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(54) **REMOVABLE TUBE HEAT EXCHANGER AND HEADER PLATE**

LÖSBARES ROHR FÜR WÄRMETAUSCHER UND ENDPLATTE

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EP-A- 0 481 178 **DE-C- 891 994**
FR-A- 418 770 **US-A- 2 468 924**
US-A- 4 344 478

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EP 1 097 347 B1

Description

[0001] The present invention is directed to a heat exchanger as defined in the preamble of claim 1.

[0002] Such a heat exchanger is known from FR-A-418 770.

[0003] Heat exchangers typically are formed of a plurality of tube and fin assemblies, the ends of which extend through apertures in opposed header plates. A heating or cooling fluid, e.g., oil, air, etc. flows through the tubes. The tube and fin assemblies must be able to withstand system operating pressures without leaking. Elastomeric seals are sometimes used within the apertures in the header plates to seal the tube within the header plate thus forming a tube to header plate joint. FR-A-418 770 describes such an elastomeric seal in an aperture with a non-uniform diameter at at least three locations, wherein the seal engages shoulders formed by these non-uniform diameters.

Also DE-C-891 994 discloses an elastomeric seal in an aperture of a header plate with non-uniform diameters.

[0004] Some heat exchanger designs allow the tube and fin assemblies to be removable such that a damaged tube can be replaced without dismantling an entire heat exchanger. According to the prior art heat exchangers, the tubes are removed by raising a first end of a tube into the first of two header plates via a first aperture having a cylindrical seal along the entire length of the header plate opening until the second end of the tube clears the second of two header plates. The second end of the tube is swung outwardly to clear the edge of the second header plate and the tube, which is now angled relative to the first header plate, is then pulled from the first header plate, freeing it from the heat exchanger. Prior art aperture and seal designs allow an elastomeric seal to seat within the first header plate in order to seal the tube during heat exchanger operation, and also allow angular movement of a tube for removal and installation from the header plates. See, US Patent 3,391,732, US Patent No. 4,344,478, US Patent No. 4,216,824, US Patent 4,930,568, 5,433,268. However, prior art aperture and seal designs do not optimize the ability of the heat exchangers to withstand high operating pressures while also allowing easy removal and installation of individual heat exchanger tubes. Accordingly, it is an object of the present invention to provide an aperture and seal configuration to improve the ability of a heat exchanger to withstand high operating pressures while also allowing easy removal and installation of individual heat exchanger tubes. It is an additional object of the present invention to provide a heat exchanger header plate which reduces or wholly overcomes some or all of the difficulties inherent in prior known heat exchangers having field removable heat exchanger tubes such as pressure capabilities, seal integrity, and overall heat exchanger life expectancy.

[0005] The invention reaches these objects by providing a header plate for a heat exchanger of the above-mentioned type, characterized in that the diameter at each location is sufficiently large enough to accommodate insertion of a flow tube into the aperture at an insertion angle α to the longitudinal axis L to allow insertion and removal of a flow tube from the heat exchanger without disassembling a frame of the heat exchanger, where α is greater than zero degrees.

[0006] Embodiments of the present invention may be used to advantageously provide a heat exchanger having advantageous pressure capabilities while facilitating the removal and installation of individual heat exchange tubes without disassembling the frame of the heat exchanger. The heat exchangers of the present invention include at least a top tank having a top header plate, a bottom tank having a bottom header plate, a frame work connecting the top and bottom tanks, apertures in the top and bottom header plates, seals and flow tubes configured to withstand system operating pressure. In accordance with one aspect of the present invention more fully described with reference to the Figures, the top header plate includes a plurality of apertures with each aperture having a nonuniform diameter of the interior aperture wall, for example, as determined at at least two, three or four locations from one end of the aperture to the other. The diameters of the aperture, and thus the wall of the aperture itself, are configured to allow a flow tube to be inserted into or removed from a heat exchanger frame via the aperture at an insertion angle. The insertion angle is defined as the angle at which the flow tube is inserted into or removed from the aperture and is determined in part by the length of the flow tube, the distance between top and bottom header plates and the direction of insertion of the flow tube into the aperture. The insertion angle must be sufficient to allow the flow tube to be inserted into the top header plate while avoiding contact with the bottom header plate. In this manner the flow tube can be inserted up into the aperture in the top header plate and then lowered into a corresponding aperture in the bottom header plate. The aperture, therefore, has a tolerance for the angled movement of a flow tube relative to its normal position when installed between header plates, i.e. the configuration of the wall of the aperture allows for the angled movement of the flow tube during removal or installation.

