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(54) **BRAZED PLATE HEAT EXCHANGER WITH FREEZING DETECTION SYSTEM**

(57) A brazed plate heat exchanger (10) comprises a plurality of heat exchanger plates (12A, 12B, 12C) which are stacked onto one another. The heat exchanger plates (12A, 12B, 12C) are obtained by forming from respective metal sheets and are permanently joined to each other through brazing by means of a braze material, so as to form a plate package (30) provided with first plate interspaces (32) for a first fluid and second plate interspaces (34) for a second fluid. Each of the heat exchanger plates (12A, 12B, 12C) is provided with a plurality of portholes (P1, P2, P3, P4) and with one or more side edges (26, 28) which form the outer perimeter of the heat exchanger plates (12A, 12B, 12C). The brazed plate heat exchanger (10) comprises a plurality of cells (36) having a predefined internal volume (V). Each cell (36) is integral with a corresponding heat exchanger plate (12A, 12B, 12C) and is separated by the first plate interspaces (32) and/or the second plate interspaces (34) through respective deformable wall portions (38). The deformable wall portions (38) have a mechanical strength which is lower than the average mechanical strength of the metal sheets of the heat exchanger plates (12A, 12B, 12C). At least one channel (40) is provided between each cell (36) and one of the side edges (26, 28) of the heat exchanger plates (12A, 12B, 12C), each channel (40) putting in fluid connection the internal volume (V) of the respective cell (36) with the environment outside the brazed plate heat exchanger (10).

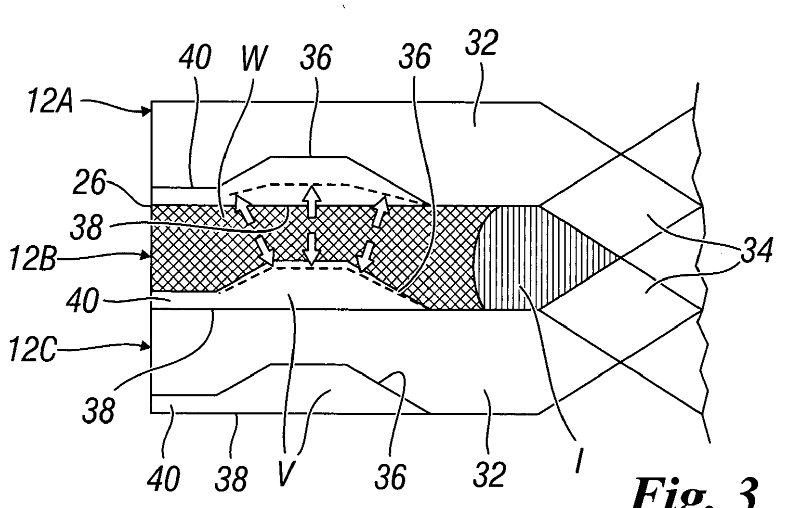

Fig. 3

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Description

Field of the invention

[0001] The present invention refers in general to a plate heat exchanger and, more specifically, to a brazed plate heat exchanger used as an evaporator, wherein the heat exchanger plates are provided with an improved system for detecting freezing of at least one of the two fluids flowing inside the heat exchanger.

Background of the invention

[0002] Heat exchangers are devices used to transfer heat between two or more fluids. A plate heat exchanger is a specific type of heat exchanger wherein metal plates are used to transfer heat between two fluids. Plate-type heat exchangers generally comprise a start plate, an end plate and a plurality of intermediate plates stacked onto one another, so as to form flow channels between them. In a plate-type heat exchanger, the two fluids at different temperatures (one of which is usually identified as the refrigerant fluid) respectively flow through plate channels obtained between opposite surfaces of pairs of adjacent heat exchanger plates: in this way the two fluids exchange their thermal content. These fluids can flow counter-current or co-current and their leak-free circulation is ensured by gaskets or by the junctions between the heat exchanger plates.

[0003] The flow channels between the heat exchanger plates are commonly obtained by providing both plate surfaces with a corrugated pattern. In other words, both plate surfaces are provided with a pressed pattern of ridges and grooves. When the heat exchanger plates are stacked onto one another, the ridges of a first heat exchanger plate contact the grooves of an adjacent heat exchanger plate and these plates are thus kept at a distance from each other through spacer elements. In this way the flow channels are formed.

[0004] A common way of manufacturing a plate-type heat exchanger is to braze the heat exchanger plates together. This way of manufacturing requires that the heat exchanger plates are provided with a brazing material. During manufacturing, the heat exchanger plates stacked onto one another and placed in a furnace having a temperature sufficiently hot to at least partially melt the brazing material. After the temperature of the furnace has been lowered, the brazing material will solidify, allowing the heat exchanger plates to become joined to one another to form a compact and strong heat exchanger.

[0005] Brazed plate heat exchangers, also known by the acronym "BHE", can be used as evaporators. When a brazed plate heat exchanger is used as an evaporator, a first fluid, usually water, is cooled as it loses heat to a second fluid, i.e., a refrigerant fluid, which evaporates. Under special conditions of low temperature and fluid flow rate, freezing may occur in the water circuit of a BHE evaporator. As fluid temperatures and flow vary in the channel area, ice development occurs progressively, so the duration time of these critical conditions is another important parameter to consider.

[0006] The flow channels of a BHE evaporator can withstand water freezing without consequences even if the above critical conditions occur. However, the situation becomes dangerous for the mechanical integrity of the BHE evaporator when some water becomes trapped in an enclosed space and freezes in a second time, resulting in volume expansion. This can happen, for example, because previously formed ice can create ice plugs around water. The volume of ice expands about 7% more than the volume occupied by water. If trapped, the ice stresses the walls that confine it (in this case the surface of the plates) with extremely strong forces. Another effect is that the ice, as it expands, has a "piston effect" on the trapped water, increasing its pressure.

[0007] Plate breaking rarely happens the first time freezing occurs. Usually a few (but not many) freeze-melt-freeze cycles are required. In any case, fixing a system after a BHE evaporator break caused by freezing costs a lot of money and time. In addition, one must consider the fact that potentially environmentally harmful refrigerants (i.e., refrigerants that are flammable, toxic, and/or have high GWP values) are usually circulating in a BHE evaporator. For these reasons, the release of refrigerant into the environment must be avoided for safety and environmental reasons.

[0008] To avoid or reduce breaking risk, the plates of BHE evaporators for low-temperature fluid applications are designed following certain rules to avoid as much as possible the forming of water traps. In addition, working conditions limits (involving the above parameters of fluid temperature, fluid flow rate and duration time) for specific BHE evaporators and applications are fixed. However, the actual working conditions of a BHE evaporator are sometimes difficult to predict and control. For example, the actual water flow rate is sometimes unknown. There may also be a malfunction of the control system of the BHE evaporator, or its wrong setting up (e.g., too low water limit temperature), or a combination of all these factors.

[0009] Document CN-A-113432461 discloses a brazed plate heat exchanger wherein the heat exchanger plates have specific joints that function as ice damage points. These joints need to be surrounded by elastically deformable surfaces of the channels within which liquid flows that may be subject to freezing. The brazed plate heat exchanger therefore requires a complex and expensive manufacturing process to obtain the ice damage points.

[0010] Document CN-U-203274588 discloses a brazed plate heat exchanger provided with a containing groove with a temperature sensor. The temperature sensor has the purpose of signaling a possible freezing of the fluid. However, the temperature sensor is only one and is located at a specific position in the heat exchanger and is therefore arranged to detect the fluid temperature only at that specific position.

