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(54) **ENERGY EXCHANGE DEVICE BETWEEN MEDIA WITH IMPROVED STRUCTURE AND PERFORMANCES**

ENERGIEAUSTASUCHAPPARAT ZWISCHEN MEDIEN MIT VERBESSERTER STRUKTUR UND LEISTUNG

DISPOSITIF D'ECHANGE DE CHALEUR ENTRE FLUIDES AVEC STRUCTURE ET PERFORMANCE AMELIOREE

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(73) Proprietor: **Stamenic, Aleksandar**
15353 Sabac (RS)

(72) Inventor: **Stamenic, Aleksandar**
15353 Sabac (RS)

(74) Representative: **Vlahovic, Slobodan**
Radoja Dakica 35/32
11070 Beograd (RS)

(56) References cited:
EP-A2- 0 351 247
WO-A1-2015/063503
WO-A2-2009/024854
GB-A- 2 463 482
GB-A- 2 521 114
US-A- 3 212 571
US-A1- 2015 101 334

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Description

Field of invention

[0001] The invention generally belongs to the field of heat exchangers. According to the International Patent Classification (IPC Intel.), the present invention is classified and designated F28, a broader classification, which refers to heat exchange in general.

[0002] Since the invention is characterized by its structure, it can also be designated F28F - structural elements of devices for heat exchange and transfer for general application.

Technical problem

[0003] The inventors aimed to improve the thermal performances of the heat exchanger core, primarily in a way that the essential parameters of the working fluids can be easily controlled.

[0004] Furthermore, using such an improved heat exchanger core, the inventors have designed a heat exchanger that is easy to manufacture, use and maintain, suitable for use in a variety of commercial and residential premises, and in a variety of industries. Also, the inventors aimed to design a heat exchanger that has a smaller mass in relation to the existing heat exchangers of the same power and the same material.

Prior art

[0005] The inventors have consulted the patent databases and found that there are inventions of heat exchangers that include a structure that has helical tubes, a stepwise distance between the tubes, and a crossflow of fluids such as EP0351247 (A2) or US20100096115A1 - Multiple concentric cylindrical co-coiled heat exchanger or US3403727A - Crossflow countercurrent heat exchanger with inner and outer-tube sections made up of closely packed coaxially nested layers of helicoidally wound tubes. A device according to the preamble of claim 1 is disclosed in WO 2009/024854 A2.

[0006] Some other similar inventions such as US4893672A - Counter-flow heat exchanger with helical tube bundle or GB685848 (A) - Improvements relating to the construction of tubular heat exchangers do not include crossflow of fluids or a stepwise distance between the tubes. None of the previous patents contains a counterflow and a crossflow heat exchanger, made by winding helical tubes (coils) into each other through structural reinforcements, which are an integral part of the heat exchanger core and which enable stepwise/zigzag arrangement of coils and arrangement of tubes of each coil exactly in the middle position and at the same distance between the tubes of adjacent coils in the entire heat exchanger core and together they make the heat exchanger surface. Also, none of these patents discloses structural reinforcements that would be made so that their inner and outer edge correspond to the required coil pitch and that the inner edge additionally follows the angle of the coil on which they are placed and that the outer edge follows the angle of the next coil.

Summary of the present invention

[0007] The invention is defined in claim 1.

[0008] The present invention is a design solution of a counterflow and crossflow heat exchanger, made by winding helical tubes (coils) successively through structural reinforcements, which are an integral part of the heat exchanger core, and which enable stepwise/zigzag arrangement of coils, and arrangement of tubes of each coil exactly in the middle position and at the same distance between the tubes of adjacent coils in the entire heat exchanger core, and together they make the heat exchanger surface.

[0009] Structural reinforcements are made so that their inner and outer edge correspond to the required coil pitch and that the inner edge additionally follows the angle of the coil on which they are placed and that the outer edge follows the angle of the next coil.

[0010] Two fluids, the first fluid and the second fluid, can pass through this energy exchange device. Furthermore, this device may include a central router with conical extensions and structural reinforcement support, wherein a basic structural reinforcement on which the first helical coil is wound is placed on the central router having conical extensions on both sides, and wherein the central router is to direct the flow of the first fluid towards the coils and prevent the passage of the first fluid through the central part of the heat exchanger core, and wherein the conical extensions direct the flow of the first fluid as close as possible to the outer walls of the coils through which the second fluid moves. All odd- numbered coils (the first, the third, the fifth,...) are parallel to each other in both transverse and longitudinal planes of the heat exchange core, while also all even- numbered coils (the second, the fourth, the sixth,...) are parallel to each other in both transverse and longitudinal planes of the heat exchange core. The diameters of the d pipes from which all the coils are made are the same. Each coil in the heat exchanger core has a different diameter, wherein all coils have the same coil pitch, and each coil has a different thread angle. The structural reinforcements have a sinusoidal or wavy or wavy-zigzag shape, whereby the shape of the structural reinforcements represents bearings on which the coils move when wound into the heat exchanger core.

[0011] Structural reinforcements comprise an inner edge and an outer edge, wherein they correspond to the required coil pitch, and wherein the inner edge additionally follows the thread angle of the coil on which they are placed, and the outer edge follows the angle of the next coil, wherein the first coil has the diameter, the pitch and the thread angle of the first coil. The first structural reinforcement, which is placed on the first coil and follows the pitch, additionally follows the angle of the first coil with the inner edge, and with the outer edge, it follows the angle of the next second coil and so on till the last wound coil.

[0012] At least two structural reinforcements are placed on each coil in turn, and most preferably three or more, arranged at equal distances along the diameters of the coils with structural reinforcements placed on each subsequent coil so that they are not in the same plane with the structural reinforcements of the previous coil.

[0013] The basic structural reinforcements are connected by welding to the central router and each subsequent structural reinforcement to the next wound coil in turn in the heat exchanger core, where the structural reinforcements also enable stepwise or zigzag arrangement of coils, and the arrangement of tubes of each coil exactly in the middle position and at the same distance between the tubes of adjacent coils in the entire heat exchanger core, transverse to the second fluid. This energy exchange device may further comprise structural reinforcement supports, on which holes are drilled so that one end of the structural reinforcement is inserted into each hole, wherein each of the structural reinforcement supports has as many holes drilled both vertically and horizontally as necessary to place at least two structural reinforcements on each coil.

[0014] The advantage of the present invention is reflected in simple manufacture, improved thermal performances, simple control of essential parameters of the working fluids, easy modularity for application in commercial, residential premises, and in various industries, and easy modularity for smaller/higher powers.

Brief description of the drawings

[0015] The invention is described in detail on the example of the draft where:

Figure 1 - illustrates the manufacturing solution of the heat exchanger in trimetry
Figure 2- represents an orthogonal drawing of the present invention - top view
Figure 3- represents an orthogonal drawing of the present invention - front view
Figure 4- illustrates one cross-section with penultimate structural reinforcement
Figure 5- illustrates a shortened cross-section in trimetry
Figure 6- illustrates a shortened cross-section with the displayed last structural reinforcement
Figure 7- illustrates a detail of the position of the first and the second coil concerning the first structural reinforcement with the indicated angle of the coil Figure 8- illustrates a selected structural reinforcement
Figure 9- represents an orthogonal drawing - a cross-section of the first example with 8 coils
Figure 10- represents an orthogonal drawing - a front view of the first example with 8 coils
Figure 11- represents an orthogonal drawing - a cross-section of the first example with 8 coils
Figure 12- illustrates a side view of the first example with 8 coils
Figure 13- illustrates structural reinforcement support- with a cross-section of the first example with 8 coils in trimetry
Figure 14- illustrates the heat exchanger core with structural reinforcement supports-with a cross-section of the first example with 8 coils in trimetry
Figure 15- illustrates a partial cross-section of the heat exchanger core with structural reinforcement supports of the first example with 8 coils in trimetry
Figure 16- illustrates an enlarged sectional view of several coils with the indicated flow of the first fluid and the distance between the coils
Figure 17- illustrates an example of heat exchanger inlet and outlet reduction for standard working fluid connectors and application
Figure 18- illustrates an example of connecting several heat exchangers of lower power

A list of reference signs used in drawings

[0016]

101 - central router
102 - conical extension
103 - holes on the casing for the passage of tubes with expansions