[0007] According to one embodiment, a seal is fixedly provided at a point within the aperture, such as the seal being retained within a groove within the wall of the aperture. According to an additional embodiment, differing diameters of the wall of the aperture provide shoulders which support the seal and retain the seal within the aperture upon installation and removal of the flow tube and also provide support for the seal during high or low pressure operation of the heat exchanger. According to one embodiment, the aperture has a groove within the interior wall of the aperture which fixedly retains the seal with the diameter of the aperture on either side of the seal being capable of allowing the angled insertion and removal of the flow tube. The flow tube protrudes at least into the header plate and engages the seal which is seated between the flow tube and the header plate. In a certain embodiment, the flow tube may also protrude

beyond the header plate. As previously stated, the aperture has a diameter or other configuration sufficient to provide a tolerance to angled movement of the flow tube through the aperture. In this manner, the aperture may have one or more diameters greater than the diameter of the flow tube along a given axis. The seal also has a diameter or other configuration or dimension sufficient to engage the flow tube in a manner to allow high pressure operation of the heat exchanger when the flow tube is approximately perpendicular to the header plate yet allows angled movement of the flow tube through the aperture, i.e. the seal also has dimensions sufficient to allow it to be compressed to a certain design compression when the tube is fully inserted into the aperture and brought perpendicular to the header plates.

[0008] In accordance with an additional aspect of the present invention, a header plate for a heat exchanger has one or more circular apertures through the plate wherein each aperture has at least two differing diameters within the header plate. Alternatively, the aperture may have as many as three or four diameters represented by adjacent sections or portions with the diameter of each section or portion being the same as or different from another section or portion. The words "section" and "portion" are used interchangeably herein. According to one nonlimiting example, the header plate has an aperture with a first portion having a first diameter. The first portion is designed so that its diameter is sufficiently large to allow a flow tube to be inserted at an angle to the centerline of the aperture as a whole without interference detrimental to the condition of the flow tube or header plate. The first portion also provides support for one face of the seal. A second portion of the aperture having a second diameter is adjacent the first portion, with the second diameter being larger than the first diameter. The second portion retains the seal and allows the seal to be compressed to a design compression when the tube is fully inserted and brought to the approximate perpendicular. A third portion of the aperture having a third diameter is adjacent the second portion, with the third diameter being smaller than the second diameter. The third portion provides support for a second face of the seal and is also sufficiently large in diameter to allow the flow tube to be inserted at an angle to the centerline of the aperture as a whole without interference. A fourth portion having a fourth diameter is adjacent the third portion, with the fourth diameter being sufficiently large in diameter to allow the flow tube to be inserted at an angle to the centerline of the aperture as a whole without interference. Alternatively, the fourth portion can be of a conical design with a diameter gradually increasing toward the tank side of the header plate. According to one embodiment of the present invention, the diameters of the first, third, and fourth portions of the aperture progressively increase in diameter to allow the flow tube to be inserted at an angle to the centerline of the aperture as a whole.

