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(54) A heat exchanger

(57) Disclosed is a heat exchanger (1) comprising a first flow channel (2) positioned in thermal contact with a second flow channel (3) for heat exchange between a first fluid flowing in the first flow channel (2) and a second fluid flowing in the second flow channel (3). The first flow channel (2) comprises a number of first sections (4) and the second flow channel (3) comprises a number of second sections (5), wherein a first section (4) of the first flow channel (2) abuts at least three of the second sections (5) of the second flow channel (3). The first section (4) and a succeeding first section (4) of the first flow channel (2) are arranged on opposite sides of an intermediate second section (5) of the at least three second sections (5) of the second flow channel (3), wherein the first section (4) and the succeeding first section (4) are connected by means of a first connector (6) extending across the width of the intermediate second section (5) so that the first connector (6) is extending substantially parallel with a section plane (8) formed by the general longitudinal extend of the first section (4) and the succeeding first section.

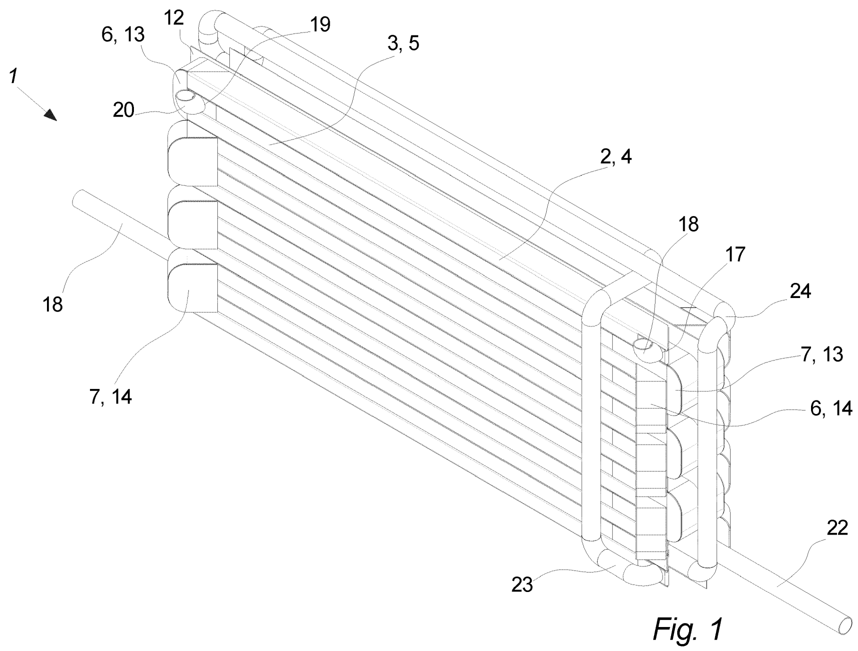

Fig. 1

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Description

Field of the Invention

[0001] The present invention relates to a heat exchanger comprising a first flow channel positioned in thermal contact with a second flow channel for heat exchange between a first fluid flowing in said first flow channel and a second fluid flowing in said second flow channel.

Background of the Invention

[0002] Counterflow heat exchangers for liquid manure and similar viscous liquids are often built as tube in tube and require frequent cleaning. Cleaning of these heat exchangers is usually very difficult due to the construction or involves a heavy wear on the material of the heat exchanger when using acid.

[0003] Thus, from the European patent EP 1 957 924 B1 it is therefore known to form a counterflow heat exchanger by means of a cold channel and a hot channel having longitudinal sections running alternately to form a first row on a first side of the heat exchanger and then continuing to run alternately on the other side to form a second row on the other side of the heat exchanger so that e.g. most of the longitudinal sections of the hot channels will abut three longitudinal sections of the cold channel. Since the longitudinal sections of the two channels are arranged in alternate succession of each other, two succeeding longitudinal sections of one channel are connected by means of connectors extending across the side of an intermediate longitudinal section of the other channel. However, this design entails a relatively high pressure drop through the heat exchanger and a complex manufacturing process.

[0004] It is therefore an object of the present invention to provide for a heat exchanger design with a reduced pressure drop and/or a more simple manufacturing process.

The invention

[0005] The invention relates to a heat exchanger comprising a first flow channel positioned in thermal contact with a second flow channel for heat exchange between a first fluid flowing in the first flow channel and a second fluid flowing in the second flow channel. The first flow channel comprises a number of first sections and the second flow channel comprises a number of second sections, wherein a first section of the first flow channel abuts at least three of the second sections of the second flow channel. The first section and a succeeding first section of the first flow channel are arranged on opposite sides of an intermediate second section of the at least three second sections of the second flow channel, wherein the first section and the succeeding first section are connected by means of a first connector extending across the width of the intermediate second section so that the first connector is extending substantially parallel with a section plane formed by the general longitudinal extend of the first section and the succeeding first section.

[0006] It is advantageous to arrange the first connector so that the general flow path through the first connection extends substantially parallel with the section plane in that this will severely reduce the direction change of a fluid flowing through the first flow channel thus reducing pressure drop.

[0007] Furthermore, making the first connector extend across the "top" of the upper part of the intermediate second section enables that the entire first flow channel can be formed and pressure tested before the second flow channel is formed. This is advantageous in that when the second flow channel is not closed yet; easy access to substantially all the corners of the first flow channel is enabled.

[0008] It should be noted that in this context the term "substantially parallel" should be understood as the two planes being parallel or at least almost parallel. It is evident to the skilled person that the pressure drop is also severely reduced if the first connector plane is only almost parallel with the section plane i.e. if the angle between the first connector plane and the section plane was 1°, 2°, 3°, 5°, 7° or even 10°.

