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(54) Evaporator with aerodynamic first dimples to suppress whistling noise

(57) A heat exchanger assembly including a plurality of pairs **(20)** of plates **(22)** disposed in series for fluid flow from a pass through one pair **(20)** of plates **(22)** to a pass through the next pair **(20)** of plates **(22).** Each pair **(20)** of plates **(22)** includes a central rib **(28)** to define a U-shaped passage **(26)** having a fluid entering leg and a fluid exiting leg interconnected by an open bottom interconnecting the legs below the lower end of the engaging ribs **(28).**

A plurality of first dimples **(36)** project into the passage **(26)** to interact with fluid flow through the passage **(26)** and each of the first dimples **(36)** has an aerodynamic, e.g., tear-drop, shape to reduce whistling noise in the latter pairs **(20)** of plates **(22).**

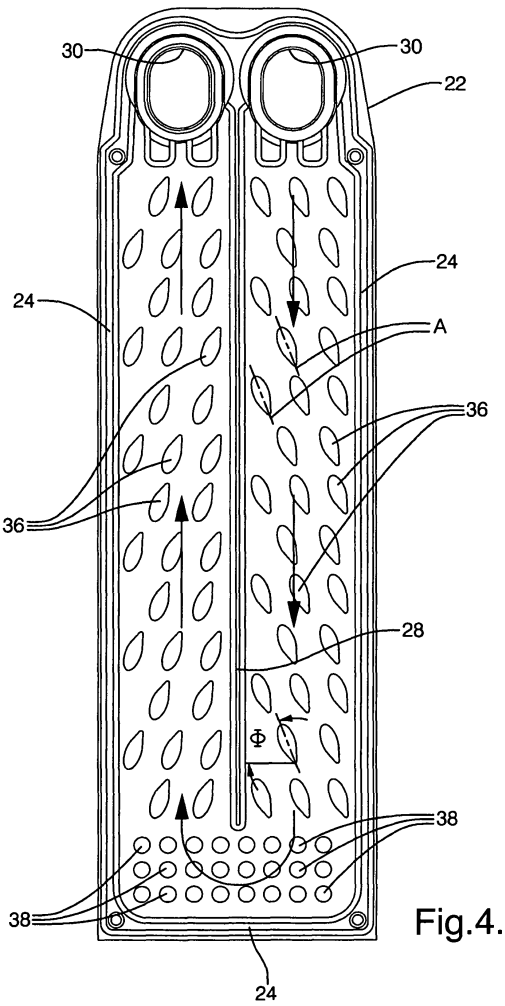


Fig.4.

EP 1 715 278 A2

Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger assembly, and more particularly, to an evaporator for a heating and/or air conditioning system (HVAC) for automotive vehicles.

BACKGROUND OF THE INVENTION

[0002] An evaporator of the type to which the subject invention pertains exchanges heat between a cooling fluid and air. A stack of virtually identical plates are positioned symmetrically in pairs having mating edges and a concave region delimited by the edges to define a fluid passage. The plates have tubular projections defining an inlet for entering fluid to the passage and an outlet for exiting fluid from the passage to thereby establish a direction of fluid flow. Each inlet is connected to the outlet of the preceding pair of plates and each outlet is connected to the inlet of the next pair of plates. Actually, each pair of plates includes a central rib to define a U-shaped passage having a fluid entering leg and a fluid exiting leg interconnected by an open bottom. Examples of such heat exchangers are described in U. S. Patents 5,111,878 to Kadle and 5,409,056 to Farry, Jr. et al.

[0003] Hot and humid air flows between the consecutive pairs of plates. The plates are usually stamped of thin gauge metal and a plurality of first dimples are stamped into the plates to project into the passage to interact with fluid flow through the passage. These first dimples can be identical in shape, position and orientation or they can be of various shapes as illustrated in U. S. Patent 6,289,982 to Naji. They project into the interior of the passage formed by the pairs of plates and thus allow better heat exchange by agitating the cooling fluid flow, and especially by promoting its movement in a turbulent flow. These first dimples can be formed by an assembly method, particularly by brazing two bosses opposite each other. In this case, the plates forming a pair of plates are the same as one another, and each boss has an equivalent height of approximately one-half of the depth of the U-shaped passage, that is to say of the distance from the opposing plates.