Summary of the invention

[0011] One object of the present invention is therefore to provide a brazed plate heat exchanger which is capable of resolving the drawbacks of the prior art in a simple, inexpensive and particularly functional manner.

[0012] In detail, one object of the present invention is to provide a brazed plate heat exchanger, in particular but not exclusively used as an evaporator, that is capable to alert the plant owner, and thus also the heat exchanger manufacturer, that freezing has occurred in the heat exchanger due to operating conditions, particularly as early as the first time freezing occurs, when the damages are limited and did not take to any break of the heat exchanger and refrigerant leaking.

[0013] Another object of the present invention is to provide a brazed plate heat exchanger that allows the plant owner to take corrective actions to bring the working parameters back within the allowed limits and set the control parameters accordingly.

[0014] These and other objects are achieved according to the present invention by providing a brazed plate heat exchanger as set forth in the attached claims.

[0015] Further features of the invention are underlined by the dependent claims, which are an integral part of the present description.

[0016] The brazed plate heat exchanger according to the present invention comprises a plurality of heat exchanger plates which are stacked onto one another. The heat exchanger plates are obtained by forming from respective metal sheets. The heat exchanger plates are permanently joined to each other through brazing by means of a braze material, so as to form a plate package provided with first plate interspaces for a first fluid and second plate interspaces for a second fluid. Each heat exchanger plate is provided with a plurality of portholes and with one or more side edges which form the outer perimeter of the heat exchanger plates. The heat exchanger comprises a plurality of cells having a predefined internal volume, wherein each cell is integral with a corresponding heat exchanger plate and is separated by the first plate interspaces and/or the second plate interspaces through respective deformable wall portions. The deformable wall portions have a mechanical strength which is lower than the average mechanical strength of the metal sheets of the heat exchanger plates. At least one channel is provided between each cell and one of the side edges of the heat exchanger plates. Each channel puts in fluid connection the internal volume of the respective cell with the environment outside the heat exchanger.

[0017] Preferably, each cell is located near one of the side edges of the heat exchanger plates. Always preferably, each cell is located between one of the portholes and one of the side edges of the heat exchanger plates.

[0018] According to a preferred aspect of the invention, the deformable wall portions have an average thickness which is lower than the average thickness of the metal sheets of the heat exchanger plates. Alternatively, according to another preferred aspect of the invention, the deformable wall portions are provided with one or more bends with low radius. As a further alternative, according to a further preferred aspect of the invention, the deformable wall portions are made of a metal material which is different from the metal material from which the metal sheets of the heat exchanger plates are made.

[0019] According to a preferred embodiment, at least part of the cells is provided with sensor means for detecting the deformation and/or breakage of the deformable wall portions respectively associated with the cells. Preferably, the sensor means can comprise:

- at least one colored fluid substance having a viscosity which is greater than the viscosity of the first fluid and the second fluid: this colored fluid substance at least partially fills the internal volume of a single cell and is arranged to leak out of the respective channel in case of deformation and/or breakage of the deformable wall portions;
- at least one electrically conductive fluid substance, which at least partially fills the internal volume of a single cell, and at least one electrically conductive cable, which connects the internal volume of this single cell to an electronic control unit of the heat exchanger through the respective channel: this electrically conductive fluid substance is arranged to generate and send an electric signal to the electronic control unit through the cable in case of deformation and/or breakage of the deformable wall portions;
- at least one elastic element, which is in direct contact with the deformable wall portion of a single cell, and at least one electrically conductive cable, which connects the internal volume of this single cell to the electronic control unit of the heat exchanger through the respective channel and is in direct contact with the elastic element: an elastic deformation of the elastic element occurs in case of deformation and/or breakage of the deformable wall portion, and this elastic deformation generates and sends an electric signal to the electronic control unit through the cable.

[0020] According to a preferred embodiment of the invention, the heat exchanger comprises pair of adjacent cells, wherein the two cells of a single pair of adjacent cells are respectively located in two adjacent first plate interspaces and/or two adjacent second plate interspaces. The two cells of a single pair of adjacent cells are separated from each other and from the adjacent first plate interspaces and/or the adjacent second plate interspaces by at least one deformable wall portion.

[0021] Preferably, pairs of adjacent cells are mutually connected through a connection conduit which is in turn in fluid connection, through at least one of the channels, with a single lateral opening obtained on one of the side edges of the heat exchanger plates. More preferably, these pairs of adjacent cells and the connection conduit are filled with an inert gas. Even more preferably, at least one probe is connected to the lateral opening. This probe is capable of detecting changes in pressure and/or temperature values of the inert gas.

[0022] According to a further preferred embodiment of the invention, the heat exchanger comprises one or more fluid collector tanks, which are located outside the heat exchanger and are designed to collect the fluid exiting the heat exchanger through at least one of the channels. The fluid collector tanks are preferably provided with one or more fluid level sensors and/or with one or more overflow discharge conduits.

Brief description of the drawings

[0023] The features and advantages of a brazed plate heat exchanger according to the present invention will be clearer from the following exemplifying and nonlimiting description, with reference to the enclosed schematic drawings, in which:

Figure 1 is a side view of a generic embodiment of a brazed plate heat exchanger;

Figure 2 is a plan view of the brazed plate heat exchanger of Figure 1;

Figure 3 is a schematic partial sectional view of the brazed plate heat exchanger of Figure 1, wherein the main components of the freezing detecting system according to the invention are shown in a first embodiment thereof;

Figure 4 is a schematic perspective view of a component of the freezing detecting system;

Figure 5 is another schematic partial sectional view of the brazed plate heat exchanger of Figure 1, wherein the main components of the freezing detecting system according to the invention are shown in a second embodiment thereof;

Figures 6A and 6B show respective possible position of the components of the freezing detecting system;

Figure 7 is another partial sectional view of the brazed plate heat exchanger of Figure 1, showing the operation of the freezing detecting system according to the invention;

Figure 8 is another partial sectional view of the brazed plate heat exchanger of Figure 1, showing further components of the freezing detecting system;

Figure 9 is another partial sectional view of the brazed plate heat exchanger of Figure 1, wherein the main components of the freezing detecting system are shown in a third embodiment thereof;

Figure 10 is a sectional view showing the operation of the freezing detecting system of figure 9;

Figure 11 is another sectional view showing the operation of the freezing detecting system of figure 9;

Figure 12 is another sectional view showing other components of the freezing detecting system of figure 9; and

Figure 13 is a schematic view showing further components of the freezing detecting system according to the invention.

Detailed description of the invention

[0024] With reference in particular to Figures 1 and 2, a brazed plate heat exchanger 10 is shown. The heat exchanger 10 comprises, in a per se known manner, a plurality of heat exchanger plates 12A, 12B, 12C stacked onto one another. Typically, the heat exchanger plates 12A, 12B, 12C are stacked onto one another between a first end plate 14 and a second end plate 16 of the heat exchanger 10. Each heat exchanger plate 12A, 12B, 12C is obtained by forming from a respective metal sheet. The first end plate 14, the second end plate 16 and the heat exchanger plates 12A, 12B, 12C are permanently joined to each other through brazing by means of a braze material, so as to form a plate package 30. The plate package 30 is thus provided (see for example Figure 3) with first plate interspaces 32 for a first fluid and second plate interspaces 34 for a second fluid. The first fluid and the second fluid may be any suitable heat transfer fluid. For example, the first fluid can be the hotter fluid and the second fluid can be the colder fluid. The second fluid is therefore the cooling fluid, and it receives the heat from the first fluid. More specifically, if the heat exchanger 10 is used as an evaporator, the first fluid can be water and the second fluid can be a refrigerant fluid.