[0009] It should also be noted that in this context the term "a section plane formed by the general longitudinal extend of the first section and the succeeding first section" should be understood as the plan in which both first sections extend longitudinally i.e. the section plane intersecting the general longitudinal extend of the two first sections. However, it is important to emphasise that this interpretation does to limit the sections to being formed completely straight. In an embodiment, some or all of the sections could comprise bends, corrugations or other - e.g. to induce turbulent flow in the sections - and even though such a sections only locally would intersect the section plane the sections would still have a general longitudinal extend intersecting and defining the section plane.

[0010] Furthermore, it should be noted that in this context the term "connector" should be understood as any kind of pipe, tube, channel, duct, conduit, hose or other suitable to act as connection means between two succeeding sections of a heat exchanger.

[0011] In an aspect of the invention, said intermediate second section and a succeeding second section are arranged on opposite sides of said succeeding first section and wherein said intermediate second section and said succeeding second section are connected by means of a second connector extending across the width of said succeeding first section in a connector plane intersecting said section plane.

[0012] It is more simple and cost-efficient to arrange the second connector to pass next to the first connector - e.g. instead of through it - and it is therefore advantageous to arrange the first connector and the second connector in two different planes arranged to intersect each other.

[0013] It should be noted that in this context the terms "succeeding first section" and "succeeding second section" should be understood as the next sections in the flow path of a normally functioning heat exchanger i.e. the succeeding first section is arranged in direct continuation of a (preceding) first section substantially only separated by a first connector.

[0014] In an aspect of the invention, the angle between said section plane and said connector plane is between 10° and 100°, preferably between 20° and 80° and most preferred between 30° and 60°.

[0015] If the angle between the section plane and the connector plane becomes too big the direction change of the flow through the connectors arranged in the connector plane is so significant that the pressure drop is significantly increased. However, if the angle between the section plane and the connector plane becomes too little it becomes very difficult to arrange the first connectors and the second connectors next to each other. Thus, the present angle ranges presents an advantageous relationship between efficiency and design.

[0016] In an aspect of the invention, substantially half of said first connectors and said second connectors are arranged to extend substantially parallel with said section plane and the remaining connectors are arranged to substantially extend in said connector plane.

[0017] Forming half of the connectors in one of the planes and the remaining connectors in the other is advantageous in that it hereby is possible to form an entire heat exchanger where all the connectors alternately pass next to each other, hereby optimising design and simplifying the manufacturing process.

[0018] In an aspect of the invention, substantially half of said first connectors are arranged to extend substantially parallel with said section plane and substantially half of said second connectors are arranged to extend substantially parallel with said section plane.

[0019] Forming the heat exchanger so that substantially half of the connectors of the first flow channel and substantially half of the connectors of the second flow channel are arranged to extend substantially parallel with said section plane is advantageous in that the reduced pressure drop hereby is split substantially even between the two flow channels.

[0020] Furthermore, by distributing the connectors arranged parallel with the section plane substantially evenly between the two channels ensures that all the sections of a flow channel can be connected to connectors arranged parallel with the section plane - at least in one end. Given the parallelism of these connectors, a hole in the outer side wall of these connectors would provide access to the connected section in direct continuation of the longitudinal extend of the section - thus enables easy access to the inside of the section and thus enabling an easy cleaning process.

[0021] In an aspect of the invention, said first connector is arranged to substantially intersect the direction of the longitudinal extent of said intermediate second section.

[0022] Hereby is achieved and advantageous embodiment of the invention.

[0023] In an aspect of the invention, said first connector partly extends between connection legs of said second connector.

[0024] Forming the connectors so that they alternately plait or weave in between each other is advantageous in that it provides for a compact heat exchanger design with a more reduced pressure drop.

[0025] In an aspect of the invention, said first sections and said second sections are formed with a square cross section.

[0026] Forming the sections with a square cross section is advantageous in that it enables efficient heat exchange between the two flow channels and enables a simple manufacturing process.

[0027] In an aspect of the invention, said first sections and said first connectors substantially have the same cross section and/or wherein said second sections and said second connectors substantially have the same cross section.

[0028] Forming the respective sections and connectors with substantially the same cross section is advantageous in that pressure drop due to shape change of the flow channel is reduced or avoided.

[0029] In an aspect of the invention, connectors arranged to extend substantially parallel with said section plane comprise cleaning holes.

[0030] Providing cleaning holes in the "straight" connectors is advantageous in that these holes will enable access straight into the longitudinal extend of the sections thus enabling that the sections can be cleaned efficiently by means of a straight and relatively rigid object.

[0031] In an aspect of the invention, the first section and the succeeding first section are arranged to extend substantially parallel.

[0032] In an aspect of the invention, the first section, said second section and the succeeding first section are arranged to extend substantially parallel.

[0033] In an aspect of the invention, the first section and the succeeding first section are arranged so that flow through said first section runs in a direction substantially opposite the direction of flow in said succeeding first section during normal operation of said heat exchanger.