[0004] Unfortunately the flow of cooling fluid in this type of evaporator can produce a noise, particularly a "whistling", i.e., a tonal noise emanating from a plate-type evaporator used in certain automotive climate control systems under transient conditions. It is believed that this tonal noise occurs when gaseous refrigerant at sufficiently high velocities flows over the first dimples. It is further believed that the tonal noise is caused by periodic flow instability (manifested as vortices) in the wake of the first dimples. When the vortex shedding frequency is near the natural frequency of the gas column perpendicular to the direction of flow, a strong acoustic oscillation of the vapor column is excited, and it is this resonant oscillation that is believed to be the source of the tonal noise or whistle.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0005] The invention resides in each of the first dimples having an aerodynamic shape including a large bulbous leading portion extending into a longer and tapering trailing portion with the leading portion being disposed into the fluid flow from the inlet to the outlet.

[0006] The aerodynamic first dimples of this invention will suppress or eliminate the instability that is produced in the dimple wake when gaseous refrigerant flows over the first dimples. An additional advantage of the aerodynamic first dimples of this invention is a reduction in refrigerant pressure drop. By providing the aerodynamic first dimples of the subject invention in combination with the regular dimples of other shapes, i.e., providing the aerodynamic first dimples in selected positions, flow-induced transient tonal noise, such as whistles, are suppressed without significantly sacrificing cooling capacity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] 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 perspective view of a plurality of pairs of plates incorporating the subject invention in a heat exchanger assembly;

Figure 2 is a cross sectional perspective view taken along line 2-2 of Figure 1;

Figure 3 is an exploded perspective view of two pairs of plates employed in the heat exchanger of Figures 1 and 2; and

Figure 4 is an elevational view of one plate incorporating the subject invention and

Figure 5 is an elevational view of one plate using known dimples for use in passes prior to the passes in which the subject invention is incorporated.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0008] A heat exchanger assembly is variously shown in the Figures and includes as a basic component at least one pair **20** of plates **22.** The plates **22** can be identical and disposed in mirror relationship to one another. The plates **22** have mating edges **24** and a concave region delimited by the edges **24** to define a fluid passage **26.** The assembly includes a plurality of pairs **20** of the plates **22** disposed in series for fluid flow from a pass through one pair **20** of plates **22** to a pass through the next pair **20** of plates **22,** as illustrated by the arrows in Figure 3. Each pair **20** of plates **22** includes a central rib **28** to define a U-shaped passage **26** having a fluid entering

leg and a fluid exiting leg interconnected by an open bottom interconnecting the legs below the lower end of the engaging ribs **28.** The plates **22** have tubular projections **30** defining an inlet for entering fluid to the passage **26** and an outlet for exiting fluid from the passage **26** to thereby establish a direction of fluid flow, as indicated by the arrows in Figures 1 and 4.

[0009] As is well known, the heat exchanger assembly normally includes air-fins **32** disposed between adjacent pairs **20** of plates **22** for enhancing heat exchange between air flowing (as shown by the air flow arrow in Figure 1) through the air-fins **32** and fluid flow through the passage **26** defined by each pair **20** of plates **22.** As shown in Figure 2, additional fluid-fins **34** may be disposed in the fluid passages **26** although in the preferred embodiment such internal fins would not be included.

[0010] A plurality of first dimples **36** project into the passage **26** to interact with fluid flow through the passage **26** and each of the first dimples **36** has an aerodynamic shape including a large bulbous leading portion extending into a longer and tapering trailing portion with the leading portion being disposed into the fluid flow from the inlet to the outlet. The aerodynamic shape of each of the first dimples **36** is tear-drop shaped.

