plane 26 is perpendicular to the direction of gravity.

[0017] The heat exchanger 28 includes a first manifold 38 and a second manifold 40 extending in spaced relationship with one another. The heat exchanger 28 includes a plurality of tubes 42 spaced from one another and extending between and engaging the first manifold 38 and the second manifold 40 for communicating fluid between the first manifold 38 and the second manifold 40. Preferably, each of the tubes 42 extends in parallel with one another. The panels 32, 34 defining the screen 36 allows the movement of air through the support assembly 22 to facilitate the transfer of heat between the tubes 42 of the heat exchanger 28 and the air moving around the tubes 42.

[0018] Preferably, fins 44 are disposed on the tubes 42 to increase the surface area of the tubes 42 to increase heat transfer from the air passing around the tubes 42. The fins 44 are preferably louvered to increase the surface area of the fins 44 and to increase heat transfer performance.

[0019] The support assembly 22 encloses the heat exchanger 28. The heat exchanger unit 20 also includes heat exchanger equipment (not shown) as known to one skilled in the art. The support assembly 22 encloses heat exchanger equipment. For example, the heat exchanger equipment includes a compressor and an expansion valve.

[0020] The heat exchanger equipment also includes a fan 46 for blowing air over the tubes 42 of the heat exchanger 28. As shown in Figure 1, the fan 46 is shown as a fan blade. The fan blade is shown for illustrative purposes to show the location and the blowing direction of the fan 46 and it should be appreciated that the fan 46 may include any type of fan blade or blower. The fan 46 moves air through the support assembly 22.

[0021] The support assembly 22 as shown in Figure 1 is a cuboid, i.e. a rectangular box; however it should be appreciated that the support assembly 22 may be any shape. For example, the support assembly 22 may cylindrical. In such a configuration, preferably the side panels 32 are curved and the tubes 42, as shown in Figure 10, extend along arced paths between the first manifold 38 and the second manifold 40.

[0022] Preferably, the heat exchanger 28 has a brazed construction. Preferably, with respect to the brazed construction, each tube 42 has a hyper-ellipse-shaped cross-section, i.e. the cross-section is generally rectangular with rounded corners.

[0023] The liquid in the tubes 42 has a lower temperature than air surrounding the tubes 42 and fins 44, which may lead to the formation of condensate on the tubes 42 and fins 44. At least a portion of each of the tubes 42 extends angularly relative to the first plane 26 for draining condensate along the tubes 42 toward a common drainage point 62 to remove the condensate from the tubes 42 and focus the condensate to the common drainage point 62. In other words, each tube includes a continuously inclined surface for efficient drainage of condensate.

[0024] Because the condensate is drained from the tubes 42, the condensate is not subject to freezing on the tubes 42. In other words, in certain conditions the condensate would be subject to freezing on the tube and fins 44 if the condensate was not drained from the tubes 42. Frozen condensate on the tubes 42 would prevent the movement of air around the tubes 42 and the fins 44, which would lead to a decrease in heat transfer.

[0025] Because the condensate is focused to the common drainage point 62, the condensate is easily managed and drained away from the heat exchanger unit 20. In other words, the condensate is drained toward the common drainage point 62 to prevent the splashing or dripping of condensate from the tubes 42 to the support assembly 22 along the length of the tubes 42. For example, a tray (not shown) may be disposed below the common drainage point 62 to collect the condensate. Because the condensate is directed toward the common drainage point 62, the tray need not extend below the tubes 42 along the length of the tubes 42 but rather only below the common drainage point 62.

[0026] Specifically, the tubes 42 preferably include a first section 48 extending at a first angle A relative to the first plane 26. Preferably, the first angle is greater than or equal to 5 degrees.

[0027] Preferably, the support assembly 22 is arranged such that the first plane 26 is perpendicular to the direction of gravity. In other words, preferably the support surface 24 is disposed on a surface that is perpendicular to the direction of gravity. When the first plane 26 is perpendicular to the direction of gravity, gravitational forces act on the condensate to move the condensate along the first section 48 of the tubes 42.

[0028] The first angle A preferably maximizes the drainage of condensate from the tubes 42 while minimizing unused space in the support assembly 22. In other words, the support assembly 22 is aesthetically pleasing when the side panels 32 of the support assembly 22 extend upwardly perpendicularly to the first plane 26. In such a configuration, when the tubes 42 extend at the first angle A relative to the first plane 26, unused space being generally triangularly-shaped exists above the tubes 42 and below the tubes 42. Figure 11 illustrates an effect of varying magnitudes of the first angle A on the air flow resistance of the heat exchanger. For example, as shown in Figure 11, the first angle A having a magnitude of 90 degrees results in the lowest air flow resistance and the first angle A having a magnitude of 0 degrees results in the highest air flow resistance. In other words, as the magnitude of the first angle A is increased, the condensation is better drained from the tubes resulting in a decrease in air flow resistance of the heat exchanger. When the first angle A has a magnitude of 5 degrees, the increase in pressure differential across the heat exchanger resulting from the first angle A being 0 degrees is reduced by approximately half. However, it should be appreciated that the first angle A may be of any magnitude that maximizes the drainage of condensate from the tubes 42 while minimizing unused space in the support assembly 22.

[0029] The heat exchanger 28 is coupled to the support assembly 22 in any manner known to one skilled in the art. For example, the heat exchanger 28 may include a bracket engaging the support assembly 22. The bracket may extend from one of the manifolds 38, 40. Alternatively, the heat exchanger 28 may include a core reinforcement plate extending between the manifolds 38, 40 and the bracket may extend from the core reinforcement plate.

[0030] The bracket may be sized and shaped to be snapped onto or press-fit onto the manifold or the core reinforcement plate. Alternatively, the bracket may be brazed to the manifold or the core reinforcement plate or may be extruded with the manifold.

[0031] For example, the support assembly 22 may include a plate extending vertically with the bracket extending from the manifold and engaging the plate such that at least a portion of each of the tubes 42 extends angularly relative to the first plane 26. In another configuration, for example, the support assembly 22 may include a crossbar extending horizontally with the bracket extending from the core reinforcement plate and engaging the crossbar such that at least a portion of each of the tubes 42 extends angularly relative to the first plane 26.