[0034] In an embodiment of the heat exchanger, a second section of the second flow channel abuts at least three first sections of the first flow channel. Preferably, the walls in the heat exchanger form a plurality of cavities to form at least two flow channels. For example, first cavities may be connected via first connectors forming a first flow channel and second cavities may be connected via second connectors forming a second flow channel. A cavity may form a section of the first flow channel or the second flow channel. Preferably, the first flow channel and the second flow channel have common walls to improve heat exchange between fluids in the respective channels. For example, a first section of the first flow channel may have a common wall with at least three different second sections of the second flow channel. Preferably, heat exchanger module has a body with walls including a first outer wall, a second outer wall, a third outer wall, a fourth outer wall, a first end wall, and a second end wall. Further, the heat exchanger module may comprise inner walls forming a plurality of cavities or sections of flow channels in the body of the heat exchanger module. Preferably, an inner wall forms a common wall between a first section and a second section of the respective flow channels. The heat exchanger module may have a first port and a second port. The first port may form an inlet and/or an outlet at an end of the first flow channel, and the second port may form an inlet and/or outlet at the other end of the first flow channel. Further, the heat exchanger module may comprise a third port and a fourth port. The third port may form an inlet and/or an outlet for the second flow channel, and the fourth port may form an inlet and/or an outlet for the second flow channel. The ports may have module connectors, e.g. fittings, for coupling the heat exchanger module to other heat exchanger modules and or external units such as a cleaning system or containers holding first and second fluids. Preferably, the module connectors when intercoupling heat exchanger modules have a cross section corresponding to the cross section of the sections of the flow channels, which they communicate or connect. Preferably, the first sections of the first flow channel are tubular and second sections of the second flow channel are tubular. Preferably, the first sections and the second sections extend along a straight first axis having a length from about 0.5 m to about 10 m. In a preferred embodiment of the present invention, the sections have a length of about 3 m. In an embodiment of the present invention, the walls of the heat exchanger module form a first flow channel with a polygonal cross section. In a preferred embodiment of the present invention, the walls of the heat exchanger module form a first flow channel with first sections having a four-sided cross section. In an embodiment of the present invention, the walls of the heat exchanger module form a second flow channel with a polygonal cross section. In a preferred embodiment of the present invention, the walls of the heat exchanger module form a second flow channel with second sections having a four-sided cross section. The sections of the respective flow channels may have a substantially polygonal cross section with side lengths from about 10 mm to about 200 mm, such as from about 30 mm to about 100 mm, e.g. about 50 mm. Preferably, the sections have a four-sided cross section, e.g. a rectangular cross section and/or a square cross section, with side lengths from about 10 mm to about 200, preferably from about 25 mm to about 100 mm, more preferably from about 30 mm to about 60 mm, such as about 40 mm or about 50 mm.

[0035] The first and second flow channel may be dimensioned, such that a fluid flow from about 0.8 m/s to about 1.7 m/s can be obtained in the flow channels. In a preferred embodiment of the present invention, one or more of the sections of the flow channels, preferably all, have a square cross section with a side length from about 30 mm to about 100 mm, such as about 40 mm, about 50 mm, about 60 mm, about 70 mm, or about 80 mm.

[0036] In another preferred embodiment of the present invention, the sections of the flow channels have a rectangular cross section, e.g. having the dimensions 30 mm x 40 mm or 40 mm x 50 mm.

[0037] Preferably, the first sections and the second sections of the heat exchanger module are alternately arranged in two columns including a first column and a second column such that a first section in the first column abuts two second sections in the first column and one second section in the second column. Thus, a first section in the first column may have a common inner wall with a second section in the first column, a common inner wall with another second section in the first column, and a common inner wall with a second section in the second column. Preferably, each section is delimited by or defined by at least a part of an outer wall. The heat exchanger module may comprise first connectors. The first connectors may connect first sections to form the first flow channel or at least a part thereof.

[0038] Furthermore, the heat exchanger module may comprise second connectors. The second connectors may connect second sections to form the second flow channel or at least a part thereof.

[0039] In a preferred embodiment of the present invention, the connectors are welded to the outer walls of the heat exchanger module thereby connecting sections of the respective flow channels through openings in the outer walls. Preferably, the openings in the outer walls are rectangular and/or quadratic having a cross section corresponding to the cross section of the sections for provision of substantially uniform flow channels. In an embodiment, the connectors are secured in threaded engagement with the walls. In an embodiment of the present invention, the connectors may connect sections of the respective flow channels through openings in the end walls.

[0040] Preferably, the first and/or the second connectors have a cross section corresponding to the cross section of the sections which they communicate or connect. Thereby drop of pressure around the connector may be minimized or substantially avoided. Thus, the connectors may have a polygonal cross section with a side length from about 30 mm to about 100 mm, such as a square cross section with a side length from about 30 mm to about 100 mm, such as about 40 mm, about 50 mm, about 60 mm, about 70 mm, or about 80 mm. Preferably, the connectors are positioned near or at the ends of the first and second sections.

[0041] Further, the heat exchanger module may have one or more cleaning holes. Preferably, one or more cleaning holes are provided for each of the cavities forming the sections of the flow channels. In a preferred embodiment, a cleaning hole for each of the cavities forming the sections of the flow channels is provided, e.g. in the first end wall of the heat exchanger module. More preferably, a cleaning hole for each of the cavities forming the sections of the flow channels may further be provided in the second end wall of the heat exchanger module. The one or more cleaning holes may comprise an engagement member, e.g. a threading or a bayonet socket that may be adapted for engagement with a plug member. The one or more cleaning holes provide user access to the different sections of the heat exchanger thereby facilitating manual cleaning or removal of blockages in the flow channel. Further, the heat exchanger module may comprise one or more plug members for sealing the one or more cleaning holes. The one or more plug members comprise an engagement member, e.g. a threading or a bayonet socket, for detachable engagement with the engagement member of a cleaning hole.

[0042] It is an important advantage of the present invention that a user has easy access to the different sections of the flow channels for convenient removal of any blockages that may arise during use. The plug members are readily detachable and mountable.

[0043] Preferably, the heat exchanger module is made of stainless steel, such as AISI 304 or AISI 316, however any other suitable steel type may be used. Preferably, the heat exchanger module is made of an acid-resistant steel type. Hereby cleaning of the heat exchanger with acidic fluids is rendered possible. In an embodiment suitable for non-aggressive fluids, at least a part of the heat exchanger module, e.g. the inner walls and/or the outer walls, may be made of a metal having high thermal conductivity compared to stainless steel, such as black steel, aluminium, or copper. In an embodiment, the walls may be coated with an acid resistant material.