104- heat exchanger core sheath
105- structural reinforcement support
1050- hole on the structural reinforcement support
106- shield
107- commutator (collector) of tubes with expansions 108- heat exchanger core vents
110- tubes with expansions (at the beginning and the end of each coil the same for all coils)
112- longitudinal axis
120- length of the heat exchanger core 130- diameter of the heat exchanger core
200- heat exchanger core
201- first coil (helical tube)
202- second coil
203 -third coil
204 -fourth coil
205-fifth coil
206-sixth coil
207-seventh coil
208-eighth coil
289-penultimate coil
290 - last coil
291-the inner edge of structural reinforcement
292- the outer edge of structural reinforcement
293- bulge
294 -recess
295- diameter of d pipe from which all coils are made
300- basic structural reinforcement
301- first structural reinforcement
302- second structural reinforcement
303- third structural reinforcement
304- fourth structural reinforcement
305- fifth structural reinforcement
306-sixth structural reinforcement
307- seventh structural reinforcement
308- eighth structural reinforcement
389- penultimate structural reinforcement
390- last structural reinforcement
320- the distance between coil tubes transverse to the second fluid
310- thickness of the material from which all structural reinforcements are made
311- wall thickness of tubes from which all coils are made
400- the flow of the first fluid
402- the flow of the second fluid
410- the inlet of the first fluid
420- the inlet of the second fluid
411- the outlet of the first fluid
421- the outlet of the second fluid
412- diameter of adjusted inlets and outlets of the first fluid for standard connectors
422- diameter of adjusted inlets and outlets of the second fluid for standard connectors
430- the first point
431- the second point
501- diameter of the first coil
589- diameter of the penultimate coil
590- diameter of the last coil
600- coil pitch
601- thread angle of the first coil
602- thread angle of the second coil
689- thread angle of the penultimate coil
690- thread angle of the last coil

Detailed description of the invention

[0017] The energy exchange device between media with improved structure and performances in one embodiment contains the following parts: sheath 104, shield 106, commutator (collector) 107, coils or helical tubes 201, 2012, 203, 204, 205, 206, 207, 208, 289, 290, tubes with expansions 110, central router 101 with conical extensions 102, structural reinforcements 300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390 and structural reinforcement support 105.

[0018] Usually, basic structural reinforcements 300 are placed on both sides of the central router 101 with conical extensions on which the first helical tube (coil) 201 will be wound. The task of the central router 101 ist to direct the flow of the first fluid 400 towards the coils 201, 202, 203, 204, 205, 206, 207, 208, 289, 290 and to prevent the passage of the first fluid 400 through the central part of the heat exchanger core 200. Conical extensions 102 direct the flow of the first fluid 400 as close as possible to the outer walls of the coils 201, 202, 203, 204, 205, 206, 207, 208, 289, 290 through which the second fluid moves 402. Central router 101 is made of pipes of a defined diameter to which conical extensions 102 are welded on both sides.

[0019] Coils of the heat exchanger core 200 are formed on the tools. A tool can be a cylinder of a defined diameter and length, made of plastic or metal with channels that correspond to the required coil and its characteristics, whereby helical tubes (coils) of given parameters are produced by turning the tool. All coils with an odd number e.g. 201, 203 to 289 are parallel in both transverse and longitudinal planes of the heat exchanger core 200. The same applies to even-numbered coils 202, 204, etc. The diameters of d pipes 295, from which all coils are made, are all the same. Each coil 201 to 289, 290 has a different diameter, and so is the diameter of the first coil 501, the diameter of the penultimate coil 589, and the diameter of the last coil 590 defined. All coils have the same coil pitch, but a different thread angle, so the first coil has a thread angle 601, the thread angle of the penultimate coil is 689, while the angle of the last coil is 690, therefore the tool is different for each coil. Coils can also be made on modified tools for pipe bending, e.g., three-cylinder, drum-like tools, and other tools known from the prior art. The pipes from which the coils are made can be made of copper, aluminum, stainless steel, dual metals, etc. The heat exchanger core 200 can be connected to the heating or cooling systems vertically or horizontally.

[0020] Structural reinforcements 300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390 enable coil winding into the heat exchanger core 200. Structural reinforcements 300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390 have a sinusoidal/wavy/wavy-zigzag shape. This form of structural reinforcements enables bearings on which the coils 201, 202, 203, 204, 205, 206, 207, 208, 289, 290 move when wound into the heat exchanger core 200. They are placed parallel to the longitudinal axis 112, and the inner edge 291 and the outer edge 292 are designed to fit the required coil pitch 600. Since the thread angle of coils 601, 689, 690 for each coil 201, 202, 203, 204, 205, 206, 207, 208, 289, 290 is different, all structural reinforcements are different, made so that the inner edge 291 additionally follows the thread angle of the coil on which they are placed, and the outer edge 292 follows the angle of the next coil. So the first coil 201 has a diameter 501, a thread pitch 600, a diameter of d pipe of which the coil 201 is made, a thread angle 601 and the first structural reinforcement 301, and so on for each subsequent coil successively. Likewise, the first structural reinforcement 301 placed on the coil 201 that follows the pitch 600, additionally follows the angle of the coil 601 for the first coil 201 with the inner edge 291 and with the outer edge 292 it follows the angle 602 of the next second coil 202 and so on to the last wound coil. At least two structural reinforcements 300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390 and most preferably three or more, arranged at equal distances along the diameters of the coils 201, 289,290 are placed on each coil in turn. On each subsequent coil, the structural reinforcements are placed so that they are not in the same plane as the reinforcements of the previous coil. The basic structural reinforcement 300 is connected by welding to the central router 101, and each subsequent structural reinforcement 301, 302, 303, 304, 305, 306, 307, 308, 389, 390 to the next wound coil in turn into the heat exchanger core 200. Structural reinforcements also enable a stepwise/zigzag arrangement of the coils and the arrangement of the tubes of each coil exactly in the middle position and at the same distance between the tubes 320 (transverse to the second fluid 402) of adjacent coils in the entire heat exchanger core 200. After placing the structural reinforcements on the last wound coil 289 or 290, a cylindrical sheath 104 of the heat exchanger is placed on them. The basic structural reinforcements 300 and the last structural reinforcements 390, can also be flat, without zigzag waves, and other aforementioned characteristics, and can be flush with the structural reinforcement of the next coil, which applies to the basic structural reinforcements 300, or with the structural reinforcement of the previous coil, which applies to the last structural reinforcements 390. Also, the coils 201,289,290 with their pair of structural reinforcements 301, 389, 390 in turn, can be welded, before being wound into the heat exchanger core 200, and then individually wound into the heat exchanger core successively.

[0021] Structural reinforcements ensure the stability of the entire heat exchanger core 200, reduction of vibrations, and a uniform distance between the coil tubes 320. They additionally increase the heat exchange surface and together with the coils they form the total exchange surface. Other modifications are also possible in the way of bonding structural reinforcements besides welding e.g. soldering, gluing, etc.

[0022] Structural reinforcements are most preferably made of the same type of material as the coils. Structural reinforcements are made of full section materials, strips, wires, etc., or capillary tubes (microchannel tubes). They are made in their molds or are being cut, for example by laser cutting, to obtain a specific shape that ensures that the coils are easily wound, successively, into the heat exchanger core. The thickness 310 of the material from which the structural reinforcements are made is one of the reasons that affect the size (interspace-gap) of the distance 320. Each structural reinforcement has the same thickness 310 of the material from which it is made. By changing the thickness 310 of their material, the size of the distance 320 decreases or increases, but always ensures a stepwise/zigzag arrangement of coils, and the arrangement of tubes of each coil exactly in the middle position and at the same distance 320 between the tubes of adjacent coils in the entire heat exchanger core 200.

[0023] To avoid welding or gluing of structural reinforcements, all structural reinforcements can be inserted into symmetrical supports 105. Figures 9 to 15 show examples of the heat exchanger core 200 with supports 105 with eight coils 201 to 208. All structural reinforcements that are inserted into the supports 105 are made according to the previously described principle. Each of the supports 105 is, most preferably, made of two identical pipes or round bars with a full section, which are welded at their centers at right angles. Structural reinforcements are inserted between the supports 105 in the holes 1050 drilled therein. In the above example, the last structural reinforcement is the eighth structural reinforcement 308. The supports 105 are made of the same type of material as the central router 101, with a diameter not larger than the diameter of the d coil pipe 295. Each of the supports 105 has as many holes drilled both vertically and horizontally as necessary to place at least two structural reinforcements on each coil. The supports 105 can be welded to the central router 101 before welding its conical extensions 102. After inserting all structural reinforcements into the supports 105, Figures 9 to 11 show, coils 201 to 208 being rotated in turn, forming the heat exchanger core 200. Also, structural reinforcements can be inserted into the supports 105 individually in turn, after winding each coil.