[0009] From the foregoing disclosure, it will be readily apparent to those skilled in the art, that is, those who are knowledgeable or experienced in this area of technology, that the present invention provides a significant technological advance. Preferred embodiments of the heat exchanger header plate of the present invention can provide improved sealing and higher operating pressures while allowing heat exchanger tubes mounted therein to be individually removable, for example without dismantling the heat exchanger. These and additional features and advantages of the invention disclosed here will be further understood from the following detailed disclosure of certain preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Certain preferred embodiments are described in detail below with reference to the appended drawings wherein:

Fig. 1 is a schematic perspective view, shown partially broken away, of tube and fin assemblies of a heat exchanger of the present invention mounted in opposed header plates;

Fig. 2 is a schematic elevation view, shown partially in section, of a tube and fin assembly being removed from the heat exchanger of Fig. 1;

Fig. 3 is a schematic section view of an aperture in the header plate of Fig. 1;

Fig. 4 is a schematic section view of a tube and fin assembly being removed the header plate of Fig. 1;

Fig. 5 is a schematic section view of an alternative embodiment of a tube and fin assembly of Fig. 1, shown mounted in a header plate with a dust seal and cupped washer; and

Fig. 6 is a cross-sectional view of alternate seal designs useful in the present invention.

[0011] The figures referred to above are not drawn necessarily to scale and should be understood to present a representation of the invention, illustrative of the principles involved. Some features of the heat exchanger header plate depicted in the drawings have been enlarged or distorted relative to others to facilitate explanation and understanding. The same reference numbers are used in the drawings for similar or identical components and features shown in various alternative embodiments. Heat exchanger header plates as disclosed herein, will have configurations and components determined, in part, by the intended application and environment in which they are used.

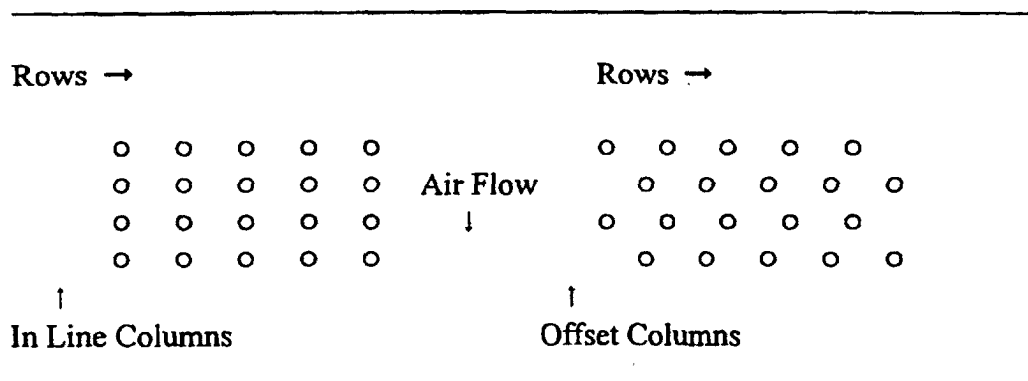
DETAILED DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

[0012] Referring to Fig. 1, a heat exchanger according to the present invention is shown partially cut away as it would be used to cool hot oil generated in the use of industrial machinery, e.g., a hydraulic transmission (not shown), and is referred to generally by the reference numeral 2. In a typical application, hot oil would flow through the inside of the flow tubes, while a cooling fluid such as air or other suitable cooling fluid would contact the outside fin section of the flow tube. It is to be understood, however, that the heat exchanger is not limited to use in cooling hot oil in industrial machinery, and may easily be used with other fluids or gases in other fields. For example, embodiments of the present invention find application in heat exchangers such as radiators used to cool an engine where coolant, such as water or antifreeze, flows through the flow tubes and fluid such as air or a suitable liquid can be used to flow around the exterior of the flow tubes. For convenience, the terms "upper" and "lower" are used herein to differentiate between the upper and lower ends of the heat exchanger and particular elements. It is to be appreciated that "upper" and "lower" are used only for ease of description and understanding and that they are not intended to limit the possible spatial orientations of the heat exchanger or its components during assembly or use.