[0044] In an embodiment, first fluid having a first inlet temperature is pumped into the first flow channel through the first port, passes the first flow channel while exchanging heat with fluid in the second flow channel, and leaves the first flow channel having a first outlet temperature through the second port. At the same time, a second fluid having a second inlet temperature may be pumped into the second flow channel through the third port, passing the second flow channel while exchanging heat with fluid in the first flow channel, and leaving the second flow channel having a second outlet temperature through the fourth port. The heat exchanger module is in particular adapted for heat exchange between liquid manure; however, the fluids may be any fluids, such as liquid manure, sludge, water in liquid and gaseous form, oil, natural gas, or other fluids.

[0045] It is an important advantage of the present invention that the heat exchanger due to its construction is compact and takes up little space compared to the amount of heat transferred. It is an important advantage of the present invention that the heat exchanger is able to transfer large amounts of heat between the fluids in the flow channels. It is a further advantage of the present invention that cleaning of the heat exchanger module is easy and can be performed without destroying, e.g. cutting, the heat exchanger module.

[0046] The walls of the heat exchanger module may have a thickness in the range from about 0.5 mm to about 20 mm, preferably from about 1 mm to about 10 mm. In a preferred embodiment of the present invention, the walls of the heat exchanger have a thickness from about 2 mm to about 5 mm, e.g. about 3 mm or about 4 mm. If the thickness of the walls is too small, a high pressure may not be employed, and if the thickness of the walls is too large, the transfer of heat between the first and second flow channel is reduced. It may be desired to employ a high pressure in the flow channels. If the first pressure in the first flow channel and the second pressure in the second flow channel are substantially the same, or the pressure difference between the first flow channel and the second flow channel is small, e.g. less than 3 bar, the thickness of the inner walls of the heat exchanger module can be small, such as around 1 mm, thereby obtaining improved heat exchange between the fluids.

[0047] The heat exchanger module may further comprise a casing. The casing supports and strengthens the outer walls to increase the possible operating pressures of the heat exchanger module. The heat exchanger module with or without a casing may operate with fluids at a high pressure, e.g. up to 12 bar or more.

[0048] The heat exchanger system according to the present invention may comprise one or more heat exchanger modules as described herein, such as two, three, four, five, ten, twenty, fifty or more heat exchanger modules. In a preferred embodiment, the heat exchanger system comprises a first heat exchanger module and a second heat exchanger module as described herein. Preferably, the heat exchanger system comprises a frame carrying the one or more heat exchanger modules. Further, the heat exchanger system may comprise a plurality, e.g. two three, four or more insulation elements for insulation of the heat exchanger modules. The insulation elements may be attached to the frame, e.g. by one or more hinges and/or adapted to support on the frame. In the heat exchanger system, one or more ports functioning as inlet/outlet of a flow channel may be provided with fittings, e.g. a T-piece, to allow easy coupling, e.g. via valves, of the flow channel to different fluid loops, such as a fluid loop with liquid manure and a fluid loop with cleaning fluid.

[0049] Preferably, the heat exchanger system according to the invention comprises one or more module connectors, such as fittings, that connect ports of the heat exchanger modules according to a desired configuration of the heat exchanger system, e.g. depending on the number of fluids to be heat exchanged, number of heat exchanger modules, etc.

[0050] Preferably, the module connectors have a cross section corresponding to the cross section of the sections of the heat exchanger modules, which they communicate or connect. Thereby drop of pressure around the module connector may be minimized or substantially avoided. Thus, the module connectors may have a polygonal cross section with a side length from about 30 mm to about 100 mm, such as a square cross section with a side length from about 30 mm to about 100 mm, such as about 40 mm, about 50 mm, about 60 mm, about 70 mm, or about 80 mm. Preferably, first fluid in a first section flows in the opposite direction of the flow of the second fluid in two adjacent second sections.

[0051] In another embodiment, a heat exchanger system could be provided, comprising one or more heat exchangers 1 as described herein. Preferably, the heat exchanger system comprises a first heat exchanger module and a second heat exchanger module that are interconnected to form a first flow channel and a second flow channel. Preferably, the first flow channel and the second flow channel have a substantially uniform cross section through the heat exchanger module.

Figures

[0052] The invention will be explained further herein below with reference to the figures in which:

Fig. 1 shows a heat exchanger according to the present invention, as seen in perspective,

Fig. 2 shows cross section through a heat exchanger, as seen from the side,

Fig. 3 shows a heat exchanger, as seen from the front,

Fig. 4 shows a heat exchanger, as seen from the bottom, and

Fig. 5 shows a heat exchanger, as seen from the side.

Detailed description

[0053] Figs. 1-5 schematically show a preferred embodiment of a heat exchanger 1 according to the present invention. The heat exchanger module 1 has walls and comprises a first flow channel 2 positioned in thermal contact with a second flow channel 3 for heat exchange between a first fluid flowing in the first flow channel 2 and a second fluid flowing in the second flow channel 3. Further, a first section 4 of the first flow channel 2 abuts at least three second sections 5 of the second flow channel 3. Further, a second section 5 of the second flow channel 3 abuts at least three first sections 4 of the first flow channel 2.

[0054] Figure 1 shows a heat exchanger 1 according to the present invention, as seen in perspective.