[0024] Based on the required power of the heat exchanger core 200, type, speed, and temperature of working fluids 400 and 402, and the required pressure drop of working fluids, the length 120 and the diameter 130 of the heat exchanger core are determined, the diameter of d pipe 295 for making coils, wall thickness 311 of pipes from which coils are made, the diameter of the first coil 501 to the diameter of the last coil 590 in turn, the number of coils and the required distance 320 are defined. By changing the coil pitch 600 and structural reinforcements, while retaining the aforementioned principle and the characteristics of their manufacture, the distance 320 is easily regulated, which enables simple control of the desired fluid pressure drop 400. The length of each coil depends on the diameter of each coil, as well as the length 120 of the core itself.

[0025] Example 2: Example of an optimized heat exchanger according to the present invention for a required power of 1850W air-water:

Basic parameters for manufacturing a heat exchanger core

First fluid 400:

air

0.0934	[kg/s] mass flow of the first fluid 400
32.0000	[C] inlet temperature of the first fluid 400

Second fluid 402:

water

4.8300	[lt/min] second fluid flow 402
8.0000	[C] inlet temperature of the second fluid 402

The required pressure drop of the first fluid is 80 Pa and of the second fluid 6 kPa

An optimized heat exchanger core according to the present invention: technical characteristics of the manufacture

d=	0.0050	[m] outer diameter of d pipes from which the coils are made
TW=	0.0005	[m] Wall thickness of pipes 311 from which coils are made
D=	0.2255	[m] Wall thickness of pipes 311 from which coils are made
L=	0.1150	[m] Length 120 of the heat exchanger core
Cn=	22.00	Total number of coils

Heat exchanger =4.7 [kg]

core weight	made of copper
Distance	320 Lg = 0.003m

[0026] The following essential parameters were obtained:

79.38	[Pa] Pressure drop of the first fluid 400
5842.15	[Pa] Pressure drop of the second fluid 402
10.0884	[C] mean temperature difference through the heat exchanger core 200
169.1566	[W/m2*K] mean heat transfer coefficient
1848.7731	[W] Thermal power extracted from the first fluid 400

[0027] All the aforementioned constructional and functional characteristics of the invention and the described example have been successfully tested by the inventor on the developed prototype. By changing the described geometrical parameters-technical characteristics of the heat exchanger core manufacture, it is possible to apply it to residential facilities (of lower power) as well as commercial facilities (of higher power) and various industry branches for cooling, heating, or recovery systems.

[0028] In the described example of the optimized heat exchanger core of small dimensions and lightweight, a high heat capacity (1850 W) is achieved, which enables a simple and flexible installation in a small space.

[0029] To facilitate coil winding into the heat exchanger core 200, each is cut at its beginning and end in such a way that all coils of the heat exchanger core reach the same normal plane on axis 112. At the beginning and end of each coil, tubes 110 with expansions of the same length are then placed on each coil individually. Holes 103 for the passage of tubes 110 with expansions that further enter straight into the commutator (collector) 107 are drilled on sheath 104. Tubes with expansions 110 can be welded, glued, etc., to coils. Shield 106 is placed between the core sheath 104 and the tubes with expansions 110 to prevent the first fluid 400 flow outside the heat exchanger core 200. Tubes with expansions 110 are most preferably made of the same material and diameter of d pipe 295 as the coils and are widened at one end where they will be drawn on the coils with standard pipe expansion tools. The commutator (collector) 107 additionally has openings 108 for venting the heat exchanger core 200.

[0030] The first fluid 400 moves around the coils and the second fluid 402 through the coils. The inlet 410 of the first fluid 400 concerning the inlet 420 of the second fluid 402 is located on the opposite side of the heat exchanger core, whereby the fluids move in opposite directions. Thus, the temperature difference in the entire heat exchanger core 200 is big and the heat exchange on the entire device is high. The first fluid 400 further moves approximately perpendicularly (crosswise/ normally) concerning the axis of the coil tube. In this arrangement coils greatly interfere with the flow of the first fluid 400, so there is continuous turbulence of the first fluid 400 around the coils. This enhances the heat exchange but also increases the pressure drop of the first fluid 400. Since the coils are arranged stepwise (stepwise arrangement of coils) in the heat exchanger core by placing in their bearings on structural reinforcements, the tubes of each coil are exactly in the middle position and at the same distance 320 (transverse to the second fluid 402) between the tubes of adjacent coils, the first fluid 400 is forced to move near the walls of the coil tubes.

[0031] In a stepwise arrangement, the tube of, e.g., the fifth coil 205, as shown in Figure 16, is located exactly in the middle position between the adjacent tubes of the fourth coil 204 and the sixth coil 206. The flow of the first fluid 400, which passes between the fourth coil 204 and the sixth coil 206 directly strikes the tube of the fifth coil 205. The flow of the first fluid 400, which passes between the fourth coil 204 and the sixth coil 206 does not release or receive sufficient heat because it is located in the middle of the passage between the fourth coil 204 and the sixth coil 206, at the first point 430. But it further passes near the pipe wall of the fifth coil 205 at the second point 431, where a lot of heat is released or received.

[0032] The heat transfer can be improved by reducing the distance from the pipe walls to the first fluid 400, i.e., by reducing the distance 320. If the distance 320 is very small, the flow of the first fluid 400 is forced to pass very closely to the pipe walls, therefore is the heat transfer higher. Basically, the thermal resistance of the flow of the first fluid 400 is proportional to the distance 320, so the heat transfer rate is proportional to the inverse length of the distance 320 between the coil tubes: $\tilde{Q} \propto Lg^{-1}$

[0033] However, if the distance 320 between the coils is too small, the first fluid 400 is forced to pass through narrow passages, so more mechanical work is necessary to overcome the resistance, i.e., there is an increase in pressure drop of the first fluid 400 through the heat exchanger core 200. This is an undesirable effect because part of the pressure is lost. The pressure drop of the first fluid 400 increases proportionally to the inverse cubic of the distance 320, i.e., $\triangle P_{\mathrm{fluidsS}} \propto L_g^{-3}$.

[0034] The above-mentioned method of the present invention manufacture achieves the maximum heat exchange for the default pressure drop of the first fluid 400. This design enables the manufacture of an axial helical countercurrent (of opposite direction) and crossflow heat exchanger core 200, and a stepwise arrangement of coils, which is simply made by winding helical tubes (coils) successively over structural reinforcements, thus achieving high heat performances and simple control of the most important parameters.

[0035] An additional advantage of the present heat exchanger core 200 is the mechanism of "self-cleaning" of the interior of the coils. Scale, other sediments, and contaminants inside the coils cause a localized increase in the speed of the second fluid 402, which increases the "pushing" of the impurity by friction between the second fluid 402 and the impurity, in such a way the inner surface of the coil cleans "itself".

[0036] The diameters 412 of the inlet of the first fluid 410 and the outlet of the first fluid 411, as well as the diameter 422 of the inlet of the second fluid 420 and the outlet of the second fluid 421 of the heat exchanger core, as shown in Figure 17, can be reduced or increased for connection to standard connectors.

[0037] The increase of the required power of the present invention can also be accomplished by binding lower powers of the heat exchanger core 200 made according to the same principle.

[0038] Figure 12 shows an example of binding multiple heat exchanger cores 200 of lower powers made according to the present invention to provide a single higher power heat exchanger. Figure 9 shows an embodiment of the heat exchanger core 200 in section with 8 coils 201, 202, 203, 204, 205, 206, 207, 208 so that it can be seen that first comes the basic structural reinforcement 300, then the first coil 201, then the first structural reinforcement 301 on it, and then the second coil 202, which is placed in the recesses 294, and on the bulges 293 of the first structural reinforcement 301 comes the third coil 203 on which comes the third structural reinforcement 303 on which comes the fourth coil 204, which is placed in the recess 294 of the third structural reinforcement 303, and on the bulges 293 of the third structural reinforcement 303 comes the fifth coil 205 on which comes the fifth structural reinforcement 305, and on it the sixth coil 206, which is placed in the recesses 294, and on the bulges 293 of the fifth structural reinforcement 305 comes the seventh coil 207, on which comes the seventh structural reinforcement 307, and on it the eighth coil 208, which is placed in the recesses 294 of that seventh structural reinforcement 307, and on the eighth coil 208 comes the last eighth structural reinforcement 308.