[0011] The first dimples **36** are combined in use with a plurality of second dimples **38** having different shapes. The second dimples **38** comprise known regular or bluff-body shapes to enhance the uniform distribution of liquid refrigerant over the plates **22** and, therefore, the heat transfer. The first dimples **36** are disposed in at least a selected section of the last pair **20** of plates **22** defining the last pass of fluid flow through the entire heat exchanger assembly. The first dimples **36** may also be disposed in at least the last two pairs **20** of plates **22** defining the last two passes. The first dimples **36** are combined with the second dimples **38** in the pair **20** of plates **22** defining the last pass. The use of aerodynamic dimples reduce heat transfer due to less intense turbulence, however, very desirable results are produced by using two kinds of dimples. The regular (or bluff-body) dimples in the earlier passes are designed to enhance the uniform distribution of liquid refrigerant over the tube plate and therefore the heat transfer. Figure 5 shows the round dimples **38** combined with oval or oblong dimples in earlier passes. The aerodynamic dimples in the last pass or last two passes or in selected tubes thereof (which typically experience high vapor superheats and velocities), are intended to suppress acoustic resonance. More specifically, the first dimples **36** are disposed in the legs and not in the bottom of the U-shaped passage **26** while the second dimples **38** are disposed in the bottom of the U-shaped passage **26** below the bottom end of the mating ribs **28.** Since the flow-induced instabilities are directly related to dimple geometry, this invention proposes "aerodynamic" or "tear-drop shaped" dimples in the last refrigerant pass (or last two passes) of the evaporator. In other words, this invention proposes the disposition of aerodynamic or tear-drop shaped first dimples **36** in the last refrigerant pass defined by the last pair **20** of plates **22,** or in the last two pairs **20** of plates **22,** or in selected sections (e.g., above the bottom-end of the mating ribs **28** of the last one or two passes as defined by the last two pairs **20** of plates **22,** it being appreciated that the dimples **36** could be used in any number or combination of passes.) The aerodynamic first dimples **36** suppress acoustic resonance in the last pass or last two passes where high vapor superheats and high velocities typically occur to cause acoustic resonance. The combination of the aerodynamic first dimples **36** with the normal second dimples **38** provides a balance between heat transfer and noise reduction.

[0012] Each first dimple **36** has an axis A and extends equally on either side of and along the axis A. In addition, each axis A is disposed at an acute angle Φ from the direction of fluid flow. Furthermore, the first dimples **36** are disposed in overlapping relationship in the direction of fluid flow.

[0013] Obviously, many modifications and variations of the present invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.

Claims

1. A heat exchanger assembly comprising;

at least one pair **(20)** of plates **(22)** having mating edges **(24)** and a concave region delimited by said edges **(24)** to define a fluid passage **(26),** said plates **(22)** having tubular projections **(30)** defining an inlet for entering fluid to said passage **(26)** and an outlet for exiting fluid from said passage **(26)** to thereby establish a direction of fluid flow,

a plurality of first dimples **(36)** projecting into said passage **(26)** to interact with fluid flow through said passage **(26),** and

characterized by each of said first dimples **(36)** having an aerodynamic shape including a large bulbous leading portion extending into a longer and tapering trailing portion with said leading portion being disposed into the fluid flow from said inlet to said outlet.

2. An assembly as set forth in claim 1 wherein said aerodynamic shape of each of said first dimples **(36)** is tear-drop shaped.

3. An assembly as set forth in claim 1 including a plurality of pairs **(20)** of said plates **(22)** disposed in series for fluid flow from a pass through one pair **(20)** of plates **(22)** to a pass through the next pair **(20)** of plates **(22).**

4. An assembly as set forth in claim 3 wherein said first dimples **(36)** are disposed in at least a selected section of said pair **(20)** of plates **(22)** defining the last pass.

5. An assembly as set forth in claim 3 wherein said first dimples **(36)** are disposed in at least the last two pair **(20)** of plates **(22)** defining the last two passes.

6. An assembly as set forth in claim 3 wherein said first dimples **(36)** are disposed in a first section and combined with a plurality of second dimples **(38)** having different shapes in said pair **(20)** of plates **(22)** defining the last pass.

7. An assembly as set forth in claim 3 wherein each first dimple **(36)** has an axis A and extends equally on either side of and along said axis A, each axis A being disposed at an acute angle Φ from said direction of fluid flow.

8. An assembly as set forth in claim 7 wherein said first dimples **(36)** are disposed in overlapping relationship in said direction of fluid flow.