[0055] In this embodiment the heat exchanger 1 comprises a number of first sections 4 extending up and down on both sides of a central wall 12. The first sections 4 are connected in the ends by means of first connectors 6 alternately formed as straight connectors 13 - i.e. connectors 13 that are extending substantially parallel with a section plane 8 formed by the general longitudinal extend of the first sections 4 - and angled connectors 14 - i.e. connectors 14 that are extending in a connector plane 9 arranged in an angle A in relation to the section plane 8 and so that the connector plane 9 is intersecting the section plane 8 - so that the first sections 4 and the first connectors 6 together form at least part of the first flow channel 2. The planes 8 and 9 can be seen in fig. 4.

[0056] Between the first sections 4 is arranged a similar number of second sections 5 connected by means of second connectors 7 also arranged alternately as straight connectors 13 and angled connectors 14 to form at least part of the second flow channel 3.

[0057] In another embodiment the first flow channel 2 would only comprise straight connectors 13 and the second flow channel 3 would only comprise angled connectors 14 or vice versa.

[0058] In this embodiment the first flow channel 2 in one end comprises a first inflow port 15 provided with a first inflow channel 16 and in the other end comprises a first outflow port 17 provided with a first outflow channel 18. Likewise, the second flow channel 3 in one end comprises a second inflow port 19 provided with a second inflow channel 20 and in the other end of the channel 3 comprises a second outflow port 21 provided with a second outflow channel 22.

[0059] As previously explained the flow channels 2, 3 extend on both sides of a central wall 12. Thus, when a flow channel 2, 3 reach the end of one side it has to continue on the other side. In this embodiment the first flow channel 2 on the first side of the wall 12 is connected to the first flow channel 2 on the other side of the wall 12 by means of a first side connector 23 and the second flow channel 3 on the first side of the wall 12 is connected to the second flow channel 3 on the other side of the wall 12 by means of a second side connector 24.

[0060] In this embodiment the first side connector 23 connects a corner on the first side with the opposite corner on the opposite side - and likewise with the second side connector 24 - to ensure a better heat exchange between the fluids flowing through the respective channels 2, 3. However, in another embodiment the side connector 23, 24 could connect the channels 2, 3 at the same end of the heat exchanger 1 and/or at the same corner.

[0061] However, it is obvious to the skilled person that the connection between the sides could be made in a multitude of ways including - but not limited to - integrated channels in the central wall 12, holes through the central wall 12, a hose, a square pipe and other.

[0062] Figure 2 shows cross section through a heat exchanger 1, as seen from the side.

[0063] In this embodiment the first flow channel 2a-o is formed by metal U-shaped sections welded to a metal central wall 12. After the first sections 2a-o have been welded to the central wall 12 the first connectors 6 (not visible in this figure) are connected to the first sections 4 to form a continuous first flow channel 2. The first flow channel 2a-o is then pressure tested and if leaks are detected the leaks can easily be repaired since the second flow channel 3 has not been established yet. It is also possible to grind down the welding between the sections 4 and the central wall 12 - e.g. to provide the finish required in the food or pharmaceutical industry - before the second flow channel 3 is established.

[0064] After pressure testing the first flow channel 2, the second flow channel 3 is established by welding a lid 25 between the first sections 4 to form second sections 5 sharing the side walls with the first sections 4. However, the sections 4, 5 could be formed in a number of different ways e.g. by means of square pipes (no central plate needed), by means of lamella welded to a central plate or other.

[0065] In this embodiment the flow direction through the flow channels 2, 3 is indicated by the letters succeeding the position numbers 2 and 3 i.e. in the first flow channel 2 the fluid enters the heat exchanger 1 in section 2a where it at the end runs through a first connector 6 (not visible) and then runs back in the other direction in section 2b. This flow pattern continues until the fluid reaches section 2g where it leaves section 2g through the first side connector 23 and is is transported to section 2h from which the flow pattern continues until section 2o is reached where the fluid leaves section 2o. Likewise, the second fluid enters the second flow channel through the second inflow port 19 and continues through the second flow channel 3 in alphabetical order until it reaches section 3o where it leaves the heat exchanger 1. The flow path of the two fluids is arranged in this counterflow configuration to ensure a better and more efficient heat exchange between the two fluids but in another embodiment the flow paths could be arranged differently e.g. entirely or partly in the same direction.

[0066] In figure 2 it is also clearly illustrated that e.g. first section 2a abuts three second sections i.e. section 3o, 3g and 3n. In another embodiment the heat exchanger 1 could comprise further layers of sections 4, 5 so that at least some of the first sections 4 would abut four second sections 5.

[0067] Figure 3 shows a heat exchanger 1, as seen from the front, figure 4 shows a heat exchanger 1, as seen from the bottom and figure 5 shows a heat exchanger 1, as seen from the side.

[0068] In figure 4 the angle A between the section plane 8 and the connection plane 9 is clearly shown. In this embodiment the angle A is approximately 45° because in this angle the angled connectors 14 may pass the straight connectors 13 while still forming a relatively straight flow path for the fluid flowing through the angled connector 14 so that pressure drop is reduced. However, in another embodiment the angle A may be larger or smaller.

[0069] As shown in fig. 5 the straight connectors 13 are in this embodiment provided with cleaning holes 11 enabling access straight into the straight sections 4, 5 to which they are connected. During normal use of the heat exchanger these cleaning holes 11 will be covered by plug means (not shown).

[0070] In an embodiment of the present invention the heat exchanger 1 is used for transfer of heat between different media, in particular for heat exchanger in relation to preheating materials that are to be employed in a process for biogas production, such as liquid manure, industrial process water, sludge and/or ooze. The heat exchanger 1 has walls and comprises a first flow channel 2 positioned in thermal contact with a second flow channel 3 for heat exchange between a first fluid flowing in the first flow channel 2 and a second fluid flowing in the second flow channel 3. In many biogas systems the biological material entering the system has a low temperature and requires heating before entering process tanks operating at different temperatures. On the other hand, material from the process tanks may have a high temperature and requires a lowering of the temperature.