Industrial or other application forms of the invention

[0039] The present invention can be industrially applied in commercial, residential premises, and various branches of industry. Figure 11 illustrates one of the applications of the invention in the automotive industry on a complete heat exchanger for cooling (intercooler) highly compressed hot air, where its purpose is to lower the air temperature with as little pressure loss as possible.

[0040] Although the present invention has been described in the most preferred embodiment, to allow a better understanding of the invention, we should bear in mind that various modifications are possible.

[0041] Also, any design improvements or alterations, that would be within the scope of the claims are considered to be covered by this application.

Claims

1. The counterflow and crossflow energy exchange device between media with improved structure and performances, that contains coils (201, 202, 203,204, 205, 206, 207, 208, 289, 290) made from tubes and structural reinforcements (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390), wherein the coils (201, 202, 203, 203, 204,205, 206, 207, 208, 289, 290) and structural reinforcements (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) form the heat exchanger core (200), and wherein the coils (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) are successively wound over structural reinforcements (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390), wherein the coils have a stepwise/zigzag arrangement, and wherein the arrangement of the tubes of each coil is exactly in the middle position and at the same distance between the tubes of adjacent coils in the entire heat exchanger core (200) wherein the first fluid (400) and the second fluid (402) can pass through said energy exchange device, **characterized in that** it further comprises a central router (101) with conical extensions (102), structural reinforcement support (105) and a basic structural reinforcement (300), wherein a basic structural reinforcement (300) is placed on both sides of the central router (101) having conical extensions (102) to which the first helical coil is wound (201), and wherein the central router (101) directs the flow of the first fluid (400) towards the coils (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) and prevents the passage of the first fluid (400) through the central part of the heat exchanger core (200), and wherein the conical extensions (102) direct the flow of the first fluid (400) to the outer walls of the coils (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) through which the second fluid (402) moves.

2. The energy exchange device, as claimed in the previous patent claim, **characterized in that** all the odd-numbered coils (201, 203, 205, 207, 289) are parallel to each other in both transverse and longitudinal planes of the heat exchanger core (200), and all the even-numbered coils (202 204, 206, 208, 290) are also mutually parallel in both transverse and longitudinal planes of the heat exchanger core (200).

3. The energy exchange device, as claimed in any of the previous patent claims, **characterized in that** the diameters of d pipes (295), from which all coils are made, are the same.

4. The energy exchange device, as claimed in any of the previous patent claims, **characterized in that** each coil (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) in the heat exchanger core (200) has a different diameter (501, 589, 590), wherein all coils have the same coil pitch (600), and wherein each coil (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) has a different thread angle (601, 689, 690).

5. The energy exchange device, as claimed in any of the previous patent claims, **characterized in that** the structural reinforcements (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) have a sinusoidal or wavy or wavy-zigzag shape, wherein the shape of the structural reinforcements forms the bearings on which the coils move (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) when wound into the heat exchanger core (200).

6. The energy exchange device, as claimed in claim 5, **characterized in that** the structural reinforcements (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) comprise an inner edge (291) and an outer edge (292), which correspond to the required coil pitch (600), and wherein the inner edge (291) additionally follows the thread angle of the coil (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) on which they are placed, and the outer edge (292) follows the angle of the next coil, wherein the first coil (201) has a diameter of the first coil (501), a coil pitch (600) and a thread angle of the first coil (601).

7. The energy exchange device, as claimed in claim 6, **characterized in that** the first structural reinforcement (301), which is placed on the first coil (201) and follows the pitch (600), additionally follows the angle of the first coil (601) with the inner edge (291), and with the outer edge (292) it follows the angle of the next second coil (602), and so on to the last wound coil.

8. The energy exchange device, as claimed in any of the previous patent claims, **characterized in that** at least two structural reinforcements (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) or three structural reinforcements or more are placed on each coil (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) in turn, arranged at equal distances along the diameters of the coils (201, 202, 203, 204, 205, 206, 207, 208, 289, 290), whereby structural reinforcements are placed on each subsequent coil so that they are not in the same plane with the structural reinforcements of the previous coil.

9. The energy exchange device, as claimed in any of the previous patent claims, **characterized in that** the basic structural reinforcements (300) are connected by welding to the central router (101), and each subsequent structural reinforcement (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) is connected to the next wound coil in turn into the heat exchanger core (200), wherein there is a stepwise or zigzag arrangement of the coils, and the arrangement of the tubes of each coil is exactly in the middle position and at the same distance between the tubes (320) of the adjacent coils in the entire heat exchanger core (200), transverse to the second fluid (402).

10. The energy exchange device, as claimed in any of the previous patent claims, **characterized in that** it comprises structural reinforcement supports (105), on which holes (1050) are drilled so that one end of the structural reinforcement is inserted into a single hole (1050), wherein each of the structural reinforcement supports (105) has as many perforated holes both vertically and horizontally as necessary to place at least two structural reinforcements on each coil.

Patentansprüche

1. Gegenstrom- und Querstrom-Energieaustauschvorrichtung zwischen Medien mit verbesserter Struktur und Leistung, **dadurch gekennzeichnet, dass** sie Spulen (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) enthält, die aus Rohren und strukturellen Verstärkungen (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) hergestellt sind, wobei die Spulen (201, 202, 203, 203, 204, 205, 206, 207, 208, 289, 290) und strukturelle Verstärkungen (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) bilden den Wärmetauscherkern (200), wobei die Spulen (201,

202, 203, 204, 205, 206, 207, 208, 289, 290) nacheinander über strukturelle Verstärkungen (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) gewickelt sind, wobei die Spulen eine stufenweise/zickzackförmige Anordnung (201, 202, 203, 204, 205, 206, 207, 208, 289, 290), und wobei die Anordnung der Rohre jeder Spule genau in der mittleren Position und im gleichen Abstand zwischen den Rohren benachbarter Spulen in dem gesamten Wärmetauscherkern (200) liegt, wobei das erste Fluid (400) und das zweite Fluid (402) durch die Energieaustauschvorrichtung strömen können, ferner umfassend einen zentralen Fräser (101) mit konischen Verlängerungen (102), einer strukturellen Verstärkung (105) und einer grundlegenden strukturellen Verstärkung (300), wobei eine grundlegende strukturelle Verstärkung (300) auf beiden Seiten des zentralen Routers (101) mit konischen Verlängerungen (102) platziert ist, an die die erste spiralförmige Spule (201) gewickelt ist, und wobei der zentrale Router (101) die Strömung des ersten Fluids (400) in Richtung der Spulen (201) lenkt, 202, 203, 204, 205, 206, 207, 208, 289, 290) und verhindert den Durchgang des ersten Fluids (400) durch den zentralen Teil des Wärmetauscherkerns (200), und wobei die konischen Verlängerungen (102) den Durchfluss des ersten Fluids (400) zu den Außenwänden der Spulen (201, 202, 203, 204, 205, 206, 207) leiten, 208, 289, 290), durch die sich das zweite Fluid (402) bewegt.

2. Energieaustauschvorrichtung, wie im früheren Patentanspruch beansprucht, **dadurch gekennzeichnet, dass** alle ungeraden Spulen (201, 203, 205, 207, 289) sowohl in der Querals auch in der Längsebene des Wärmetauscherkerns (200) parallel zueinander sind und alle geradzahligen Spulen (202, 204, 206, 208, 290) ebenfalls sowohl in der Quer- als auch in der Längsebene des Wärmetauscherkerns (200) zueinander parallel sind.

3. Energieaustauschvorrichtung, wie in einem der früheren Patentansprüche beansprucht, **dadurch gekennzeichnet, dass** die Durchmesser der d-Rohre (295), aus denen alle Spulen hergestellt sind, gleich sind.