9. An assembly as set forth in claim 3 wherein each of said pair **(20)** of plates **(22)** includes a central rib **(28)** to define a U-shaped passage **(26)** having a fluid entering leg and a fluid exiting leg interconnected by an open bottom.

10. An assembly as set forth in claim 9 wherein said first dimples **(36)** are disposed in said legs and not in said bottom of said U-shaped passage **(26).**

11. An assembly as set forth in claim 9 wherein each first dimple **(36)** has an axis A and extends equally on either side of and along said axis A, each axis A being disposed at an acute angle Φ from said direction of fluid flow.

12. An assembly as set forth in claim 11 wherein said first dimples **(36)** are disposed in overlapping relationship in said direction of fluid flow.

13. An assembly as set forth in claim 3 wherein said first dimples **(36)** are disposed in a first section and combined with a plurality of second dimples **(38)** having different shapes in said pair **(20)** of plates **(22)** defining the last pass, and including air-fins **(32)** disposed between adjacent pairs **(20)** of plates **(22)** for enhancing heat exchange between air flowing through said fins and fluid flow through said passage **(26)** defined by each pair **(20)** of plates **(22).**

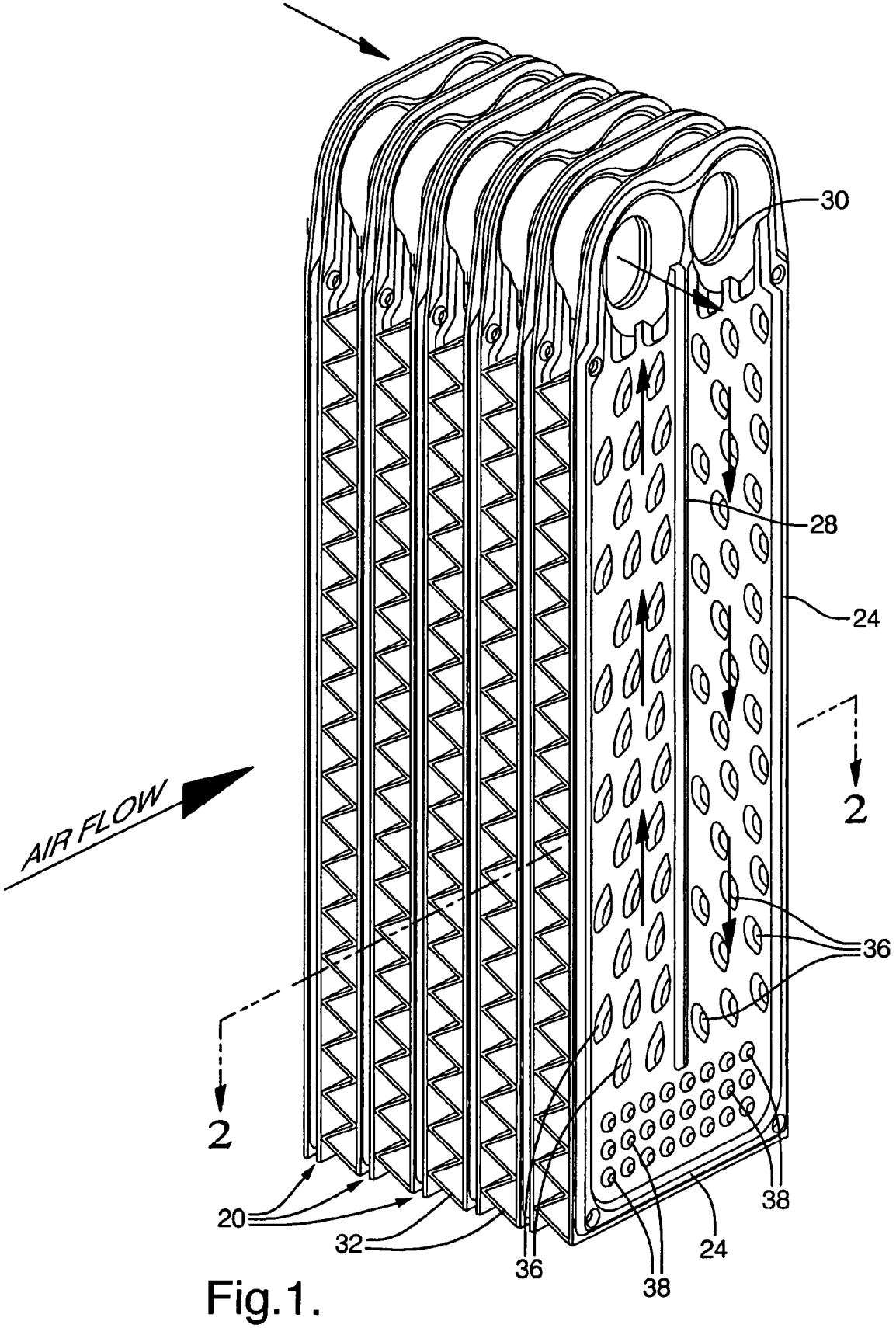


Fig.1.