[0071] In the foregoing, the invention is described in relation to specific embodiments of heat exchangers 1, flow channels 2, 3, connectors 6, 7 and other as shown in the drawings, but it is readily understood by a person skilled in the art that the invention can be varied in numerous ways within the scope of the appended claims.

List

[0072]

1. Heat exchanger
2. First flow channel
3. Second flow channel
4. First section
5. Second section
6. First connector
7. Second connector
8. Section plane
9. Connection plane
10. Connection leg
11. Cleaning holes
12. Central wall
13. Straight connector
14. Angled connector
15. First inflow port
16. First inflow channel
17. First outflow port
18. First outflow channel
19. Second inflow port
20. Second inflow channel
21. Second outflow port
22. Second outflow channel
23. First side connector
24. Second side connector
25. Lid

A. Angle between section plane and connector plane

Claims

1. A heat exchanger (1) comprising a first flow channel

(2) positioned in thermal contact with a second flow channel (3) for heat exchange between a first fluid flowing in said first flow channel (2) and a second fluid flowing in said second flow channel (3), wherein said first flow channel (2) comprises a number of first sections (4) and said second flow channel (3) comprises a number of second sections (5), wherein a first section (4) of said first flow channel (2) abuts at least three of said second sections (5) of said second flow channel (3), wherein said first section (4) and a succeeding first section (4) of said first flow channel (2) are arranged on opposite sides of an intermediate second section (5) of said at least three second sections (5) of said second flow channel (3) and wherein said first section (4) and said succeeding first section (4) are connected by means of a first connector (6, 13) extending across the width of said intermediate second section (5) so that said first connector (6, 13) is extending substantially parallel with a section plane (8) formed by the general longitudinal extend of said first section (4) and said succeeding first section (4).

2. A heat exchanger (1) according to claim 1, wherein said intermediate second section (5) and a succeeding second section (5) are arranged on opposite sides of said succeeding first section (4) and wherein said intermediate second section (5) and said succeeding second section (5) are connected by means of a second connector (7, 14) extending across the width of said succeeding first section (4) in a connector plane (9) intersecting said section plane (8).

3. A heat exchanger (1) according to claim 2, wherein the angle (A) between said section plane (8) and said connector plane (9) is between 10° and 100°, preferably between 20° and 80° and most preferred between 30° and 60°.

4. A heat exchanger (1) according to one or more of the preceding claims, wherein substantially half of said first connectors (6) and said second connectors (7) are arranged to extend substantially parallel with said section plane (8) and the remaining connectors (6, 7) are arranged to substantially extend in said connector plane (9).

5. A heat exchanger (1) according to one or more of the preceding claims, wherein substantially half of said first connectors (6, 13) are arranged to extend substantially parallel with said section plane (8) and substantially half of said second connectors (7, 13) are arranged to extend substantially parallel with said section plane (8).

6. A heat exchanger (1) according to one or more of the preceding claims, wherein said first connector (6, 13) is arranged to substantially intersect the direction of the longitudinal extent of said intermediate second section (5).

7. A heat exchanger (1) according to claim 2, wherein said first connector (6, 13) partly extends between connection legs (10) of said second connector (7, 14).

8. A heat exchanger (1) according to one or more of the preceding claims, wherein said first sections (4) and said second sections (5) are formed with a square cross section.

9. A heat exchanger (1) according to one or more of the preceding claims, wherein said first sections (4) and said first connectors (6) substantially have the same cross section and/or wherein said second sections (5) and said second connectors (7) substantially have the same cross section.

10. A heat exchanger (1) according to one or more of the preceding claims, wherein connectors (6, 7, 13) arranged to extend substantially parallel with said section plane (8) comprise cleaning holes (11).