[0025] Each heat exchanger plate 12A, 12B, 12C, as well as the first end plate 14 and the second end plate 16, is provided with a plurality of portholes, preferably four portholes P1, P2, P3 and P4. A first porthole P1 is connected to a first connection pipe 18 and communicates with the first plate interspaces 32. A second porthole P2 is connected to a second connection pipe 20 and communicates with the first plate interspaces 32. A third porthole P3 is connected to a third connection pipe 22 and communicates with the second plate interspaces 34. Finally, a fourth porthole P4 is connected to a fourth connection pipe 24 and communicates with the second plate interspaces 34. Connection pipes 18, 20, 22 and 24 may be provided extending from the first end plate 14, as shown in Figure 1, and/or from the second end plate 16.

[0026] Each heat exchanger plate 12A, 12B, 12C, as well as the first end plate 14 and the second end plate 16, can have the shape of any plane figure bounded by a closed line, such as a convex polygon or even a circle. Each heat exchanger plate 12A, 12B, 12C, as well as the first end plate 14 and the second end plate 16, is thus provided with one or more side edges 26, 28, which form the outer perimeter of the heat exchanger plates 12A, 12B, 12C, 14, 16. Preferably, as shown in Figures 1 and 2, each heat exchanger plate 12A, 12B, 12C, as well as the first end plate 14 and the second end plate 16, has a substantially rectangular shape, with two long side edges 26 and two short side edges 28, as shown in Figure 2. A longitudinal axis X extends parallel to the two long side edges 26 and transversely to the two short side edges 28.

[0027] According to the invention, the heat exchanger 10 comprises a plurality of empty structures or cells 36 having a predefined internal volume V. Each cell 36 is integral with a corresponding heat exchanger plate 12A, 12B, 12C and is separated by the first plate interspaces 32 and/or the second plate interspaces 34 through respective deformable wall portions 38. In other words, each cell 36 confines with one of the first plate interspaces 32 and/or one of the second plate interspaces 34 by the respective deformable wall portion 38. Each cell 36 is then sealed out, by means of one or more flat brazing joints, from the first plate interspaces 32 and/or the second plate interspaces 34. For example, as shown in Figure 3, the cells 36 can be put in contact with the first plate interspaces 32 of the heat exchanger 10, inside which flows a first fluid that could freeze, such as water.

[0028] The deformable wall portions 38, which partially surround the internal volume V enclosed by the cells 36, have a mechanical strength which is lower than the average mechanical strength of the metal sheets of the heat exchanger plates 12A, 12B, 12C. In the mechanics of materials, the expression "mechanical strength" means the ability of a material to withstand an applied load without failure or plastic deformation. In the present application, the expression "lower mechanical strength" means that the deformable wall portions 38 are mechanically weaker than the surrounding wall portions of the plate interspaces 32 and/or 34 between the heat exchanger plates 12A, 12B, 12C. In other words, the deformable wall portions 38 are the first wall portions of the plate interspaces 32 and/or 34 to be deformed, or even broken, by the forming of ice I (figure 3) at critical condition. At the same time, these deformable wall portions 38 are strong enough to stand the normal pressure of the fluid (water W, see figure 3) flowing into the plate interspaces 32 and/or 34.

[0029] The lower mechanical strength of the deformable wall portions 38 with respect to the other wall portions of the heat exchanger plates 12A, 12B, 12C can be obtained in several ways. For example, the deformable wall portions 38 can have an average thickness which is lower than the average thickness of the metal sheets of the heat exchanger plates 12A, 12B, 12C. Alternatively or additionally, the deformable wall portions 38 can be provided with one or more bends with low radius. As a further alternative, the deformable wall portions 38 can be made of a metal material which is different from the metal material from which the metal sheets of the heat exchanger plates 12A, 12B, 12C are made. A further possible alternative for obtaining the lower mechanical strength of the deformable wall portions 38 could also be to increase the distance between contiguous brazing joints which connects each cell 36 to the first plate interspaces 32 and/or to the second plate interspaces 34.

[0030] The deformation of the wall portions 38, and thus to the respective cells 36, absorbs part of the fluid volume increasing and causes only limited and easily recoverable troubles to the heat exchanger 10 and to the plant in which that heat exchanger works. The advantage is that, even if slightly damaged, the heat exchanger 10 don't leak and can keep working, and it is not needed to replace it. The deformation of the wall portions 38, and thus to the respective cells 36, can be used as a signal that the critical freezing conditions have been reached into the plate interspaces 32 and/or 34 of the heat exchanger 10. Because of this deformation, heat exchanger 10 can effectively work only for one (or a few) time. However, it is recommended that the damaged heat exchanger 10 be repaired as soon as possible, mainly to avoid the release of one of the two fluids, typically the refrigerant, into the environment. In general, the rule is that, once detected the freezing first time in that way, the plant owner must reset and upgrade the operative conditions of the plant to recover the safe working conditions, and so avoid reaching those critical conditions other times ahead.

[0031] As better shown in figure 4, at least one channel 40 is provided between each cell 36 and one of the side edges 26, 28 of the heat exchanger plates 12A, 12B, 12C. Each channel 40 puts in fluid connection the internal volume V of the respective cell 36 with the environment outside the heat exchanger 10. Each channel 40 is a small diameter channel, like a nozzle. The advantage of the channels 40 is that, even if a wall portion 38, and thus the respective cell 36, breaks due to the freezing, the after melted fluid (water W) leaks to the external ambient through the respective channel 40 (see Figure 7). When this situation occurs, water circuit static pressure drops down, and that also can be a signal for the issue. The water leakage through the channels 40 is easy to be found and then fixed (e.g., plugging the channels 40 by a glue), due also to the lower pressure and not dangerous fluid (water). Similar to the deformation condition, that works for one time: then a corrective action on working parameters of the heat exchanger 10 and/or the whole plant is required.

[0032] In Figures 6A and 6B two respective possible positions of a single cell 36 and its respective channel 40 are shown. For example, each cell 36 can be located near one of the side edges 26, 28 of the heat exchanger plates 12A, 12B, 12C. Alternatively or in addition, each cell 36 can be located between one of the portholes P1, P2, P3, P4 and one of the side edges 26, 28 of the heat exchanger plates 12A, 12B, 12C. In general, the location of the cells 36 can be decided according to fluid dynamic analyses (which can be done with fluid dynamics software, lab and fields test results, etc.). If needed, more than one cells 36 could be placed on different spots of the heat exchanger plates 12A, 12B, 12C.

[0033] According to a preferred aspect of the present invention, at least part of the cells 36 can be provided with sensor means for detecting the deformation and/or breakage of the deformable wall portions 38 respectively associated with these cells 36. The sensor means, some embodiments of which are schematically shown in Figure

8, can be placed inside the cells 36 and/or in connection with them. When the water W freezes, it increases its volume and elastically or permanently deforms the wall portions 38 of the cells 36, or even breaks down the wall portions 38 of the cells 36. The sensor means thus detects the deformation and/or breakage and acts as a part of the freezing detecting system to issue a warning signal.