[0032] In the alternative to or in addition to the bracket, the heat exchanger 28 may include a spacer disposed between the base 30 of the support structure and one of the manifolds 38, 40 while the other of the manifolds 38, 40 is disposed on the base 30 of the support structure such that the tubes 42 extend angularly relative to the first plane 26.

[0033] In differing configurations described below, each of the tubes 42 may include sections with a bend between each section. It should be appreciated that the configurations described below are exemplary and the heat exchanger 28 of the present invention may include any number of sections and/or bends. The bends shown in Figures 3-4 and 6-9 are at 90 degrees; however, it should be appreciated that the bends may be at any angle.

[0034] In a first embodiment of the heat exchanger, as shown in Figures 1 and 2, the heat exchanger 28 includes the first section 48. In the first embodiment, each of the tubes 42 extend perpendicularly from the first manifold 38 and from the second manifold 40. In the first embodiment, the common drainage point 62 is located at the first manifold 38. In other words, condensate on the first section 48 of each of the tubes drains along the first section toward the first manifold 38. When the condensate reaches the first manifold 38, the condensate drips down the first manifold 38 to the common drainage point 62.

[0035] In a second embodiment of the heat exchanger, as shown in Figure 3, each of the tubes 42 includes a first bend 54 connected to the first section 48 and a second section 50 extending from the first bend 54. The first bends 54 of each of the tubes 42 are spaced from one another along a first bend line 58. Preferably, the second section 50 extends perpendicularly relative to the first section 48. As in the first embodiment, each of the tubes 42 extend perpendicularly from the first manifold 38 and from the second manifold 40.

[0036] In the second embodiment, the second section 50 extends at a second angle B relative to the first plane 26. Preferably, the second angle is greater than or equal to 5 degrees.

[0037] In the second embodiment, the common drainage point 62 is located at the first manifold 38. In other words, condensate on the second section 50 of each of the tubes 42 drains along the second section 50 toward the first bend 54. This condensate at the first bend 54 as well as condensate on the first section 48 drains toward the first manifold 38. When the condensate reaches the first manifold 38, the condensate drips down the first manifold 38 to the common drainage point 62.

[0038] For illustrative purposes, Figure 2 shows line A which corresponds to the first bend line 58. Specifically, line A extends angularly relative to the first manifold 38. Preferably, line A extends at the first angle A relative to the manifolds 38, 40. In such a configuration, when the first section 48 extends at the first angle A relative to the first plane 26 and the second section 50 extends at the second angle B relative to the first plane 26, each of the first bends 54 of the tubes 42 define the first bend line 58 extending perpendicularly relative to the first plane 26.

[0039] In a third embodiment of the heat exchanger, as shown in Figure 4, each of the tubes 42 includes a second bend 56 connected to the first section 48 and a third section 52 connected to and extending from the second bend 56. The second bends 56 of each of the tubes 42 are spaced from one another along a second bend line 60. Preferably, the third section 52 extends perpendicularly relative to the first section 48. As in the first and second embodiments, each of the tubes 42 extend perpendicularly from the first manifold 38 and from the second manifold 40.

[0040] The third section 52 extends at a third angle C relative to the first plane 26. Preferably, the third angle C is greater than or equal to 5 degrees.

[0041] As shown in Figure 4, the common drainage point 62 is located at the first manifold 38. In other words, the condensate on the second section 50 of each of the tubes 42 drains along the second section 50 toward the first bend 54. This condensate at the first bend 54 as well as condensate on the first section 48 drains toward the second bend 56. This condensate at the second bend 56 as well as the condensate on the third section 52 drains toward the first manifold 38. When the condensate reaches the first manifold 38, the condensate drips down the first manifold 38 to the common drainage point 62.

[0042] For illustrative purposes, Figure 2 shows line B which corresponds to the second bend line 60. Specifically, line B extends angularly relative to the manifolds. Preferably, line B extends at the second angle B relative to the second manifold 40. In such a configuration, when the first section 48 extends at the first angle A relative to the first plane 26 and the third section 52 extends at the third angle C relative to the first plane 26, each of the second bends 56 of the tubes 42 define the second bend line 60 extending perpendicularly relative to the first plane 26.

[0043] In a fourth embodiment of the heat exchanger, as shown in Figure 5, the heat exchanger 28 includes the first section 48. In the fourth embodiment, each of the tubes 42 extend angularly from the first manifold 38 and from the second manifold 40. As in the first embodiment, in the fourth embodiment the common drainage point 62 is located at the first manifold 38.

[0044] In a fifth embodiment of the heat exchanger, as shown in Figure 6, each of the tubes 42 includes the first bend 54 connected to the first section 48 and the second section 50 extending from the first bend 54. The first bends 54 of each of the tubes 42 are spaced from one another along the first bend line 58. Preferably, the second section 50 extends perpendicularly relative to the first section 48. Each of the tubes 42 extend angularly from the first manifold 38 and from the second manifold 40.

[0045] In the fifth embodiment, as in the second embodiment, the second section 50 extends at a second angle B relative to the first plane 26. In the fifth embodiment, as in the second embodiment, the common drainage point 62 is located at the first manifold 38.

[0046] For illustrative purposes, Figure 5 shows line C which correspond to the first bend line 58. Specifically, line C extends in parallel with the manifolds 38, 40. In such a configuration, when the first section 48 extends at the first angle A relative to the first plane 26 and the second section 50 extends at the second angle B relative to the first plane 26, each of the first bends 54 of the tubes 42 define the first bend line 58 extending perpendicularly relative to the first plane 26. Because the manifolds 38, 40 and the first bend line 58 extend perpendicularly to the first plane 26, the heat exchanger efficiently fits inside the support assembly 22.