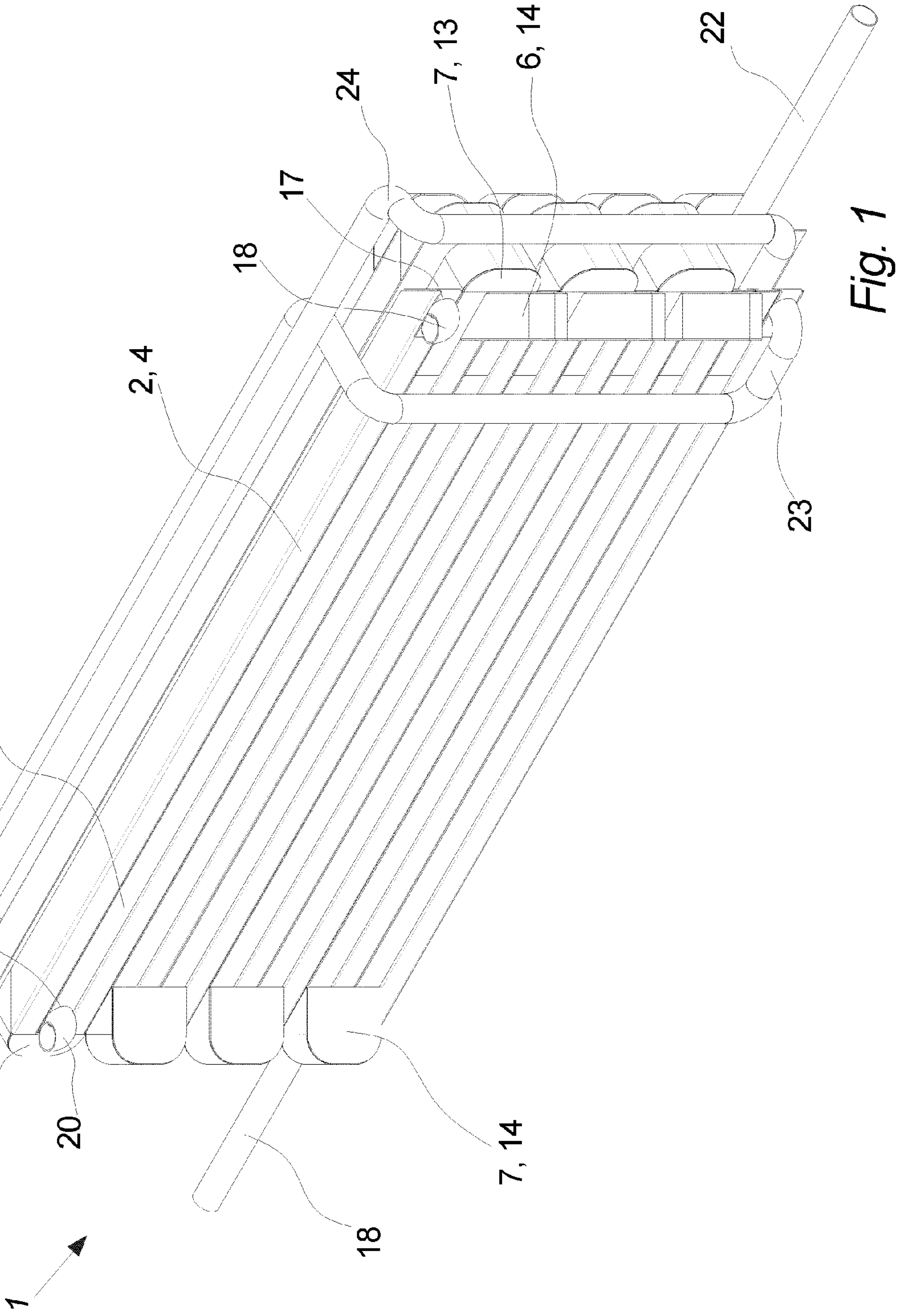
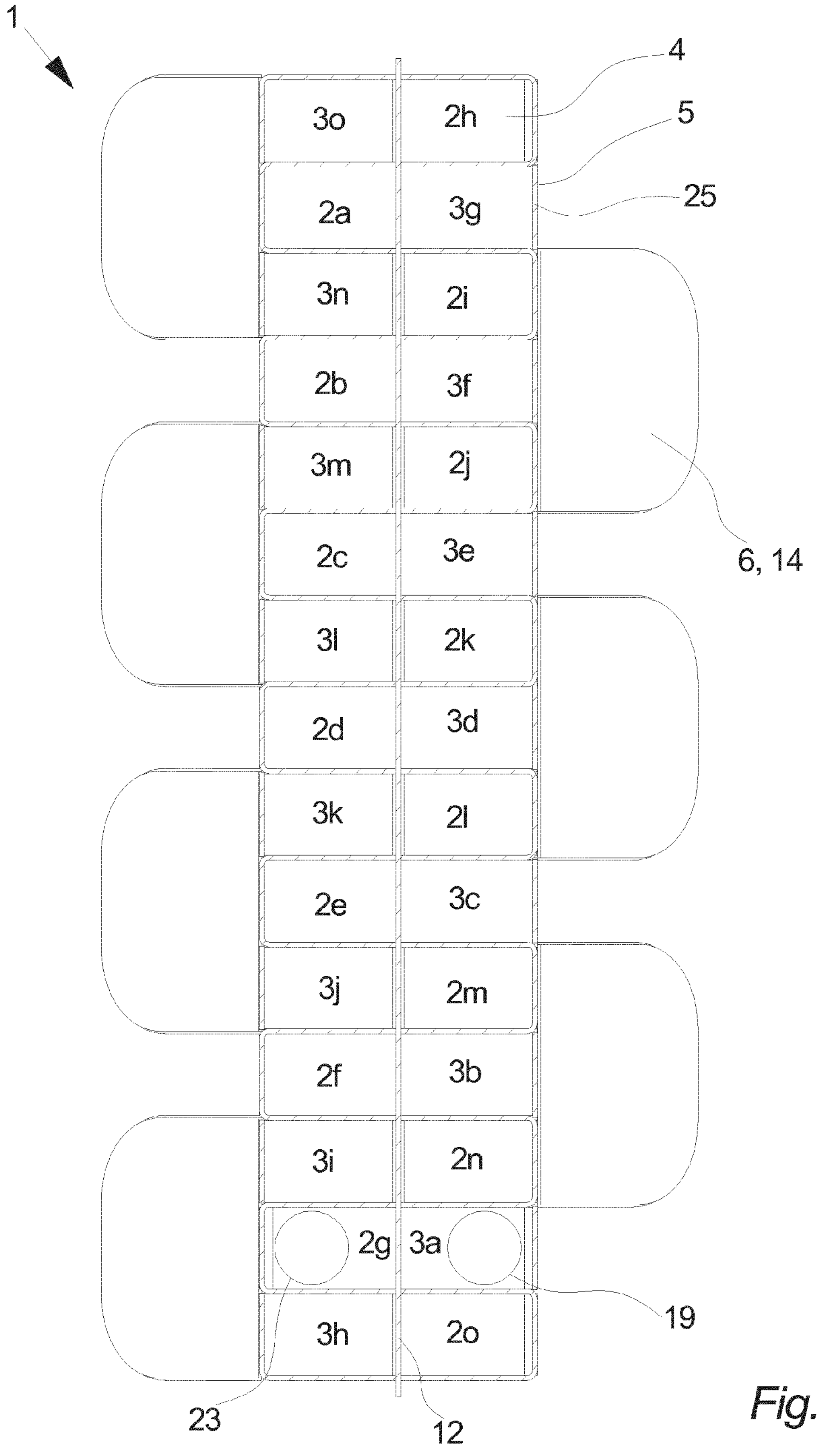