[0013] Heat exchanger 2 comprises a plurality of flow tubes 4 having a plurality of fin elements or fins 6 secured to an exterior surface thereof. Tubes 4 are mounted at a first or upper end 8 to a first or upper header plate 10 and at a second or lower end 12 to a second or lower header plate 14. Upper and lower header plates 10, 14 are fixed with respect to one another by a frame of heat exchanger 2 (not shown). Examples of tube and fin element designs useful in the present invention are shown in US Patent Nos. 4,570,704; 4,344,478; 4,216,824; 3,391,732; 5,433,268; and 5,236,045 each of which are hereby incorporated by reference in its entirety for all purposes.

[0014] Heat exchangers within the scope of the present invention include those having a plurality of heat exchanger tubes arranged in columns and rows, and interconnected to receive and pass a heating/cooling fluid (dependent upon application).

[0015] The rows extend longitudinally across the heat exchanger, substantially perpendicular to the direction of air or other external fluid flow, and the columns are substantially perpendicular to the rows. The columns, for example, may be "in-line" or "off set" as shown below (top view of tube-and-fin assemblies):



[0016] It is to be understood that alternate off set designs are within the scope of the present invention such as where tube-and-fin assemblies of every fourth row are aligned.

[0017] In a preferred embodiment, several rows of tubes 4 extend between upper and lower header plates 10, 14 forming columns. An upper end 8 of each tube 4 extends into an aperture 16 in upper header plate 10 and a lower end 12 extends into aperture 18 in lower header plate 14. Liquid flows from a first or upper tank 17 (seen in Fig. 2) above upper header plate 10 through tubes 4 into second or lower tank 19 (seen in Fig. 2) below lower header plate 14 where it then flows back to the machinery which generates the heated oil.

[0018] As shown in Fig. 1 and according to one embodiment of the present invention, a tube retainer 20 is mounted on first end 8 of each tube 4 proximate upper header plate 10. It is to be understood that tube retainer 20 is not be required for all applications of the present invention, especially those applications where a tube retainer is not necessary or desired, and accordingly certain embodiments of the present invention do not include a tube retainer. To the extent a tube retainer is desired, one embodiment of a tube retainer is as shown in 20 as a substantially C-shaped arcuate body and a plurality of planar, rectangular protruding portions 21 extending radially from the periphery of the arcuate body. Tube retainer 20 serves to hold tube 4 firmly in place within upper header plate 10 and also serves to deflect air toward fins 6. Further description of this one embodiment of a tube retainer 20 is found in U.S. Patent No. 4,344,478, the contents of which are incorporated herein by reference. It is to be understood that alternate embodiments of the

tube retainer useful in the present invention will become apparent to those skilled in the art based upon the disclosure herein. Examples of tube stays or alignment mechanisms if desired in the practice of the present invention are disclosed in US Patent No. 4,216,824, US Patent No. 4,570,704 and copending application serial no. 60/117,817 hereby incorporated by reference in its entirety.

[0019] As seen in Fig. 1, a first cap washer 22 is positioned between and abuts upper header plate 10 and tube retainer 20. A second cap washer 24 is positioned between and abuts tube retainer 20 and uppermost fin 6 or a shoulder on tube 4 (not shown). A third cap washer 26 is positioned between and abuts lower header plate 14 and a lowermost fin 6 or shoulder on tube 4 (not shown). As with the tube retainer described above, it is to be understood that the cap washers shown in Fig. 1 are not required for all applications of the present invention, especially those applications where a cap washer is not necessary or desired, and accordingly certain embodiments of the present invention do not include cap washers. In addition, the use of cap washers is by way of example only, and other configurations of washers or components performing the function of washers will become apparent to those of ordinary skill in the art based upon the present disclosure.