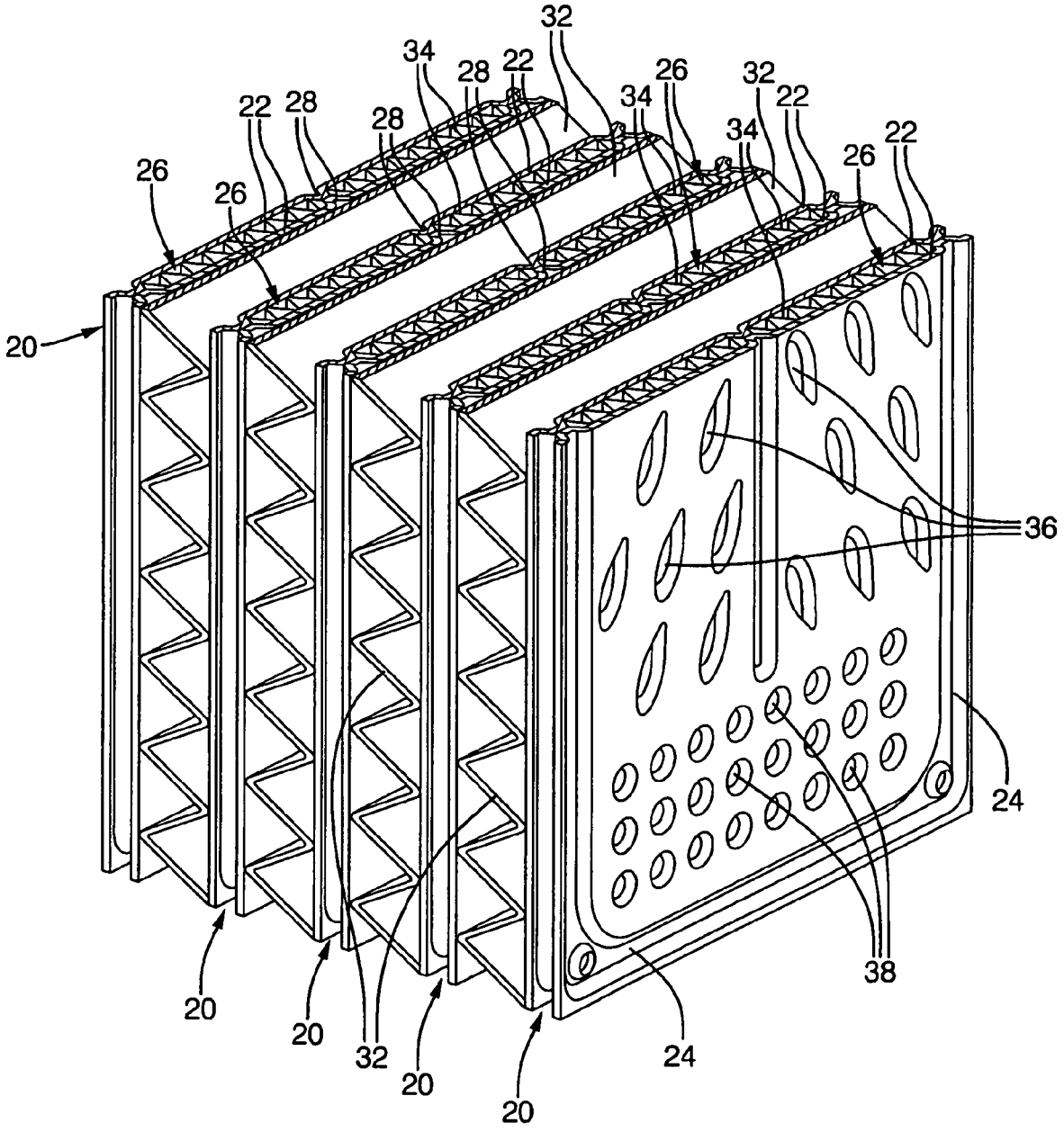

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Fig.2.