4. Energieaustauschvorrichtung, wie in einem der früheren Patentansprüche beansprucht, **dadurch gekennzeichnet, dass** jede Spule (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) im Wärmetauscherkern (200) einen unterschiedlichen Durchmesser (501, 589, 590) aufweist, wobei alle Spulen die gleiche Spulenteilung (600) aufweisen und wobei jede Spule (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) hat einen anderen Fadenwinkel (601, 689, 690).

5. Energieaustauschvorrichtung, wie in einem der früheren Patentansprüche beansprucht, **dadurch gekennzeichnet, dass** die strukturellen Verstärkungen (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) eine sinusförmige oder wellenförmige oder wellenförmige oder wellenförmige Zickzackform aufweisen, wobei die Form der strukturellen Verstärkungen die Lager bildet, auf denen sich die Spulen bewegen (201, 202, 203, 204, 205, 206, 207, 208, 289, 290), wenn sie in den Wärmetauscherkern (200) eingewickelt sind.

6. Energieaustauschvorrichtung nach Anspruch 5, **dadurch gekennzeichnet, dass** die strukturellen Verstärkungen (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) eine Innenkante (291) und eine Außenkante (292) umfassen, die der erforderlichen Spulensteigung (600) entsprechen, und wobei die Innenkante (291) zusätzlich dem Gewindewinkel der Spule (201, 202, 203, 204, 205, 206, 207, 208, 289, 290), auf denen sie platziert sind, und die Außenkante (292) dem Winkel der nächsten Windung folgt, wobei die erste Windung (201) einen Durchmesser der ersten Windung (501), eine Windungssteigung (600) und einen Gewindewinkel der ersten Windung (601) aufweist.

7. Energieaustauschvorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** die erste strukturelle Verstärkung (301), die auf die erste Spule (201) aufgesetzt ist und der Steigung (600) folgt, zusätzlich dem Winkel der ersten Spule (601) mit der Innenkante (291) folgt und mit der Außenkante (292) dem Winkel der nächsten zweiten Spule (602) folgt, und so weiter bis zur letzten gewickelten Spule.

8. Energieaustauschvorrichtung, wie in einem der früheren Patentansprüche beansprucht, **dadurch gekennzeichnet, dass** mindestens zwei strukturelle Verstärkungen (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) oder drei strukturelle Verstärkungen oder mehr nacheinander auf jeder Spule (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) angebracht sind, in gleichen Abständen entlang der Durchmesser der Windungen (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) angeordnet sind, wobei strukturelle Verstärkungen auf jeder nachfolgenden Windung so platziert sind, dass sie sich nicht in derselben Ebene mit den strukturellen Verstärkungen der vorherigen Windung befinden.

9. Energieaustauschvorrichtung, wie in einem der früheren Patentansprüche beansprucht, **dadurch gekennzeichnet, dass** die grundlegenden strukturellen Verstärkungen (300) durch Schweißen mit dem zentralen Router (101) verbunden sind und jede nachfolgende strukturelle Verstärkung (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) wiederum mit der nächsten gewickelten Spule in den Wärmetauscherkern (200) verbunden ist, wobei eine

stufenweise oder zickzackförmige Anordnung der Spulen vorliegt und die Anordnung der Rohre jeder Spule genau in der mittleren Position und im gleichen Abstand zwischen den Rohren (320) der benachbarten Spulen im gesamten Wärmetauscherkern (200) quer zur zweiten Flüssigkeit (402) liegt.

10. Energieaustauschvorrichtung, wie sie in einem der früheren Patentansprüche beansprucht wird, **dadurch gekennzeichnet, dass** sie strukturelle Verstärkungsstützen (105) umfasst, auf denen Löcher (1050) gebohrt sind, so dass ein Ende der strukturellen Verstärkung in ein einzelnes Loch (1050) eingeführt wird, wobei jede der strukturellen Verstärkungsstützen (105) sowohl vertikal als auch horizontal so viele perforierte Löcher aufweist, wie erforderlich sind, um mindestens zwei strukturelle Verstärkungen auf jeder Spule zu platzieren.

Revendications

1. Dispositif d'échange d'énergie à contre-courant et à flux croisé entre milieux à structure et performances améliorées, **caractérisé en ce qu'**il contient des bobines (201, 202, 203,204, 205, 206, 207, 208, 289, 290) constituées de tubes et de renforts structurels (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390), dans lequel les bobines (201, 202, 203, 203, 204,205, 206, 207, 208, 289, 290) et les renforts structurels (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) forment le noyau de l'échangeur de chaleur (200), et dans lequel les serpentins (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) sont successivement enroulés sur des renforts structurels (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390), dans lequel les serpentins ont une disposition en gradins/en zigzag (201, 202, 203, 204, 205, 206, 207, 208, 289, 290), et dans lequel la disposition des tubes de chaque bobine est exactement en position médiane et à la même distance entre les tubes des bobines adjacentes dans l'ensemble du noyau de l'échangeur de chaleur (200) dans lequel le premier fluide (400) et le second fluide (402) peuvent passer à travers ledit dispositif d'échange d'énergie, comprenant en outre une toupie centrale (101) avec des extensions coniques (102), un support de renfort structurel (105) et un renfort structurel de base (300), dans lequel un renfort structurel de base (300) est placé des deux côtés de la toupie centrale (101) ayant des extensions coniques (102) auxquelles la première bobine hélicoïdale est enroulée (201), et dans lequel la toupie centrale (101) dirige l'écoulement du premier fluide (400) vers les bobines (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) et empêche le passage du premier fluide (400) à travers la partie centrale du noyau de l'échangeur de chaleur (200), et dans lequel les extensions coniques (102) dirigent l'écoulement du premier fluide (400) vers les parois extérieures des serpentins (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) à travers lequel se déplace le second fluide (402).

2. Le dispositif d'échange d'énergie, tel que revendiqué dans la revendication de brevet antérieure, se **caractérise en ce que** toutes les bobines impaires (201, 203, 205, 207, 289) sont parallèles les unes aux autres dans les plans transversal et longitudinal du noyau de l'échangeur de chaleur (200), et que toutes les bobines paires (202 204, 206, 208, 290) sont également mutuellement parallèles dans les plans transversal et longitudinal du noyau de l'échangeur de chaleur (200).

3. Le dispositif d'échange d'énergie, tel que revendiqué dans l'une quelconque des revendications de brevet antérieures, **caractérisé en ce que** les diamètres des tuyaux d (295), à partir desquels toutes les bobines sont fabriquées, sont les mêmes.

4. Dispositif d'échange d'énergie, tel que revendiqué dans l'une quelconque des revendications de brevet antérieures, **caractérisé en ce que** chaque bobine (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) du noyau de l'échangeur de chaleur (200) a un diamètre différent (501, 589, 590), dans lequel toutes les bobines ont le même pas de bobine (600), et dans lequel chaque bobine (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) a un angle de filetage différent (601, 689, 690).

5. Dispositif d'échange d'énergie, tel que revendiqué dans l'une quelconque des revendications de brevet antérieures, **caractérisé en ce que** les renforts structurels (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) ont une forme sinusoïdale ou ondulée ou ondulée en zigzag, la forme des renforts structurels formant les appuis sur lesquels les bobines se déplacent (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) lorsqu'il est enroulé dans le noyau de l'échangeur de chaleur (200).

6. Dispositif d'échange d'énergie, selon la revendication 5, **caractérisé en ce que** les renforts structurels (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) comprennent un bord intérieur (291) et un bord extérieur (292), qui correspondent au pas de bobine requis (600), et dans lequel le bord intérieur (291) suit en outre l'angle de filetage de la bobine (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) sur lesquels ils sont placés, et le bord extérieur

(292) suit l'angle de la bobine suivante, dans lequel la première bobine (201) a un diamètre de la première bobine (501), un pas de bobine (600) et un angle de filetage de la première bobine (601).

7. Dispositif d'échange d'énergie, selon la revendication 6, **caractérisé en ce que** le premier renfort structurel (301), qui est placé sur la première bobine (201) et suit le pas (600), suit en outre l'angle de la première bobine (601) avec le bord intérieur (291), et avec le bord extérieur (292) il suit l'angle de la seconde bobine suivante (602), et ainsi de suite jusqu'à la dernière bobine enroulée.