[0034] The sensor means can be of various types. For example, as shown in Figure 8, the sensor means can comprise at least one colored fluid substance 42 having a viscosity which is greater than the viscosity of the first fluid and the second fluid flowing into the heat exchanger 10. This colored fluid substance 42 could be a high-viscosity colored grease like substance. This colored fluid substance 42 at least partially fills the internal volume V of a single cell 36 and is arranged to leak out of the respective channel 40 in case of deformation and/or breakage of the respective deformable wall portions 38. In other words, once a cell 36 is squeezed and/or the respective deformable wall portion 38 is deformed or broken, this colored fluid substance 42 is pushed out of the heat exchanger 10 through the respective channel 40 and becomes visible outside.

[0035] According to a different embodiment, also shown in Figure 8, the sensor means can comprise at least one electrically conductive fluid substance 44, which at least partially fills the internal volume V of a single cell 36, and at least one electrically conductive cable 46, which connects the internal volume V of this single cell 36 to an electronic control unit 50 of the heat exchanger 10 through the respective channel 40. This electrically conductive fluid substance 44 is arranged to generate and send an electric signal to the electronic control unit 50 through the cable 46 in case of deformation and/or breakage of the deformable wall portion 38 of the cell 36. For example, this electrically conductive fluid substance 44 could be a grease like conductive substance that is pushed against the electrically conductive cable 46, shortcutting its wire ends (closing circuit).

[0036] According to a further embodiment, still shown in Figure 8, the sensor means can comprise at least one elastic element 48, which is in direct contact with the deformable wall portion 38 of a single cell 36, and at least one electrically conductive cable 46, which connects the internal volume V of this single cell 36 to the electronic control unit 50 of the heat exchanger 10 through the respective channel 40 and is in direct (physical) contact with the elastic element 48. In case of deformation and/or breakage of the deformable wall portion 38, an elastic deformation of the elastic element 48 occurs: this elastic deformation generates and sends an electric signal to the electronic control unit 50 through the cable 46. For example, this elastic element 48 could be a spring, or whatever mechanical/electrical/electronic element that is pushed against the electrically conductive cable 46, shortcutting its wire ends (closing circuit).

[0037] As shown in the embodiment of Figure 9, the heat exchanger 10 can advantageously comprise pair of adjacent cells 36 obtained on both sides of a dividing wall between two adjacent first plate interspaces 32, and/or even between two adjacent second plate interspaces 34. Therefore, the two cells 36 of a single pair of adjacent cells 36 are respectively located in two adjacent first plate interspaces 32 and/or two adjacent second plate interspaces 34. These two cells 36 of a single pair of adjacent cells 36 are separated from each other and from the adjacent first plate interspaces 32 and/or the adjacent second plate interspaces 34 by at least one deformable wall portion 38.

[0038] Preferably, as shown in Figure 10, the pairs of adjacent cells 36 are mutually connected through a connection conduit 52. The connection conduit 52 is in turn in fluid connection, through at least one of the channels 40, with a single lateral opening 54 obtained on one of the side edges 26, 28 of the heat exchanger plates 12A, 12B, 12C. If the ice formation breaks the deformable wall portion(s) 38 of one or some of the cells 36, the water leakage fills all these cells 36, and so the leakage of the water is driven to the external always to a single point on the heat exchanger 10, that is, the single lateral opening 54, no matter what cell(s) 36 is actually involved. Having only one external leaking point is then easier to detect and even sensor the leakage. As for the previously described embodiment, the lateral opening 54 can be also easily plugged to stop the water leakage and allow the heat exchanger 10 working until the planned fixing. For example, the sensor means described so far can send proper signals to the electronic control unit 50 for activating an "emergency mode", allowing the heat exchanger 10 to keep working under some limitations. This would make it possible to avoid any further freezing inside the heat exchanger 10 (e.g., excluding external coil defrosting, rising minimum water temperature set points, reducing compressor speed, etc.). In this way, the heat exchanger 10 can remain active and provide at least some heating or cooling until its planned repair/replacement.

[0039] With reference to figure 12, all the cells 36 and the respective connection conduit 52 can be filled with an inert gas. At least one probe 56 can be connected to the lateral opening 54. The probe 56 can be a pressure or temperature sensor, which is capable of detecting changes in pressure and/or temperature values of the inert gas. The probe 56 is thus capable of detecting when the volume of the cells 36 is modified, due to deformations and/or breakages induced by the ice formation.

[0040] With reference to figure 13, further components of the freezing detecting system according to the invention are shown. These components comprise one or more fluid collector tanks 58, 60, which are located outside the heat exchanger 10 and are designed to collect the fluid exiting the heat exchanger 10 through at least one of the channels 40. More precisely, a first collector tank 58 can be designed for collecting the fluid exiting the multiple channels 40 of the heat exchanger 10 according to the embodiment of Figure 3, whereas a second collector tank 60 can be designed for collecting the fluid exiting the single channel 40 and the single lateral opening 54 of the heat exchanger 10 according to the embodiment of Figure 10. Preferably, at least one of the collector tanks 58, 60 can be provided with one or more fluid level sensors 62 and/or with one or more overflow discharge conduits 64, so as to monitor the amount of fluid and discharge the excess amount if necessary.

[0041] It is thus seen that the brazed plate heat exchanger according to the present invention achieve the previously outlined objects.

[0042] The brazed plate heat exchanger of the present invention thus conceived is susceptible in any case of numerous modifications and variants, all falling within the same inventive concept; in addition, all the details can be substituted by technically equivalent elements. In practice, the materials used, as well as the shapes and size, can be of any type according to the technical requirements.

[0043] The scope of protection of the invention is therefore defined by the enclosed claims.

List of references

[0044]

10: brazed plate heat exchanger;
12A: heat exchanger plate;
12B: heat exchanger plate;
12C: heat exchanger plate;
14: first end plate;
16: second end plate;
18: first connection pipe;
20: second connection pipe;
22: third connection pipe;
24: fourth connection pipe;
26: plate long side edges;
28: plate short side edges;
30: plate package;
32: first plate interspaces;
34: second plate interspaces;
36: cells;
38: deformable wall portions;
40: channels;
42: colored fluid substance;
44: electrically conductive fluid substance;
46: electrically conductive cable;
48: elastic element;
50: electronic control unit;
52: connection conduit;
54: lateral opening;
56: probe;
58: first fluid collector tank;
60: second fluid collector tank;
62: fluid level sensor;
64: overflow discharge conduit;
P1: first porthole;
P2: second porthole;
P3: third porthole;
P4: fourth porthole.

Claims

1. A brazed plate heat exchanger (10) comprising a plurality of heat exchanger plates (12A, 12B, 12C) which are stacked onto one another, wherein said heat exchanger plates (12A, 12B, 12C) are obtained by forming from respective metal sheets, wherein said heat exchanger plates (12A, 12B, 12C) are permanently joined to each other through brazing by means of a braze material, so as to form a plate package (30) provided with first plate interspaces (32) for a first fluid and second plate interspaces (34) for a second fluid, wherein each of said heat exchanger plates (12A, 12B, 12C) is provided with a plurality of portholes (P1, P2, P3, P4), and wherein each of said heat exchanger plates (12A, 12B, 12C) is provided with one or more side edges (26, 28) which form the outer perimeter of said heat exchanger plates (12A, 12B, 12C), the brazed plate heat exchanger (10) being **characterized in that** it comprises a plurality of cells (36) having a predefined internal volume (V), wherein each cell (36) is integral with a corresponding heat exchanger plate (12A, 12B, 12C), wherein each cell (36) is separated by said first plate interspaces (32) and/or said second plate interspaces (34) through respective deformable wall portions (38), wherein said deformable wall portions (38) have a mechanical strength which is lower than the average mechanical strength of the metal sheets of said heat exchanger plates (12A, 12B, 12C), and wherein at least one channel (40) is provided between each cell (36) and one of the side edges (26, 28) of said heat exchanger plates (12A, 12B, 12C), each channel (40) putting in fluid connection the internal volume (V) of the respective cell (36) with the environment outside the brazed plate heat exchanger (10).