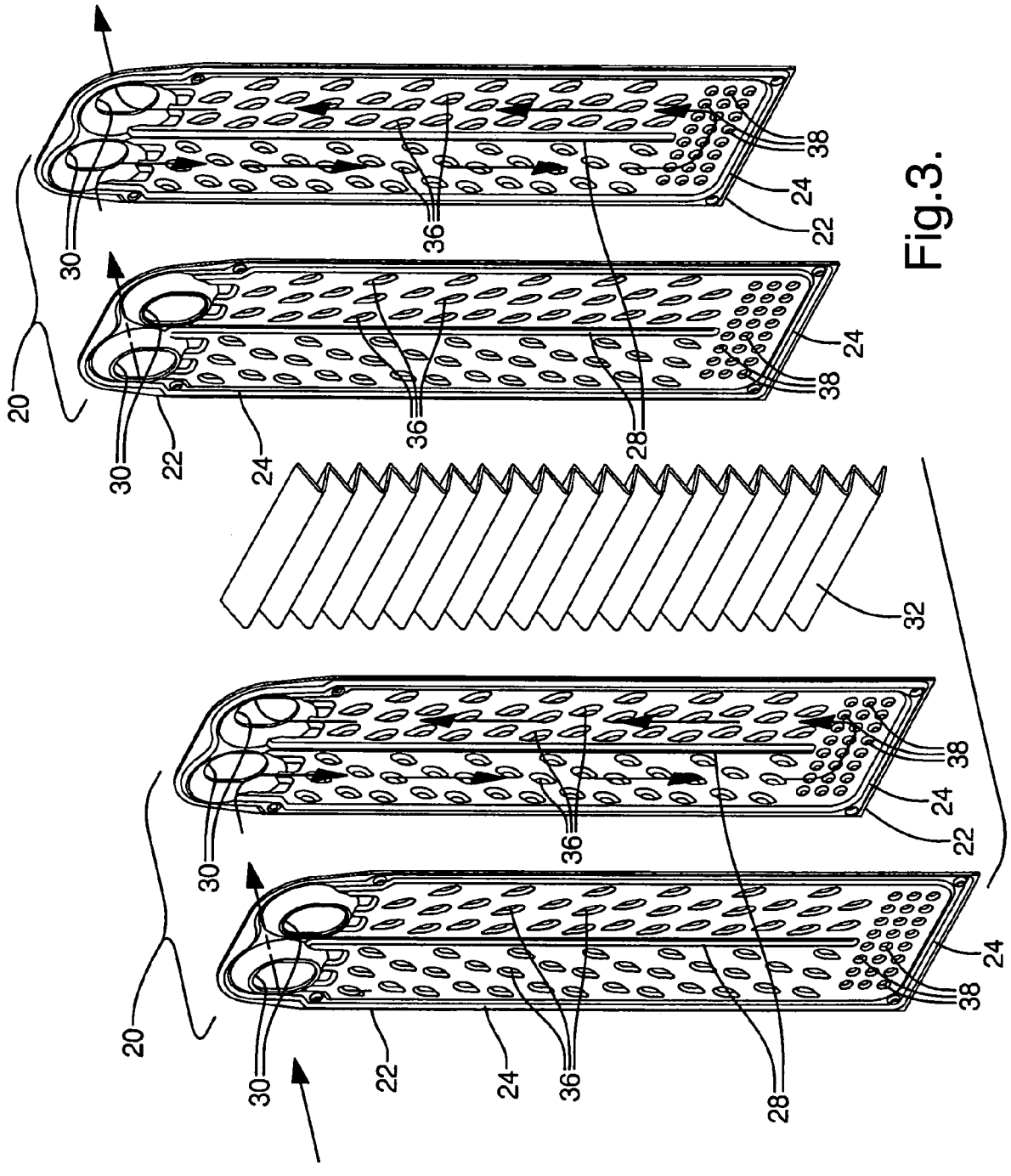


Fig.3.