8. Le dispositif d'échange d'énergie, tel que revendiqué dans l'une quelconque des revendications du brevet antérieur, **caractérisé en ce qu'**au moins deux renforts structurels (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) ou trois renforts structurels ou plus sont placés sur chaque bobine (201, 202, 203, 204, 205, 206, 207, 208, 289, 290) à tour de rôle, disposés à des distances égales le long des diamètres des bobines (201, 202, 203, 204, 205, 206, 207, 208, 289, 290), de sorte que des renforts structurels sont placés sur chaque bobine suivante de sorte qu'ils ne soient pas dans le même plan que les renforts structurels de la bobine précédente.

9. Le dispositif d'échange d'énergie, tel que revendiqué dans l'une quelconque des revendications de brevet antérieures, **caractérisé en ce que** les renforts structurels de base (300) sont reliés par soudage à la toupie centrale (101), et que chaque renfort structurel ultérieur (300, 301, 302, 303, 304, 305, 306, 307, 308, 389, 390) est relié à son tour à la bobine enroulée suivante dans le noyau de l'échangeur de chaleur (200), dans lequel il y a une disposition par étapes ou en zigzag des serpentins, et la disposition des tubes de chaque bobine est exactement en position médiane et à la même distance entre les tubes (320) des bobines adjacentes dans l'ensemble du noyau de l'échangeur de chaleur (200), transversalement au second fluide (402).

10. Dispositif d'échange d'énergie, tel que revendiqué dans l'une quelconque des revendications de brevet antérieures, **caractérisé en ce qu'**il comprend des supports de renfort structurel (105), sur lesquels des trous (1050) sont percés de sorte qu'une extrémité de l'armature structurelle est insérée dans un seul trou (1050), dans lequel chacun des supports de renfort structurel (105) comporte autant de trous perforés à la fois verticalement qu'horizontalement que nécessaire pour placer au moins deux renforts structurels sur chaque bobine.

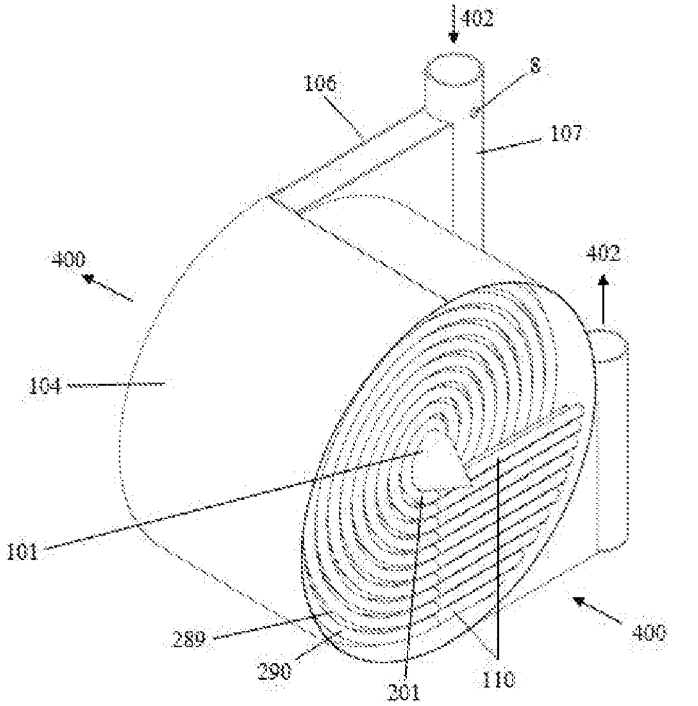


Figure 1.

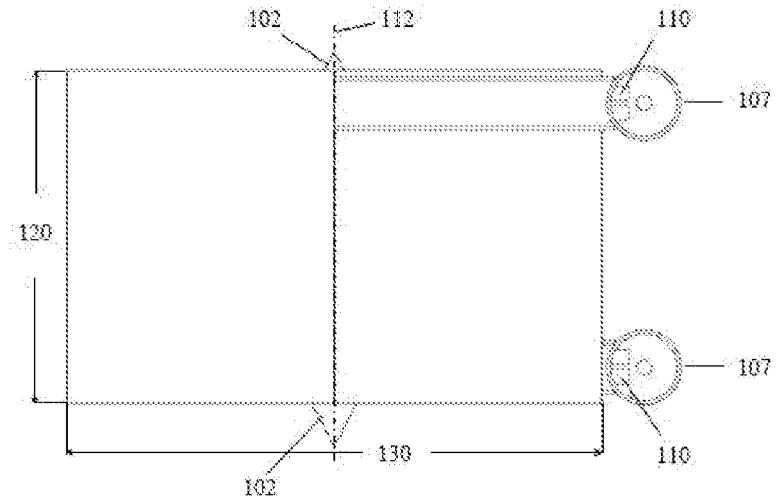


Figure 2.

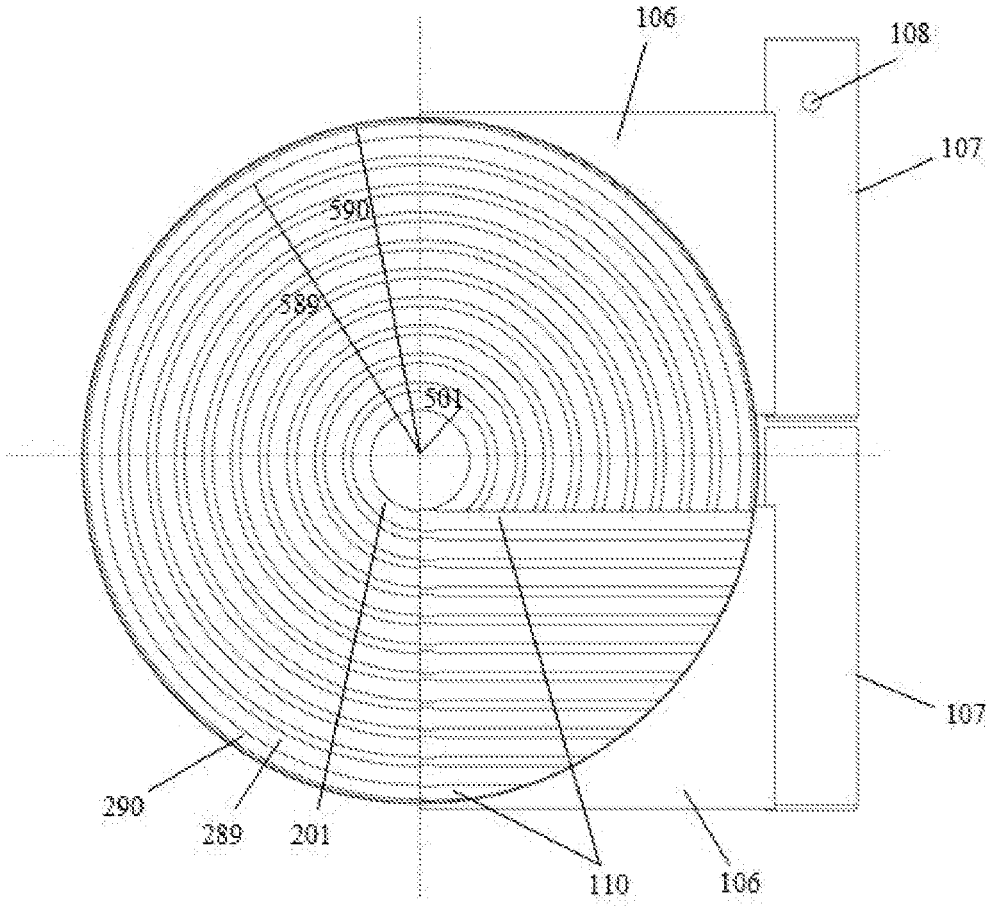


Figure 3.