2. The brazed plate heat exchanger (10) according to claim 1, **characterized in that** each cell (36) is located near one of the side edges (26, 28) of said heat exchanger plates (12A, 12B, 12C).

3. The brazed plate heat exchanger (10) according to claim 1 or 2, **characterized in that** each cell (36) is located between one of the portholes (P1, P2, P3, P4) and one of the side edges (26, 28) of said heat exchanger plates (12A, 12B, 12C).

4. The brazed plate heat exchanger (10) according to anyone of claims 1 to 3, **characterized in that** said deformable wall portions (38) have an average thickness I which is lower than the average thickness of

the metal sheets of said heat exchanger plates (12A, 12B, 12C).

5. The brazed plate heat exchanger (10) according to anyone of claims 1 to 4, **characterized in that** said deformable wall portions (38) are provided with one or more bends with low radius.

6. The brazed plate heat exchanger (10) according to anyone of claims 1 to 5, **characterized in that** said deformable wall portions (38) are made of a metal material which is different from the metal material from which the metal sheets of said heat exchanger plates (12A, 12B, 12C) are made.

7. The brazed plate heat exchanger (10) according to anyone of claims 1 to 6, **characterized in that** at least part of said cells (36) is provided with sensor means (42, 44, 46, 48) for detecting the deformation and/or breakage of the deformable wall portions (38) respectively associated with said cells (36).

8. The brazed plate heat exchanger (10) according to claim 7, **characterized in that** said sensor means comprise at least one colored fluid substance (42) having a viscosity which is greater than the viscosity of said first fluid and said second fluid, wherein said colored fluid substance at least partially fills the internal volume (V) of a single cell (36) and is arranged to leak out of the respective channel (40) in case of deformation and/or breakage of said deformable wall portions (38).

9. The brazed plate heat exchanger (10) according to claim 7, **characterized in that** said sensor means comprise at least one electrically conductive fluid substance (44), which at least partially fills the internal volume (V) of a single cell (36), and at least one electrically conductive cable (46), which connects the internal volume (V) of said single cell (36) to an electronic control unit (50) of the brazed plate heat exchanger (10) through the respective channel (40), wherein said electrically conductive fluid substance (44) is arranged to generate and send an electric signal to said electronic control unit (50) through said cable (46) in case of deformation and/or breakage of said deformable wall portions (38).

10. The brazed plate heat exchanger (10) according to claim 7, **characterized in that** said sensor means comprise at least one elastic element (48), which is in direct contact with the deformable wall portion (38) of a single cell (36), and at least one electrically conductive cable (46), which connects the internal volume (V) of said single cell (36) to an electronic control unit (50) of the heat exchanger (10) through the respective channel (40) and is in direct contact with said elastic element (48), wherein an elastic deformation of said elastic element (48) occurs in case of deformation and/or breakage of said deformable wall portion (38), and wherein said elastic deformation generates and sends an electric signal to said electronic control unit (50) through said cable (46).

11. The brazed plate heat exchanger (10) according to anyone of claims 1 to 10, **characterized in that** it comprises pair of adjacent cells (36), wherein the two cells (36) of a single pair of adjacent cells (36) are respectively located in two adjacent first plate interspaces (32) and/or two adjacent second plate interspaces (34), and wherein said two cells (36) of a single pair of adjacent cells (36) are separated from each other and from said adjacent first plate interspaces (32) and/or said adjacent second plate interspaces (34) by at least one deformable wall portion (38).

12. The brazed plate heat exchanger (10) according to claim 11, **characterized in that** said pairs of adjacent cells (36) are mutually connected through a connection conduit (52), wherein said connection conduit (52) is in turn in fluid connection, through at least one of said channels (40), with a single lateral opening (54) obtained on one of the side edges (26, 28) of said heat exchanger plates (12A, 12B, 12C).

13. The brazed plate heat exchanger (10) according to claim 12, **characterized in that** said pairs of adjacent cells (36) and said connection conduit (52) are filled with an inert gas.

14. The brazed plate heat exchanger (10) according to claim 13, **characterized in that** at least one probe (56) is connected to said lateral opening (54), wherein said probe (56) is capable of detecting changes in pressure and/or temperature values of said inert gas.

15. The brazed plate heat exchanger (10) according to anyone of claims 1 to 14, **characterized in that** it comprises one or more fluid collector tanks (58, 60), which are located outside the brazed plate heat exchanger (10) and are designed to collect the fluid exiting said heat exchanger (10) through said at least one channel (40), wherein said fluid collector tanks (58, 60) are preferably provided with one or more fluid level sensors (62) and/or with one or more overflow discharge conduits (64).