[0047] In a sixth embodiment of the heat exchanger, as shown in Figure 7, each of the tubes 42 includes a second bend 56 connected to the first section 48 and a third section 52 connected to and extending from the second bend 56. The second bends 56 of each of the tubes are spaced from one another along a second bend line 60. Preferably, the third section 52 extends perpendicularly relative to the first section 48. As in the fourth and fifth embodiments, each of the tubes 42 extend angularly from the first manifold 38 and from the second manifold 40.

[0048] In the sixth embodiment, as in the third embodiment, the third section 52 extends at the third angle C relative to the first plane 26. In the sixth embodiment, as in the third embodiment, the common drainage point 62 is located at the first manifold 38.

[0049] For illustrative purposes, Figure 5 shows line D which corresponds to the second bend line 60. Specifically, line D extends in parallel with the manifolds 38, 40. In such a configuration, when the first section 48 extends at the first angle A relative to the first plane 26 and the third section 52 extends at the third angle C relative to the first plane 26, each of the second bends 56 of the tubes 42 define the second bend line 60 extending perpendicularly relative to the first plane 26. Because the manifolds 38, 40 and the second bend line 58 extend perpendicularly to the first plane 26, the heat exchanger efficiently fits inside the support assembly 22.

[0050] In a seventh embodiment of the heat exchanger, as shown in Figure 8, each of the tubes 42 extend perpendicularly from the first manifold 38 and from the second manifold 40. Each of the tubes 42 includes the first bend 54 and the second bend 56 with the first section 48 extending between the first bend 54 and the second bend 56. The second section 50 extends from the first bend 54 and the third section 52 extends from the second bend 56. The first bend line 58, the second bend line 60, the first manifold 38, and the second manifold 40 extend in parallel.

[0051] As shown in Figure 8, the second 50 and third 52 sections of each of the tubes 42 extends in parallel with the first plane 26 while maintaining the first section 48 at the first angle A relative to the first plane 26. In the seventh embodiment, the common drainage point 62 is located at the second bend line 60. In other words, condensate on each of the tubes 42 of the first section 48 drains along the first section 48 toward the second bend 56. When the condensate reaches the second bend 56, the condensate drips down the second bend line 60 to the common drainage point 62.

[0052] In an eighth embodiment of the heat exchanger, as shown in Figure 9, each of the tubes 42 extend perpendicularly from the first manifold 38 and from the second manifold 40. In the eighth embodiment, as in the seventh embodiment, each of the tubes includes the first section 48, the second section 50, and the third section 52.

[0053] In the eighth embodiment, the first section 48 of each of the tubes 42 extends in parallel with the first plane 26. The second section 50 of each of the tubes 42 extends from the first bend 54 at the second angle B relative to the first plane 26. The third section 52 of each of the tubes 42 extends from the second bend 56 at the third angle C relative to the first plane 26. A first common drainage point 64 is located at the first manifold 38 and a second common drainage point 66 is located at the second manifold 40. In other words, condensate on each of the tubes 42 of the third section 52 drains along the third section 52 toward the first manifold 38. When the condensate reaches the first manifold 38, the condensate drips down the first manifold 38 to the first common drainage point 64. Condensate on each of the tubes 42 of the second section 50 drains along the second section 50 toward the second manifold 40. When the condensate reaches the second manifold 40, the condensate drips down the second manifold 40 to the second common drainage point 66.

[0054] The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Obviously, many modifications and variations of the present invention are possible in light of the above teachings, and the invention may be practiced otherwise than as specifically described.

Claims

1. A heat exchanger unit (20) comprising;

 a support assembly (22) having at least one support surface (24) extending in a first plane (26),
 a heat exchanger (20) coupled to said support surface (24) and fixed relative to said first plane (26) with said heat exchanger (20) including;
 a first manifold (38) and a second manifold (40) extending in spaced relationship with one another, and
 a plurality of tubes (42) spaced from one another and extending between and engaging said first manifold (38) and said second manifold (40) for communicating fluid between said first manifold (38) and said second manifold (40),

at least a portion of each of said tubes (42) extending angularly relative to said first plane (26) for draining condensate along said tubes (42) toward a common drainage point (62) to remove the condensate from the tubes (42) and focus the condensate to the common drainage point (62).

2. The heat exchanger unit (20) as set forth in claim 1 wherein said tubes (42) include a first section (48) extending at a first angle (A) relative to said first plane (26).

3. The heat exchanger unit (20) as set forth in claim 2 wherein said first angle (A) is greater than or equal to 5 degrees.

4. The heat exchanger unit (20) as set forth in claim 2 wherein each of said tubes (42) includes a first bend (54) connected to said first section (48) and a second section (50) extending from said first bend (54).

5. The heat exchanger unit (20) as set forth in claim 4 wherein said second section (50) extends perpendicularly relative to said first section (48).

6. The heat exchanger unit (20) as set forth in claim 4 wherein said second section (50) extends at a second angle (B) relative to said first plane (26).

7. The heat exchanger unit (20) as set forth in claim 6 wherein said second angle (B) is greater than or equal to 5 degrees.

8. The heat exchanger unit (20) as set forth in claim 4 wherein each of said tubes (42) includes a second bend (56) connected to said first section (48) and a third section (52) connected to and extending from said second bend (56).

9. The heat exchanger unit (20) as set forth in claim 8 wherein said third section (52) extends perpendicularly relative to said first section (48).

10. The heat exchanger unit (20) as set forth in claim 8 wherein said third section (52) extends at a third angle (C) relative to said first plane (26).

11. The heat exchanger unit (20) as set forth in claim 10 wherein said third angle (C) is greater than or equal to five degrees.

12. The heat exchanger unit (20) as set forth in claim 4 wherein each of said first bends (54) of said tubes (42) define a first bend line (58) extending perpendicularly relative to said first plane (26).

13. The heat exchanger unit (20) as set forth in claim 8 wherein each of said first bends (54) of said tubes (42) define a first bend line (58) extending perpendicularly relative to said first plane (26) and each of said second bends (56) of said tubes (42) define a second bend line (60) extending perpendicularly relative to said first plane (26).

14. The heat exchanger unit (20) as set forth in claim 4 wherein said second section (50) of each of said tubes (42) extends in parallel with said first plane (26) while maintaining said first section (48) at said first angle (A) relative to said first plane (26).