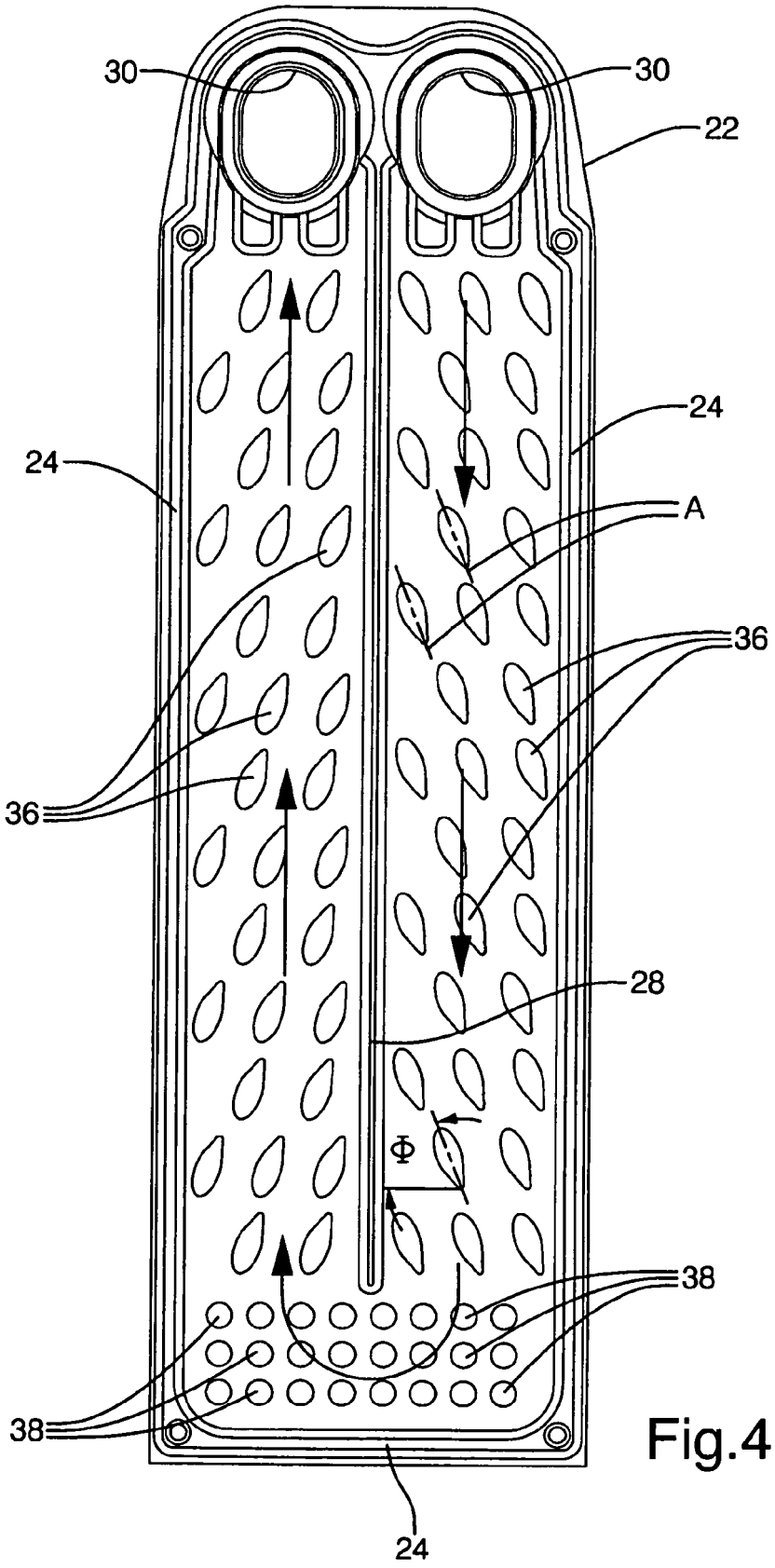


Fig.4.