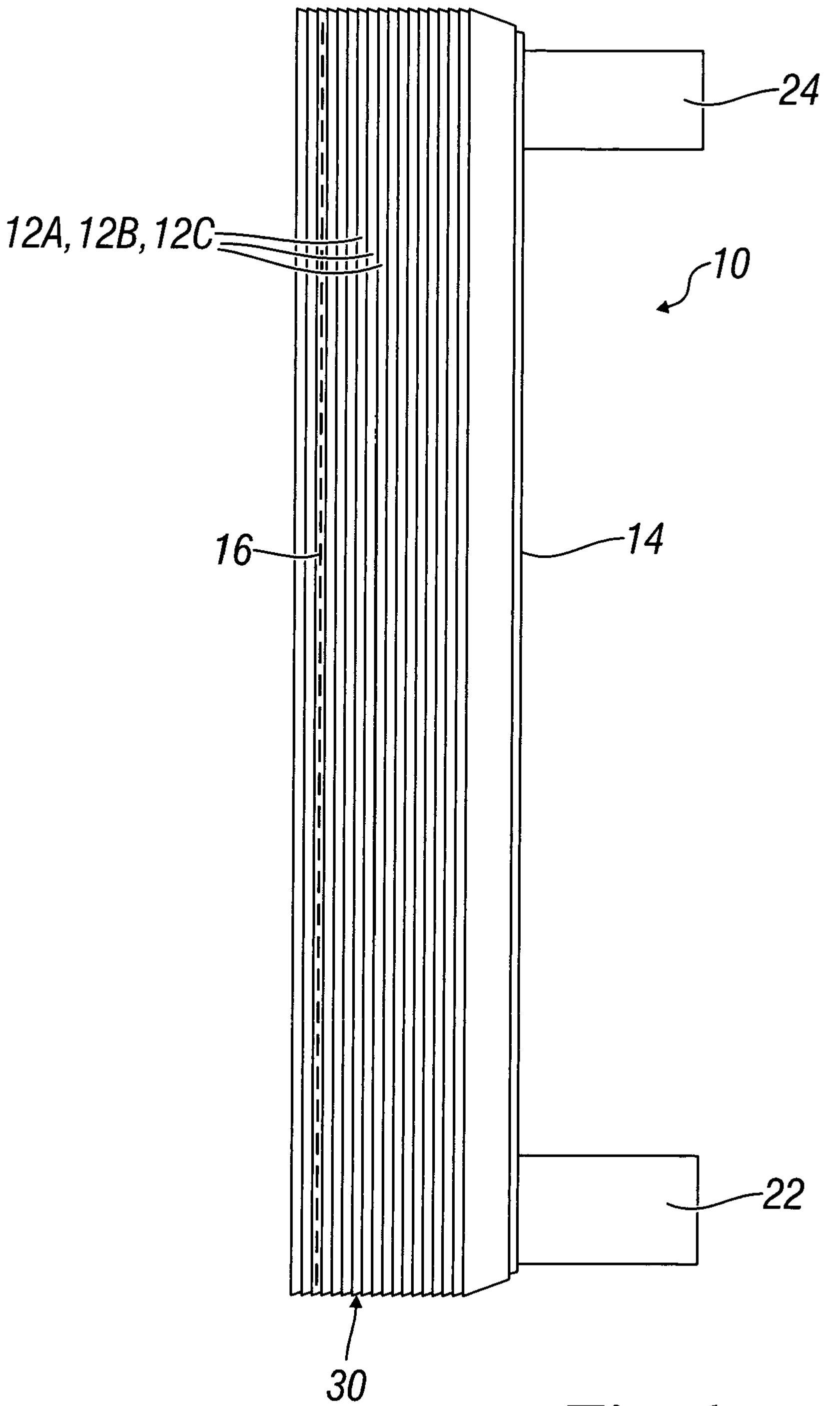

Fig. 1

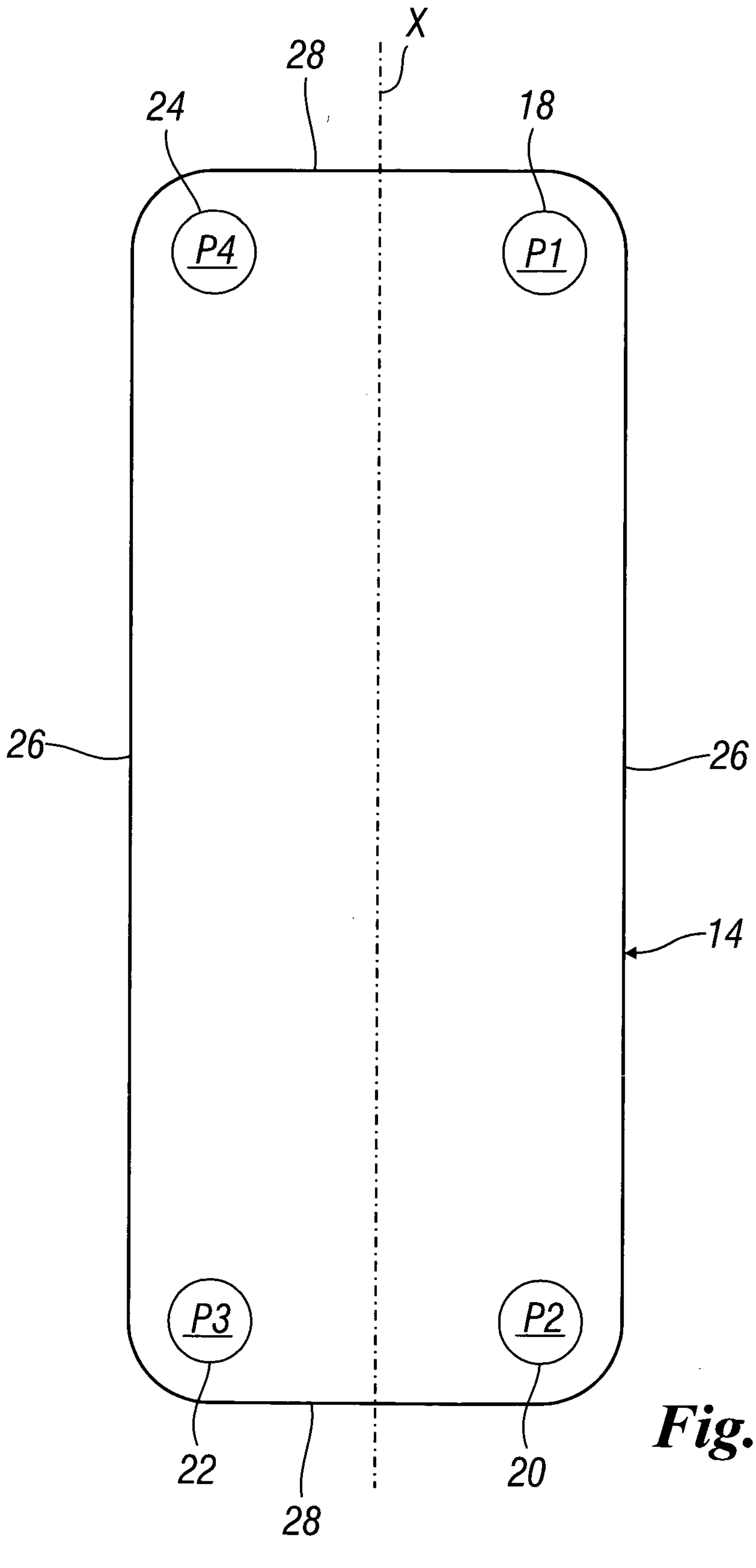

Fig. 2

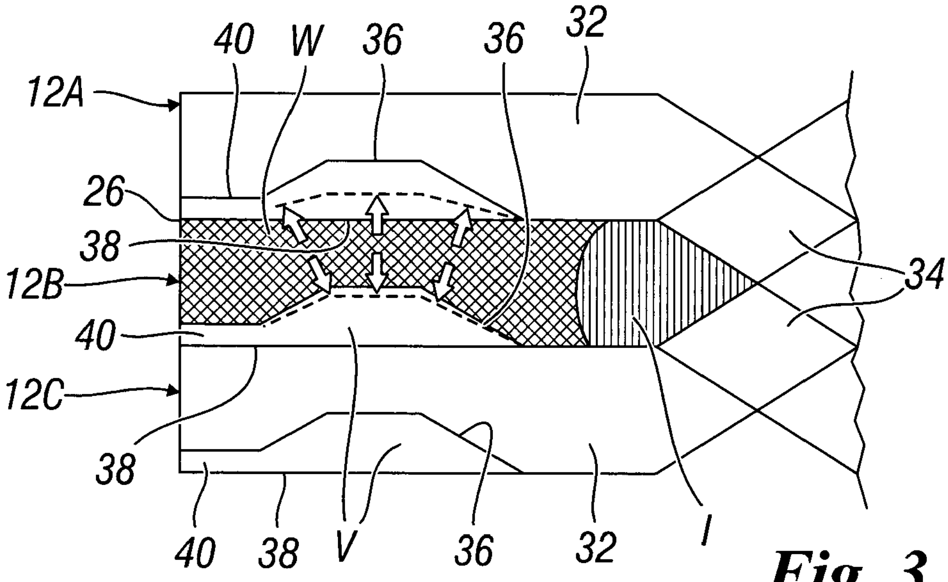

Fig. 3

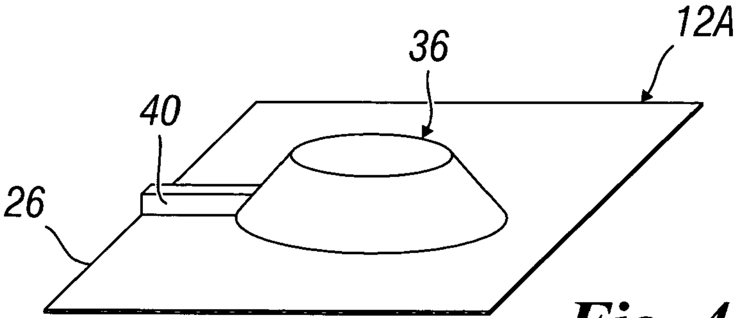

Fig. 4

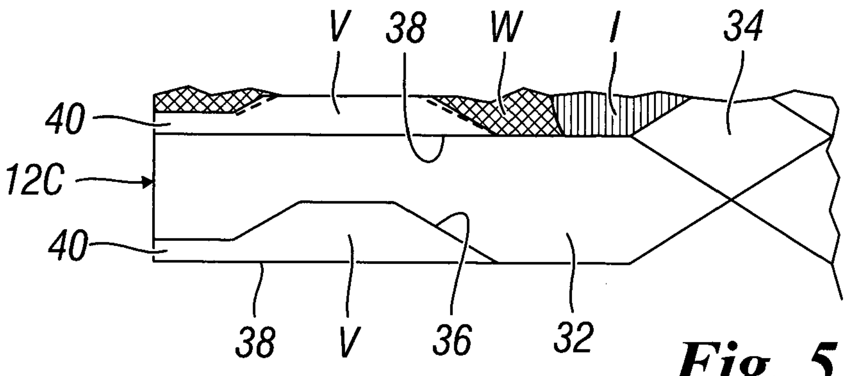

Fig. 5