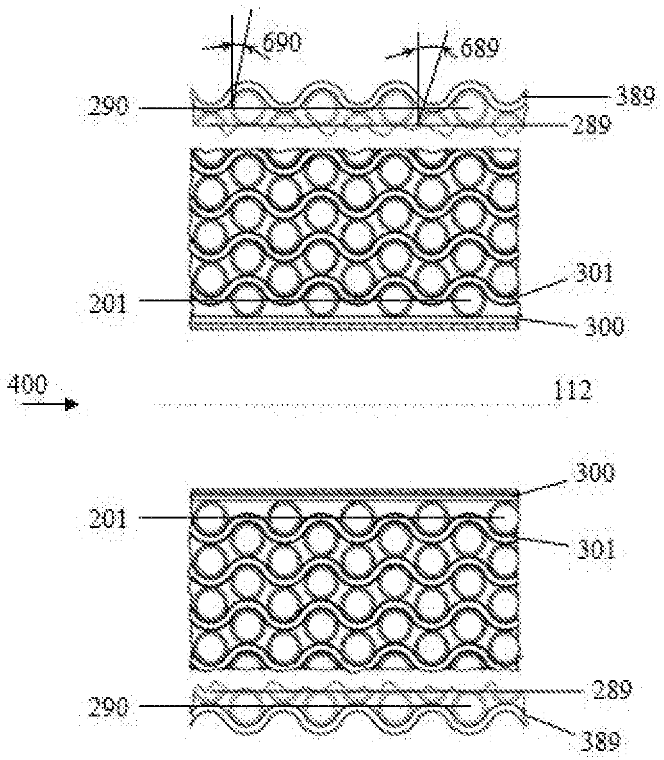


Figure 4.

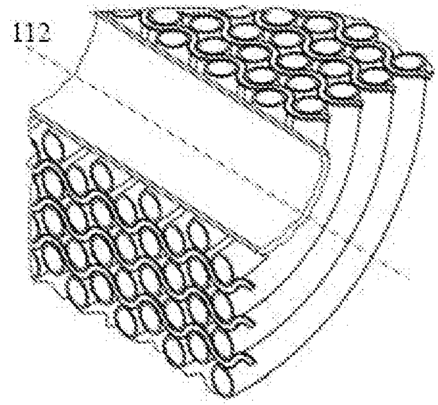
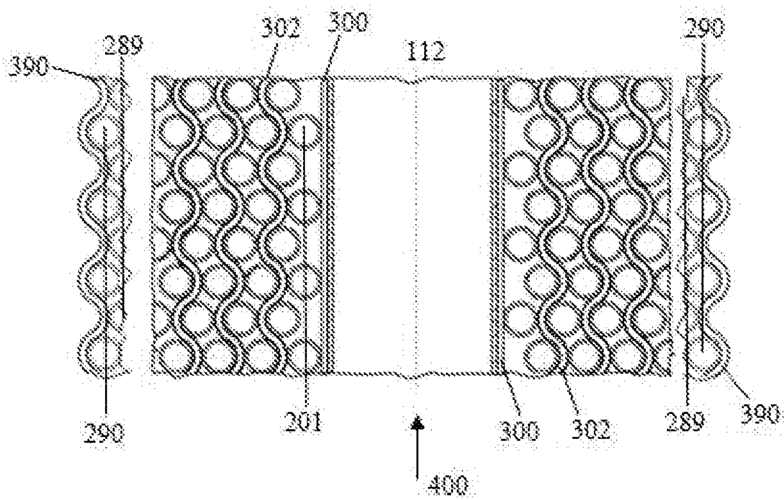


Figure 5.



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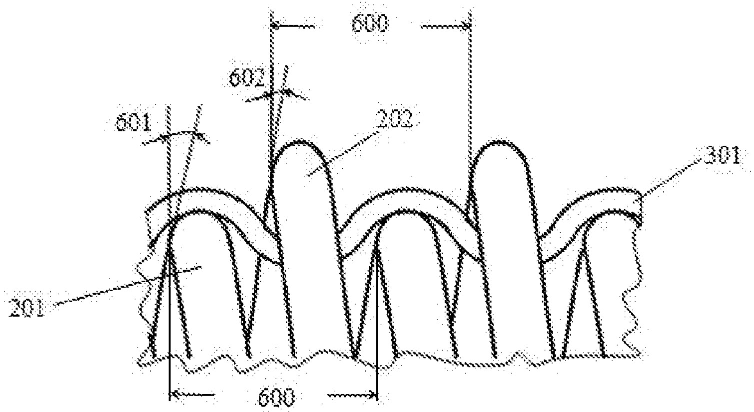

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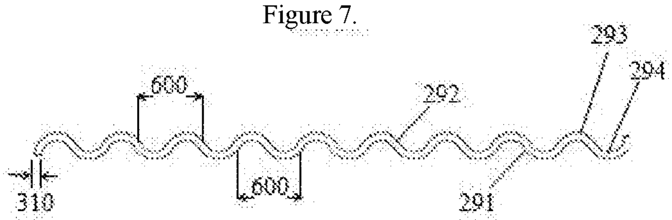

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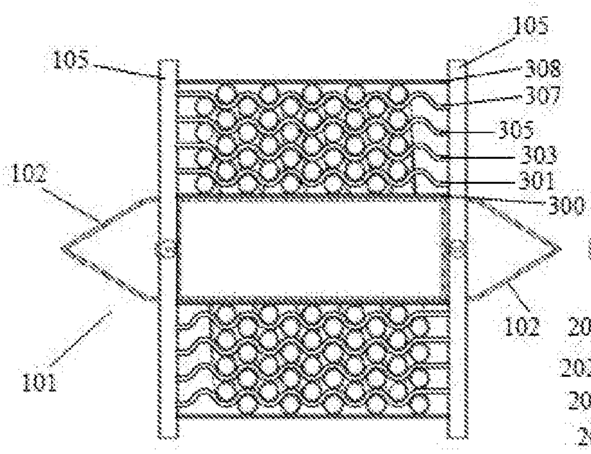


Figure 9.

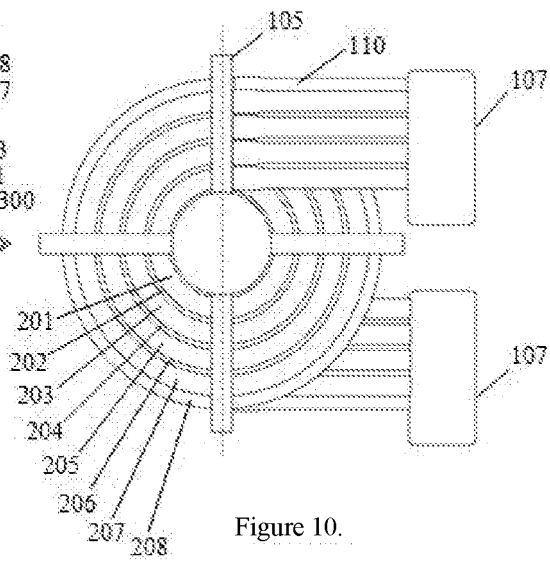
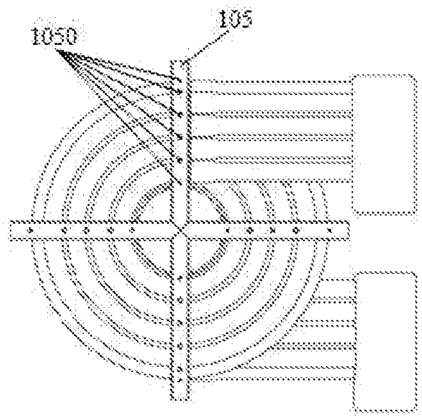


Figure 10.



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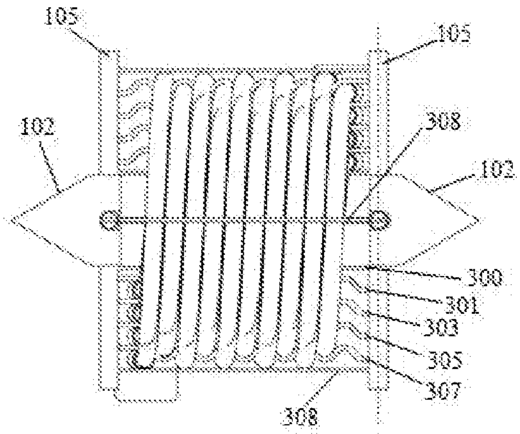

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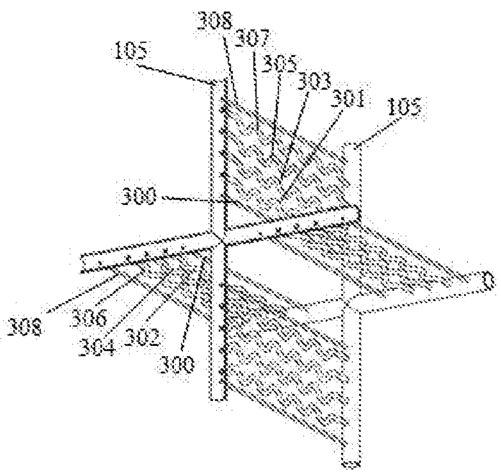