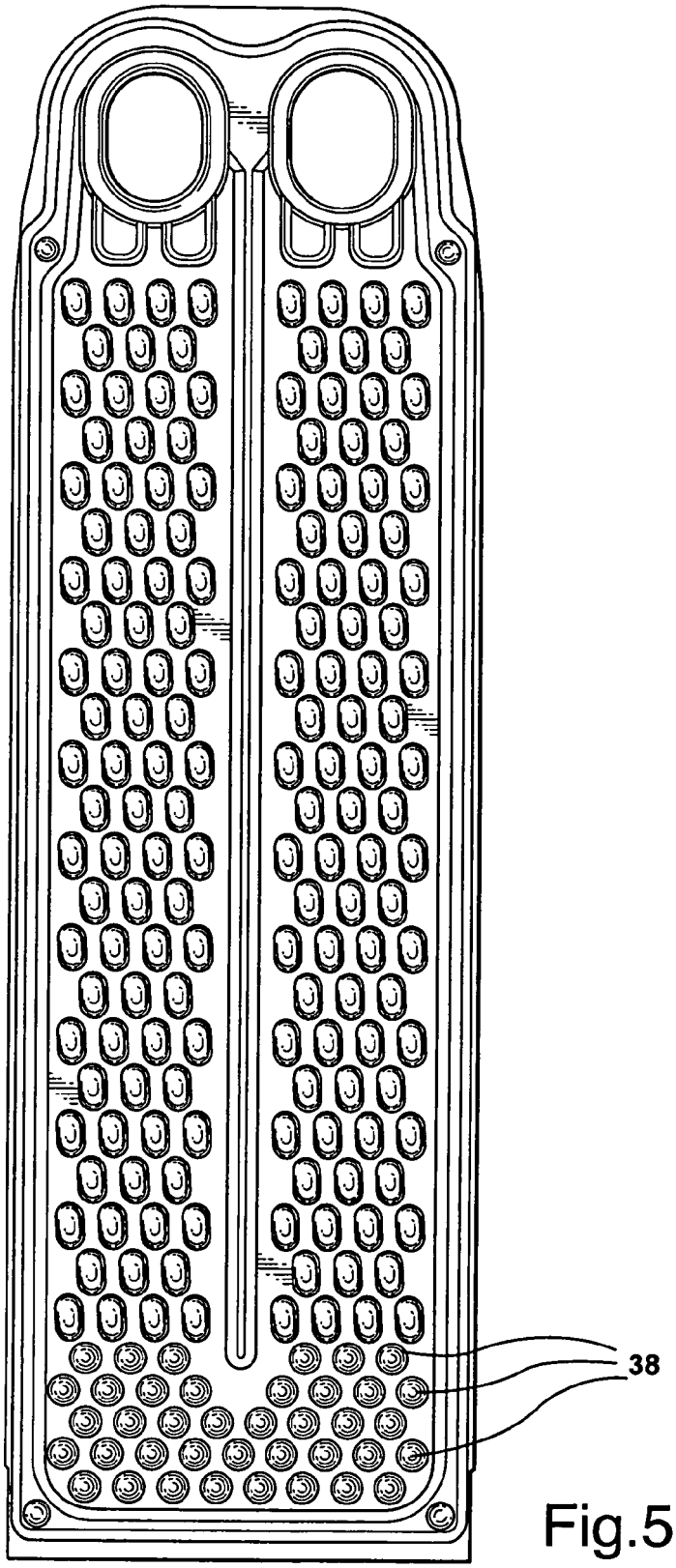


Fig.5.

REFERENCES CITED IN THE DESCRIPTION

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