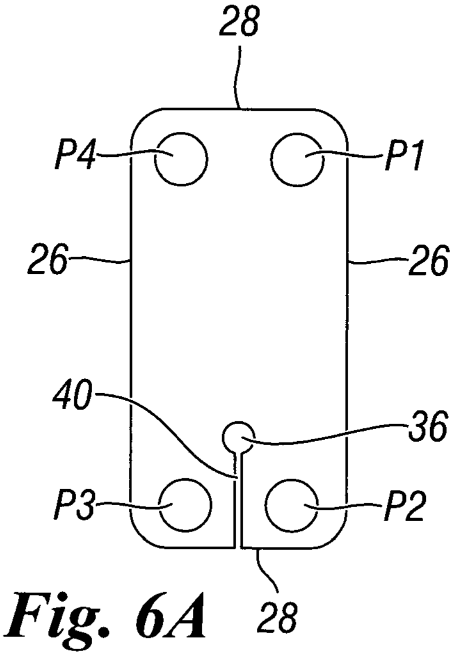

Fig. 6A

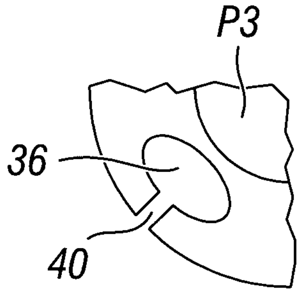

Fig. 6B

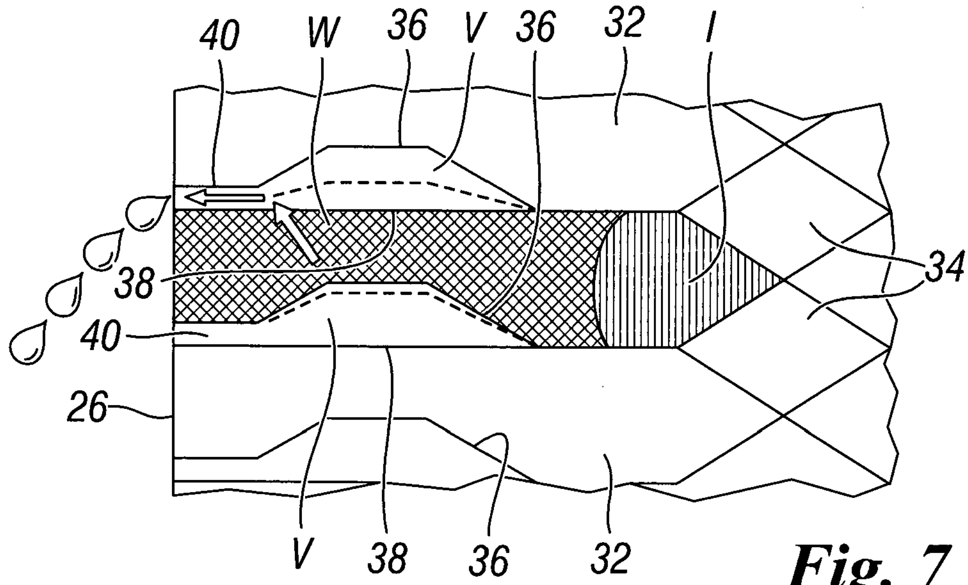

Fig. 7

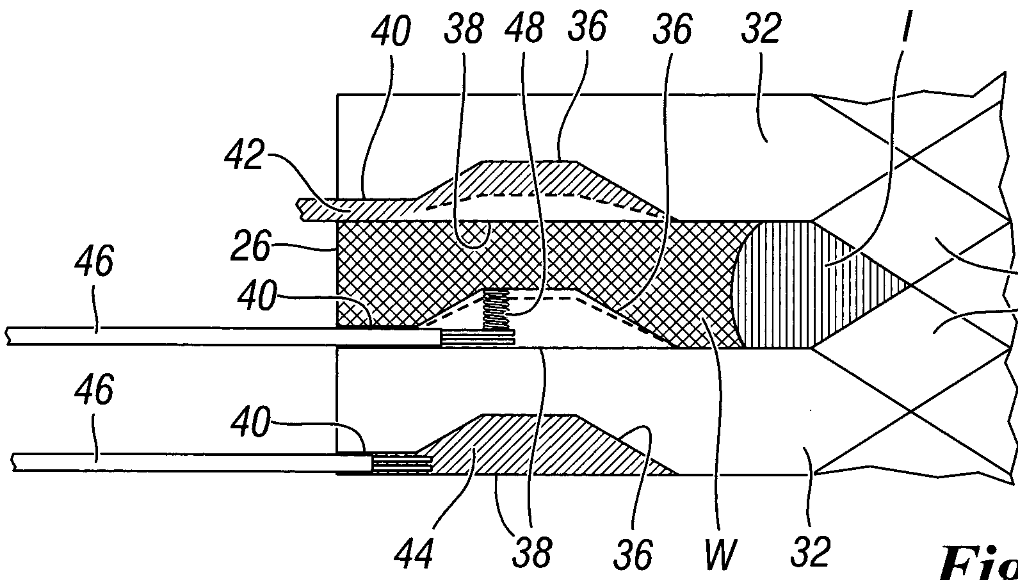
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Fig. 8