15. The heat exchanger unit (20) as set forth in claim 8 wherein said second section (50) of each of said tubes (42) extends in parallel with said first plane (26) and said third section (52) of each of said tubes (42) extend in parallel with said first plane (26) while maintaining said first section (48) at said first angle (A) relative to said first plane (26).

16. The heat exchanger unit (20) as set forth in claim 1 wherein each of said tubes (42) includes a first bend (54) and a second bend (56) with a first section (48) extending between said first bend (54) and said second bend (56) in parallel with said first plane (26), a second section (50) extending from said first bend (54) at a second angle (B) relative to said first plane (26), and a third section (52) extending from said second bend (56) at a third angle (C) relative to said first plane (26).

17. The heat exchanger unit (20) as set forth in claim 1 wherein each of said tubes (42) extend perpendicularly from said first manifold (38) and from said second manifold (40).

18. The heat exchanger unit (20) as set forth in claim 1 wherein said tubes (42) extend angularly from said first manifold (38) and from said second manifold (40).

19. The heat exchanger unit (20) as set forth in claim 1 wherein each of said tubes (42) extend in parallel with one another.

20. The heat exchanger unit (20) as set forth in claim 1 wherein said tubes (42) extend along arced paths between said first manifold (38) and said second manifold (40).

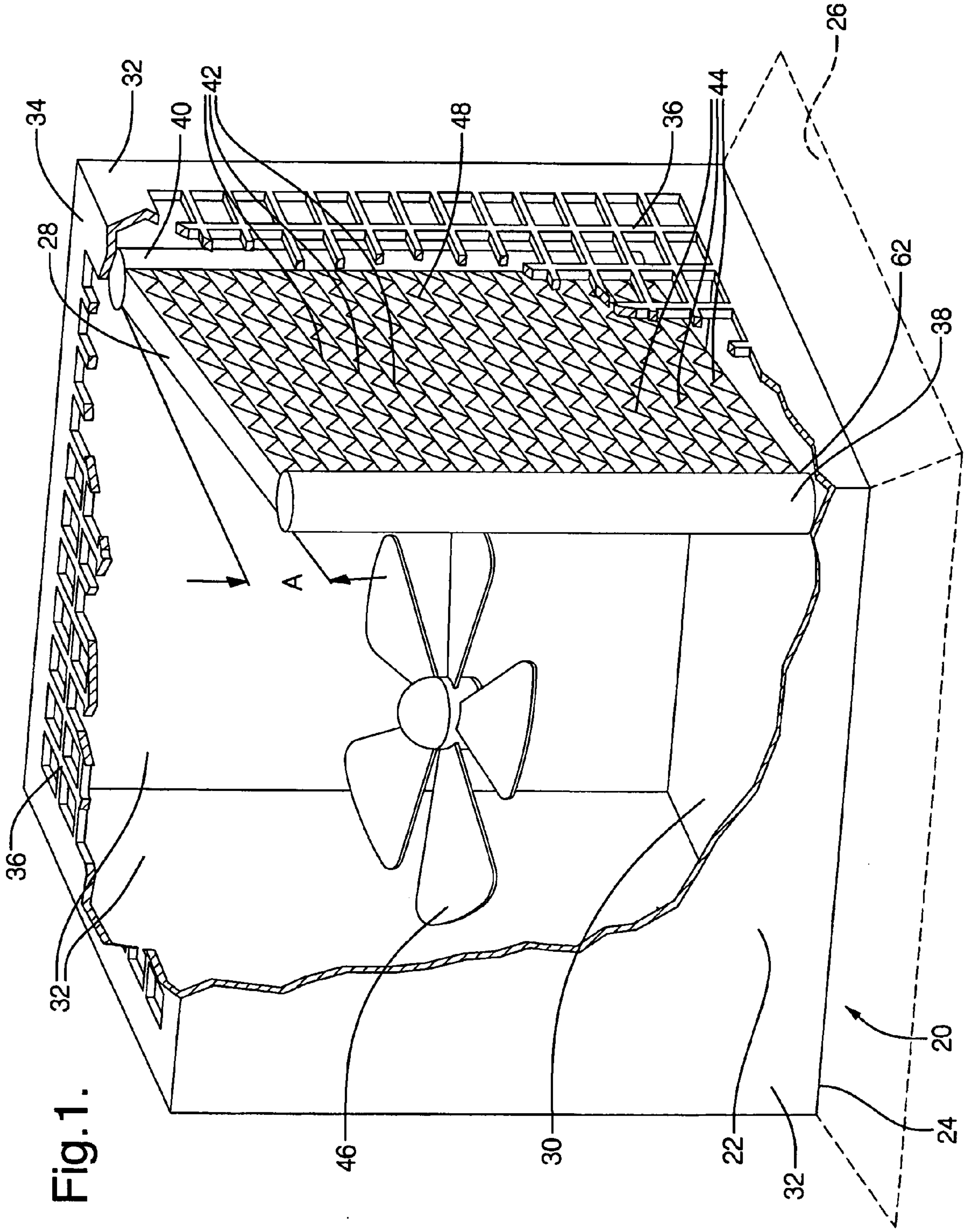


Fig.1.

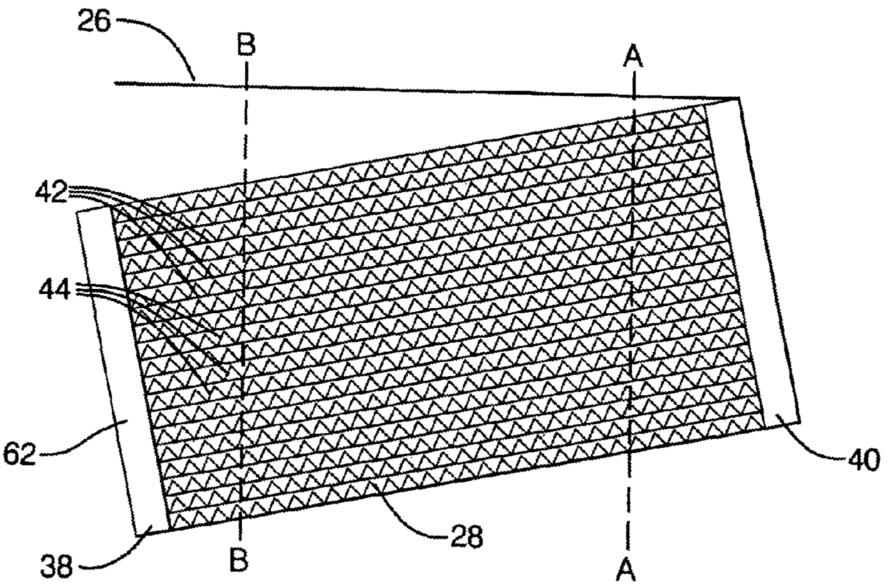


Fig.2.