Fig. 1


1
4
5
25
3o
2h
2a
3g
3n
2i
2b
3f
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6, 14
2c
3e
3l
2k
2d
3d
3k
2l
2e
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2n
2g
3a
19
3h
2o
23
12

Fig. 2

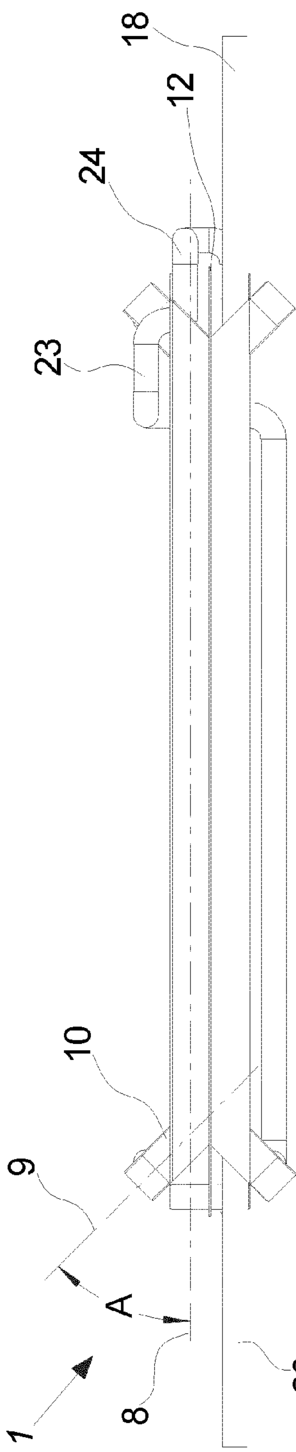

Fig. 4

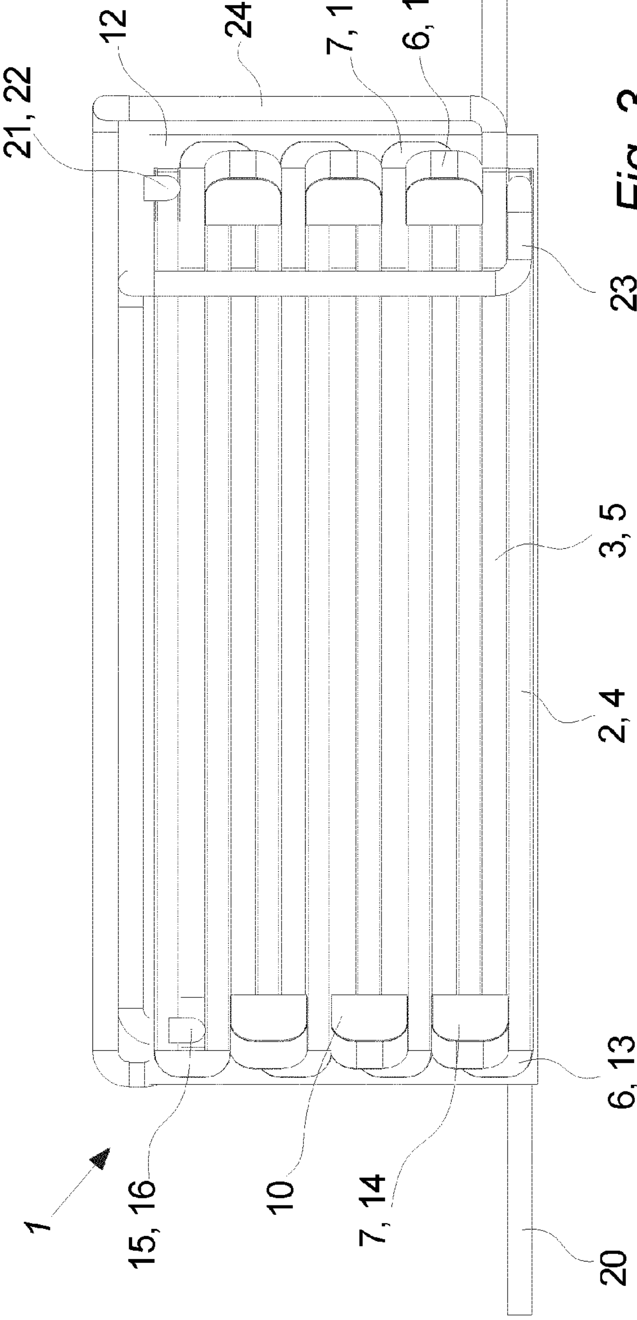

Fig. 3

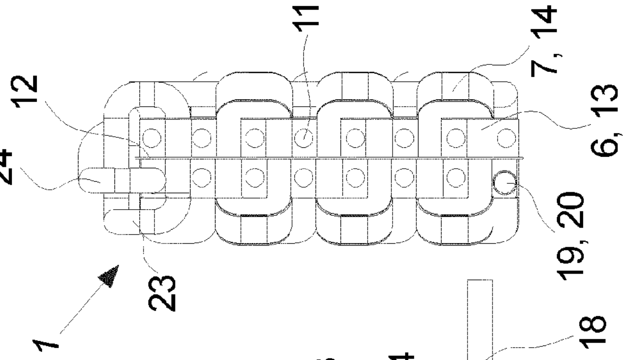

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 14 17 0927

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	7 October 2014	Vassoille, Bruno

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