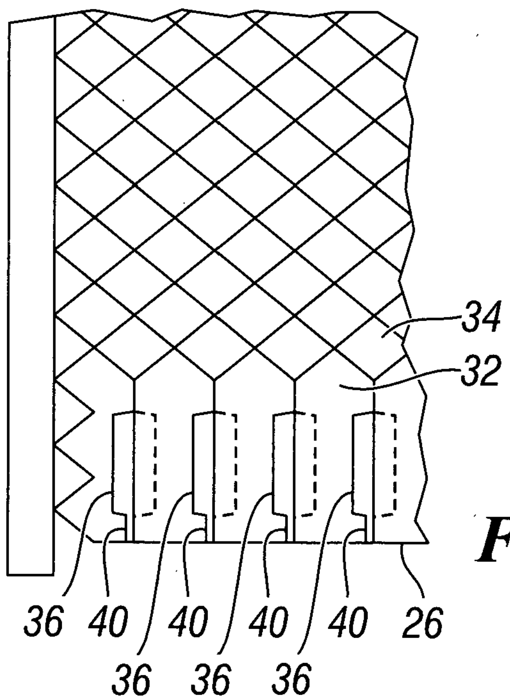
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Fig. 9

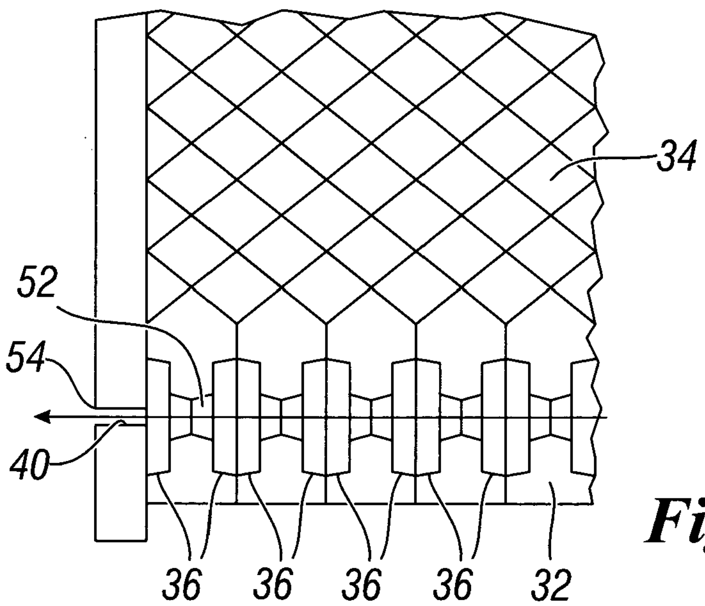

Fig. 10

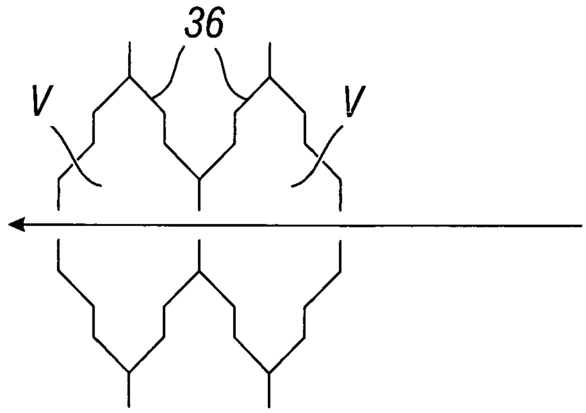

Fig. 11

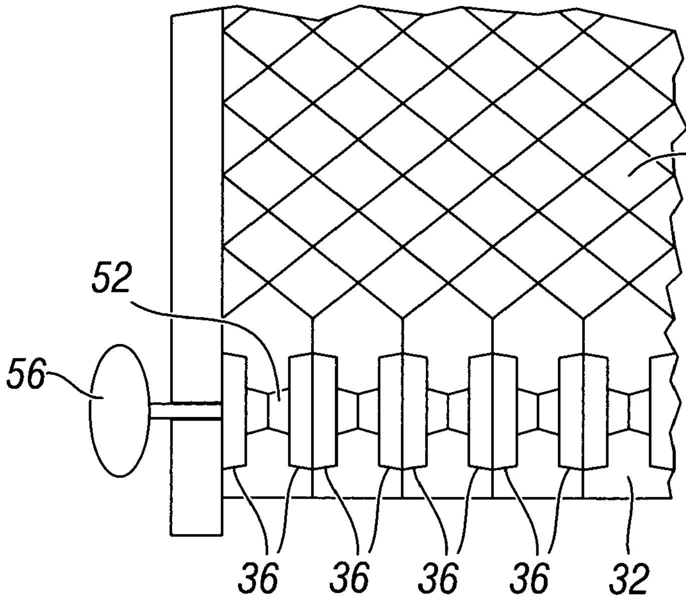

Fig. 12

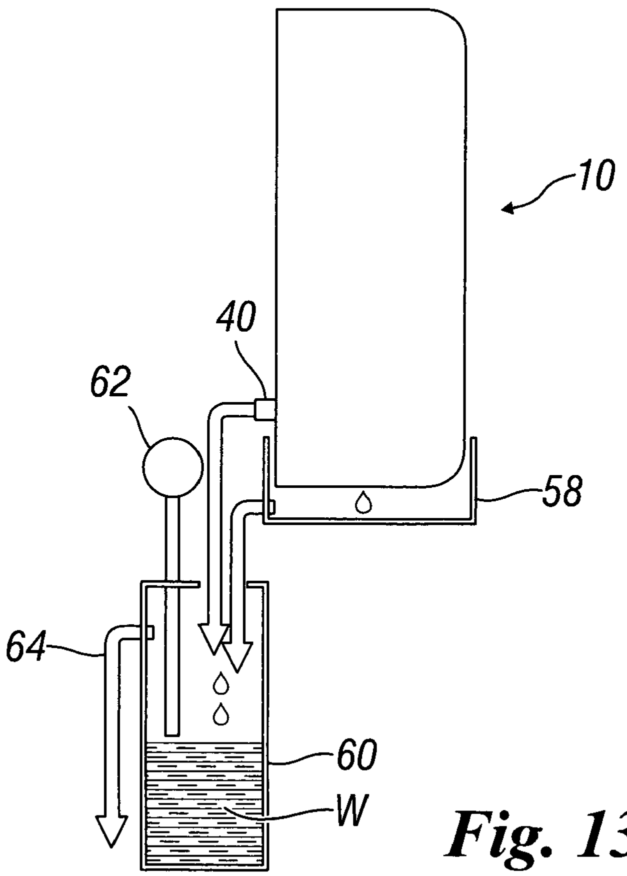

Fig. 13

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EUROPEAN SEARCH REPORT

Application Number
EP 23 42 5037

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2022/397349 A1 (NIELSEN HELGE [DK] ET AL) 15 December 2022 (2022-12-15) * paragraph [0041] - paragraph [0045]; figures 3,4 * -----	1-15	INV. F28D9/00 F28F3/00
A	WO 2022/015217 A1 (SWEP INT AB [SE]) 20 January 2022 (2022-01-20) * page 9, line 22 - page 10, line 14; figure 3 * -----	1-15	
A	US 2016/178260 A1 (GESKES PETER [DE] ET AL) 23 June 2016 (2016-06-23) * paragraph [0009] * * paragraph [0027]; figure 5 * -----	1-15	
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A	JP 2002 107089 A (HISAKA WORKS LTD) 10 April 2002 (2002-04-10) * paragraph [0018] * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC): F28D F28F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 December 2023	Vassoille, Bruno

CATEGORY OF CITED DOCUMENTS

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