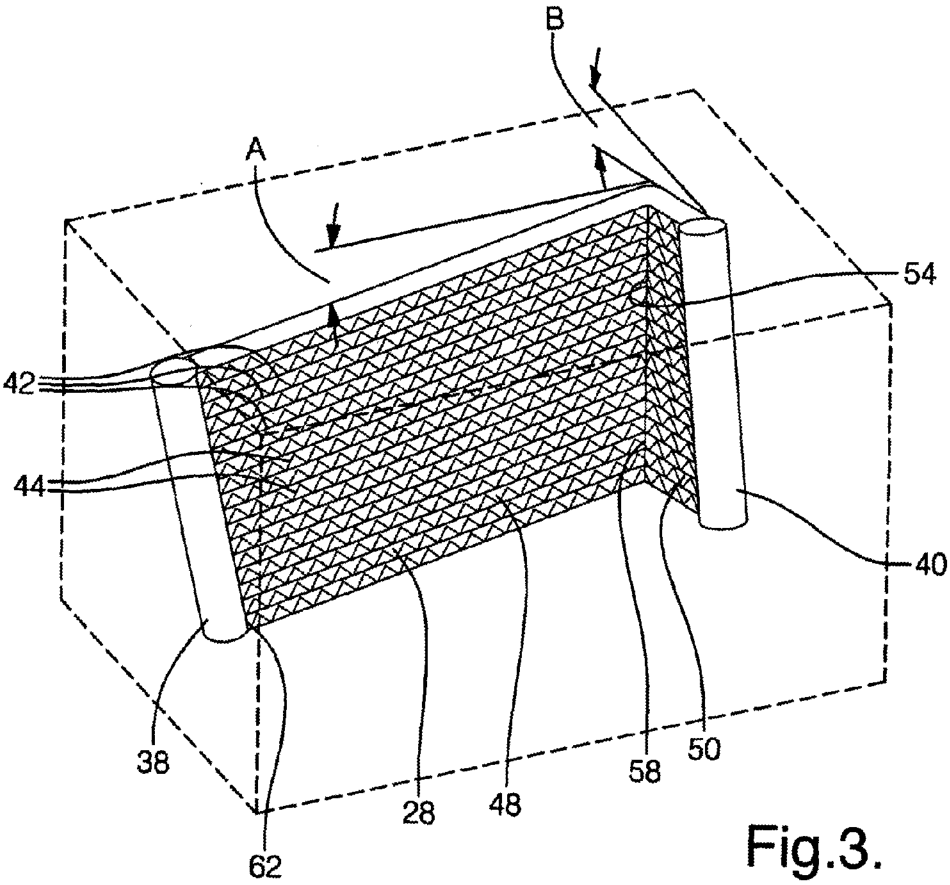


Fig.3.

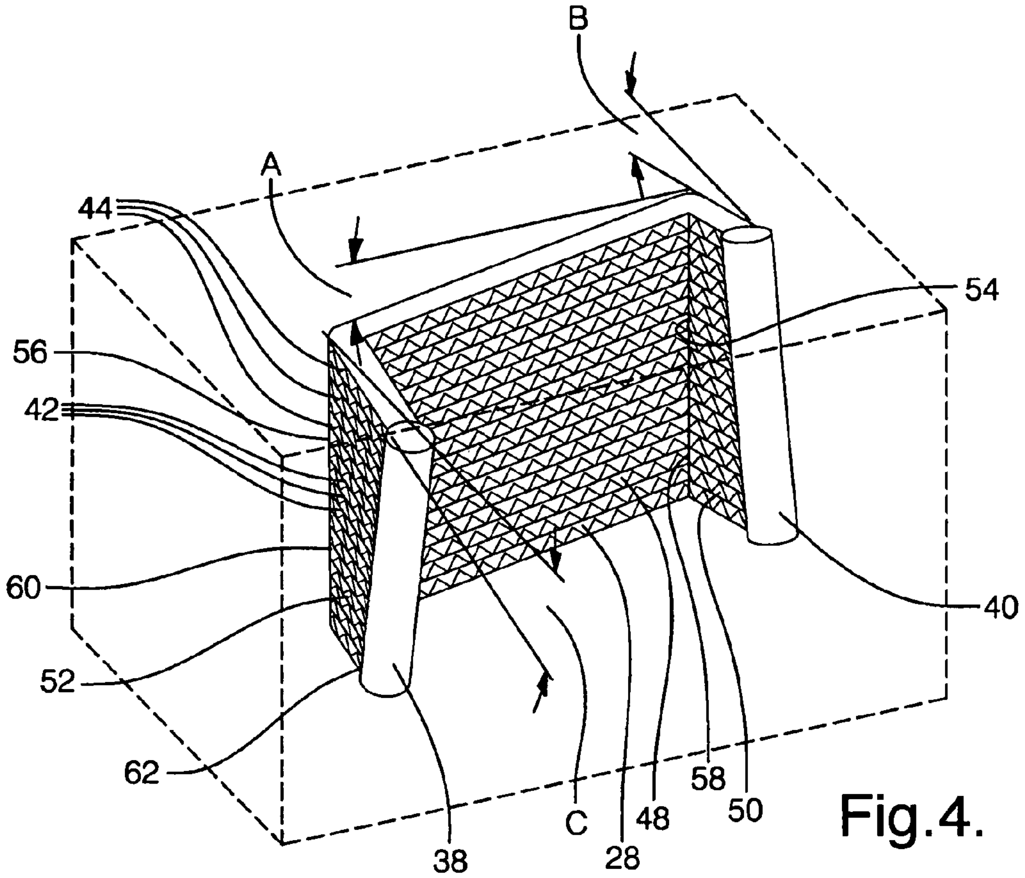


Fig.4.