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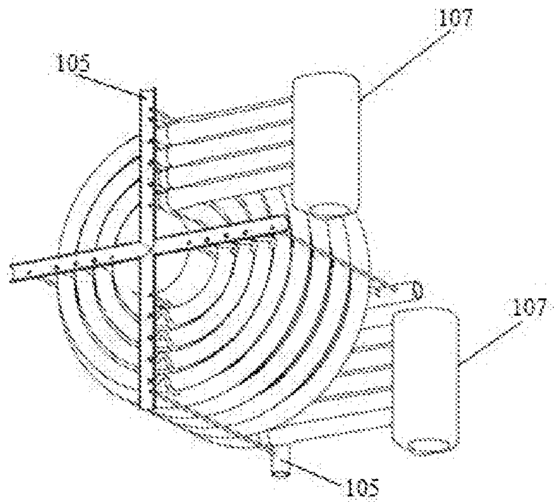

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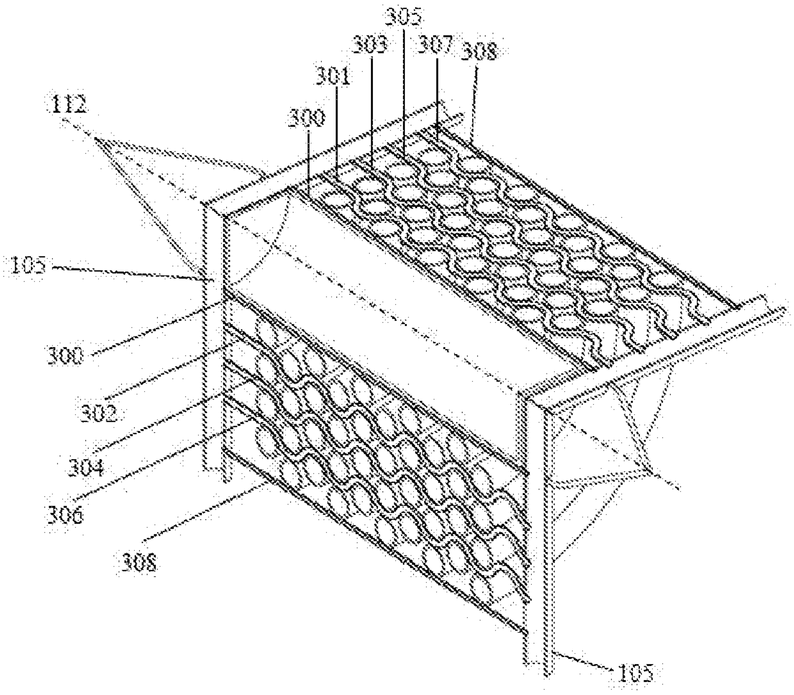

Figure 15.

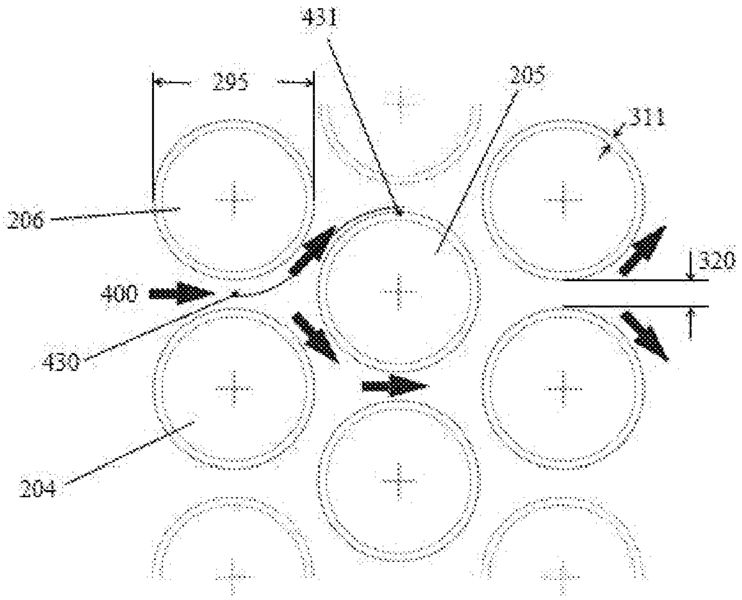

Figure 16.

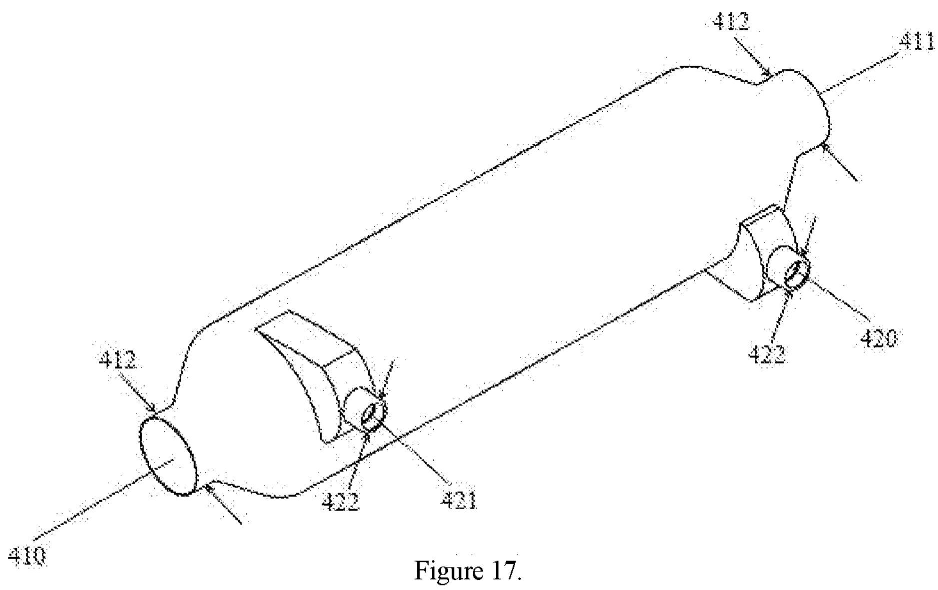

Figure 17.

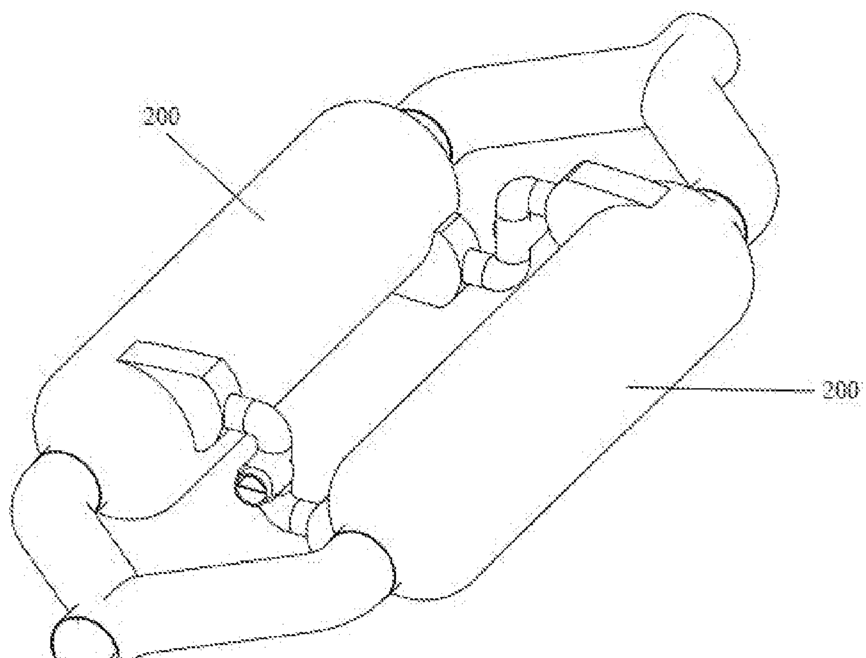

Figure 18.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0351247 A2 **[0005]**
- US 20100096115 A1 **[0005]**
- US 3403727 A **[0005]**
- WO 2009024854 A2 **[0005]**
- US 4893672 A **[0006]**
- GB 685848 A **[0006]**