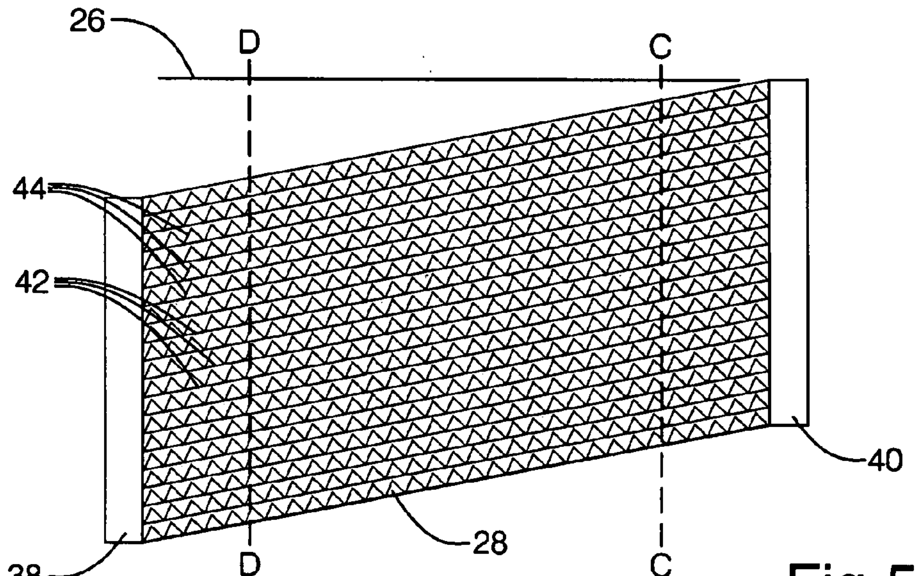


Fig.5.

Fig.6.

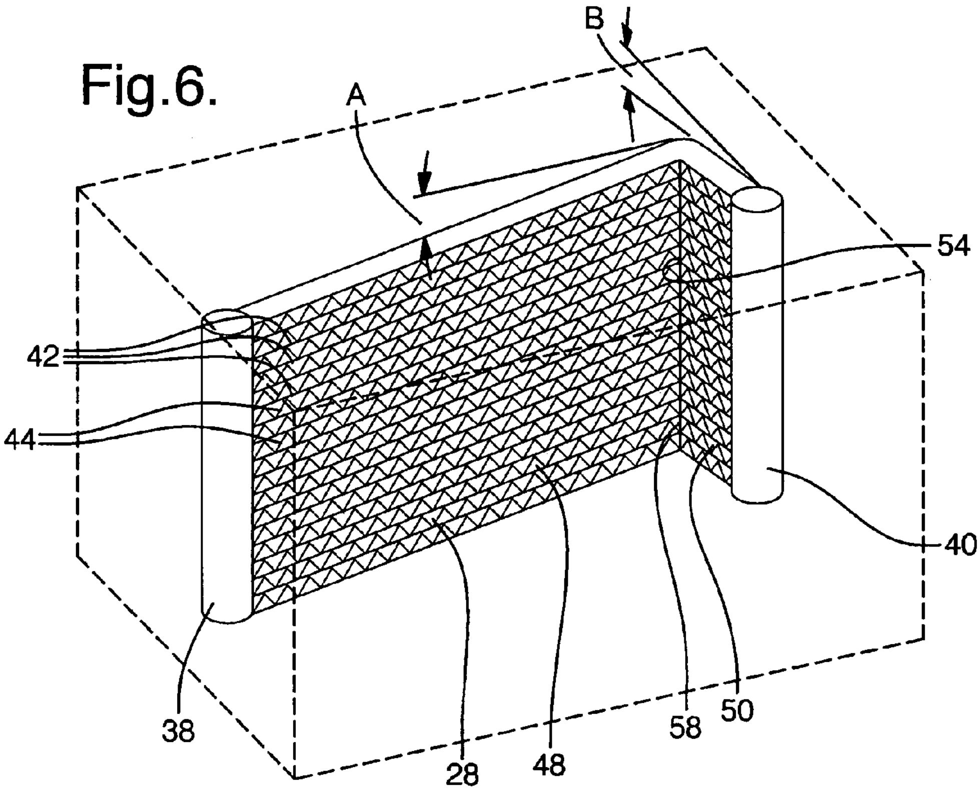


Fig.7.

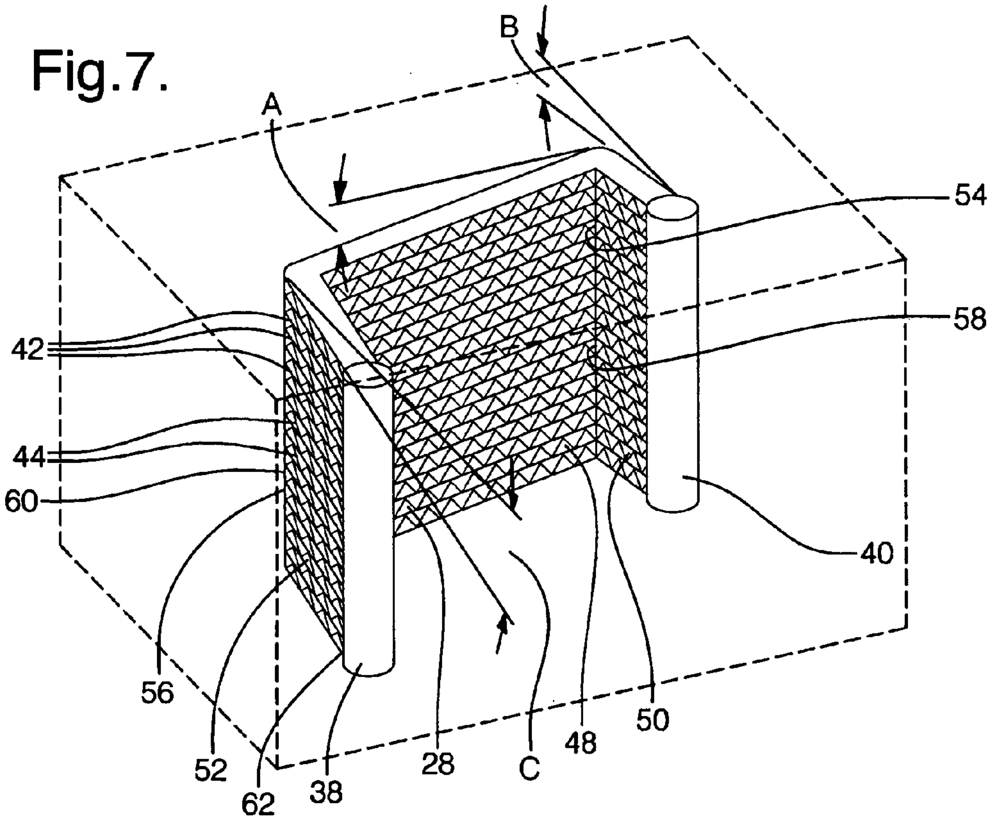


Fig.8.

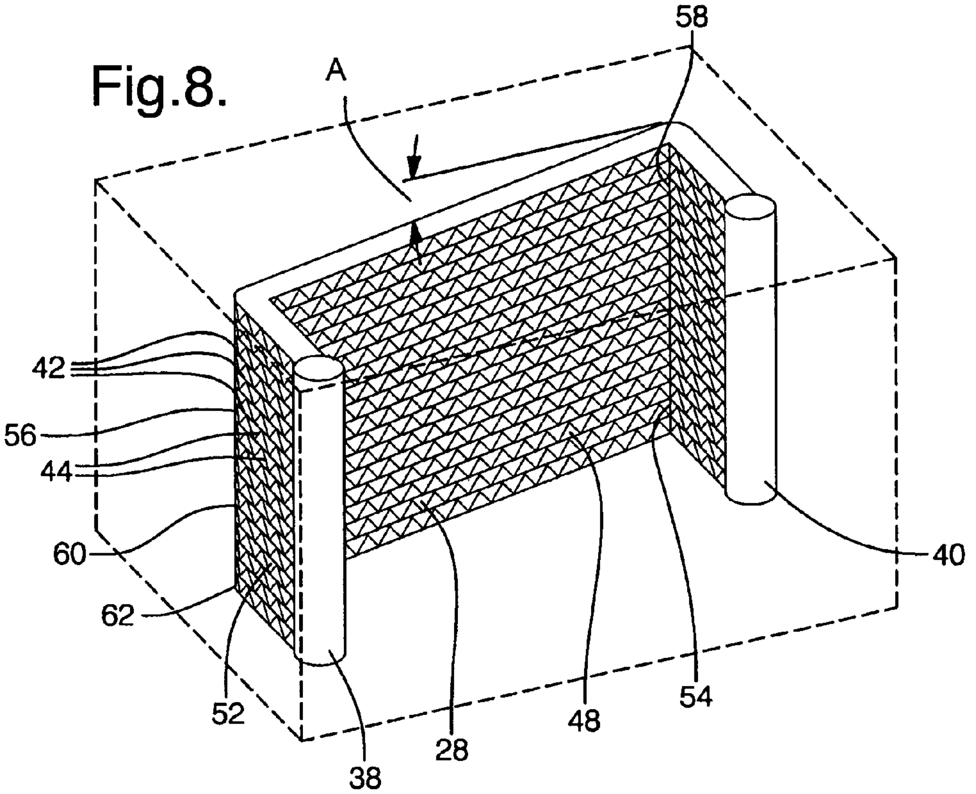
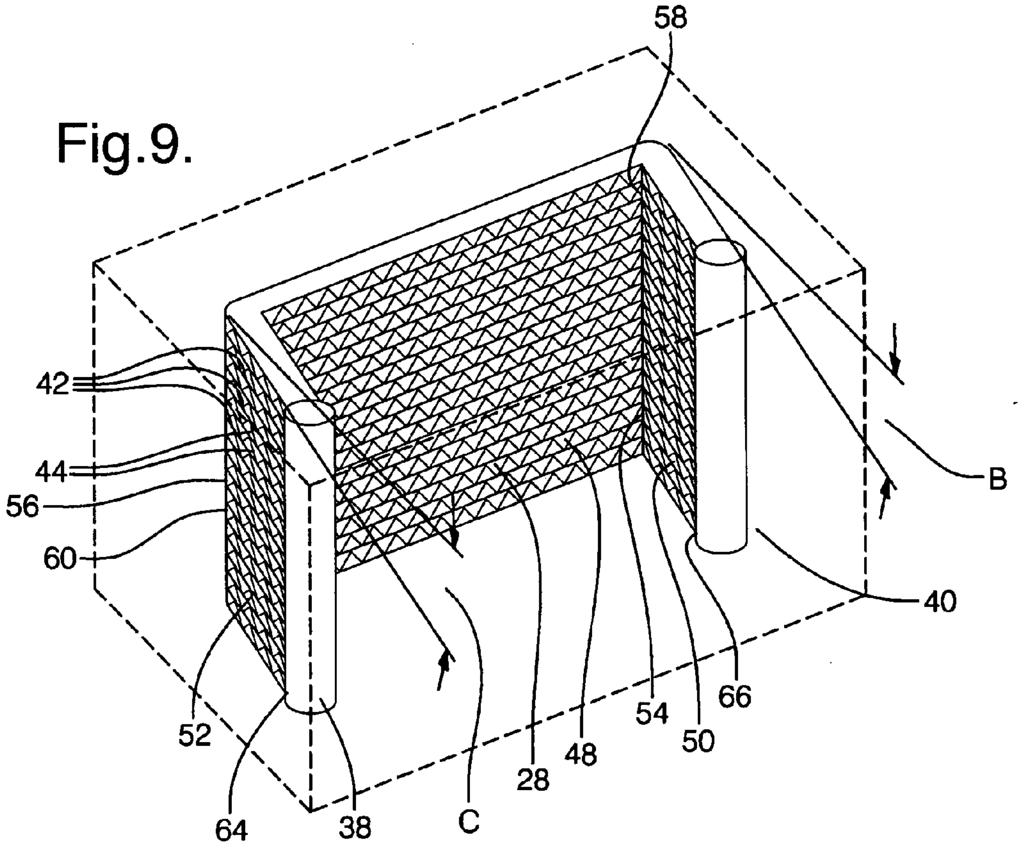

58
A
42
56
44
60
62
52
38
28
48
54
40

Fig.9.


58
42
44
56
60
B
40
52
64
38
C
28
48
54
50
66

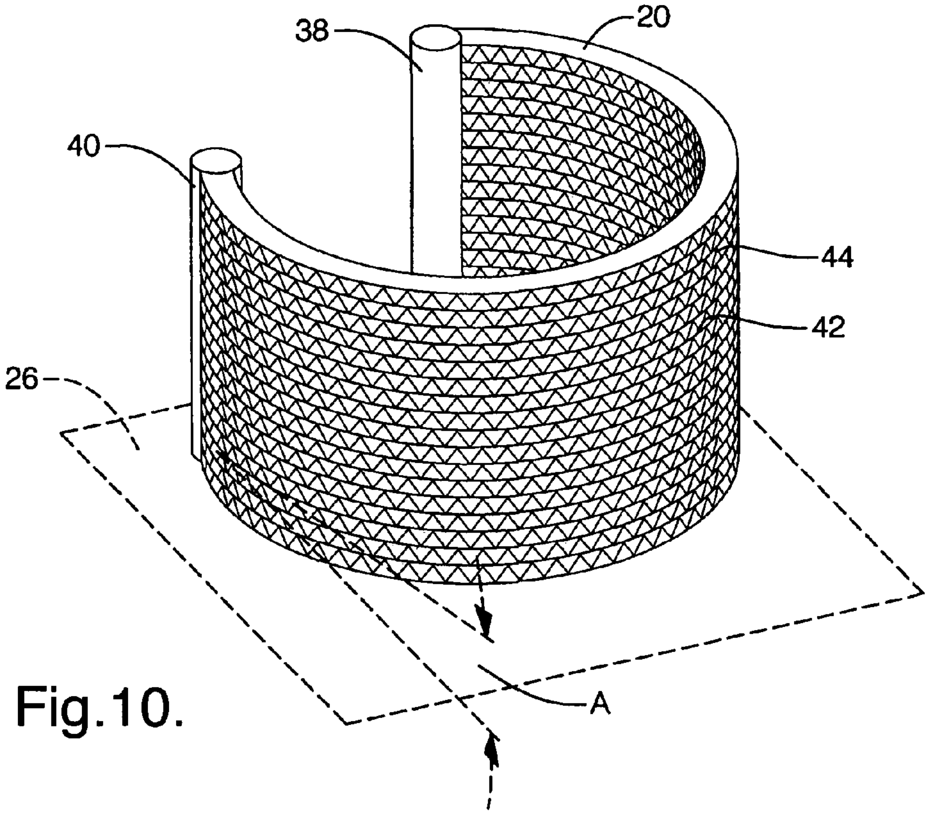

38
20
40
44
42
26
A

Fig.10.

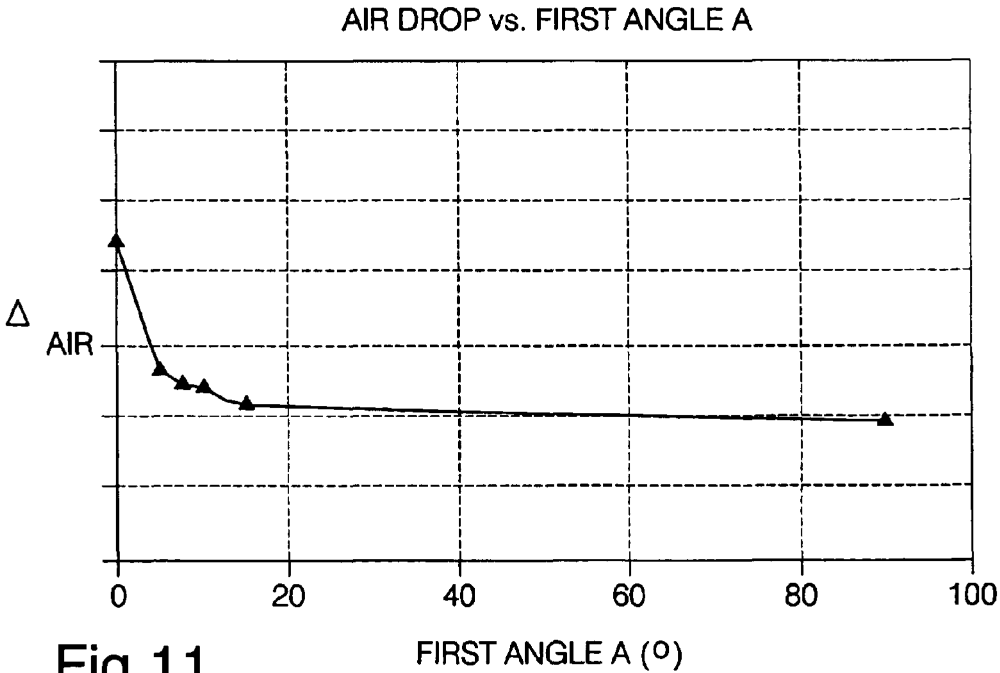

AIR DROP vs. FIRST ANGLE A
Δ AIR
0
20
40
60
80
100
FIRST ANGLE A (O)

Fig.11.