[0020] Some heat exchangers are designed so as to allow tubes 4 to be removable without the need for disassembling the frame of heat exchanger 2. This can allow quick replacement of damaged or worn tubes while minimizing the associated costs. To remove a tube 4 from heat exchanger 2, as seen in the embodiment illustrated in Fig. 2, tube retainer 20 is removed from tube 4. Upper end 8 of tube 4 is then pushed upwardly through aperture 16 of upper header plate 10 until lower end 12 is above lower header plate 14. Lower end 12 is then swung outwardly at an angle of α in the direction of arrow K or other suitable direction until it is free of lower header plate 14 and heat exchanger 2. Tube 4 is then removed from heat exchanger 2 by pulling downwardly on tube 4 until upper end 8 is free of upper plate 10. A new tube 4 can then be inserted by reversing the steps outlined above.

[0021] The upper and lower ends 8, 12 of tube 4 are exposed to system fluid at operating pressure in upper and lower tanks 17, 19, formed in part by the upper and lower header plates respectively, and, therefore, the high pressure side of the heat exchanger is that area above upper header plate 10 and below lower header plate 14. Correspondingly, the portion of tube and fin assembly 2 between the header plates which is exposed to air is considered the low pressure side. As used herein, the term "tube side" refers to the low pressure side of upper and lower header plates 10, 14 respectively, that is, the area of the upper and lower header plates typically exposed to the air and not exposed directly to the high pressure fluid in the upper and lower tanks 17, 19. Accordingly, the term "tank side" refers to the high pressure side of upper and lower header plates 10, 14, that is the area of the upper and lower header plates 10 and 14 exposed to the high pressure fluid in the upper and lower tanks 17, 19.

[0022] The construction of aperture 16 is shown in more detail in Fig. 3. Aperture has longitudinal axis L. The diameter of aperture 16 is nonuniform along longitudinal axis L, that is, it is nonuniform throughout upper header plate 10. Instead, as shown in Fig. 3, the aperture 16 has at least two different portions and preferably, has four different portions along its length, each having a diameter which may be the same or different from an adjacent portion. The tube side, or first portion 30 has a first diameter A. In certain embodiments such as that shown in Fig. 3, the tube side edge 31 of first portion 30 is beveled or, alternatively, rounded at an angle. It is to be understood that the beveling of certain portions of the aperture wall, such as those portions shown in Fig. 3, is not be required for all applications of the present invention, especially those applications where beveling is not necessary or desired, and accordingly certain embodiments of the present invention do not include the beveling at the one or more location shown in Fig. 3. According to those certain embodiments, the locations where beveling is indicated in Fig. 3 would instead be squared edges. The next portion adjacent first portion 30 is second portion 32, and has a second diameter B which is larger than diameter A. A shoulder 34 is formed between first and second portions 30, 32. Third portion 36 is adjacent second portion 32 and has a diameter C which is smaller than diameter B and typically larger than diameter A. A shoulder 38 is formed between second and third portions 32, 36. The fourth portion 40 which is immediately tank side is adjacent third portion 36 and has a diameter D which is larger than diameter C. As shown in Fig. 3, edge 42 of fourth portion 40 is beveled or, alternatively, rounded as is edge 44 of fourth portion 40.

[0023] Turning now to Fig. 4, the interaction of tube 4 with aperture 16 during removal and installation of tube 4 can be seen more clearly. A seal 50 surrounds tube 4 and is contained within second portion 32. Seals according to the present invention include those having differing sizes and shapes. For example, seals having a circular cross-section are useful within the scope of the present invention, such as those seals commonly known as "O-rings." Other useful seals include those having a square or rectangular cross-section or a cross-section resembling that of an "X," as shown in Fig. 6. Other suitable seal shapes will become apparent to those skilled in the art based upon the disclosure presented herein and the configuration of the particular aperture, flow tube and chamber within which the seal is seated. The seals may be fashioned from any suitable elastomeric material capable of withstanding operating pressures and temperatures of a given heat exchanger. Useful seals are also resistant to degradation by fluids used in a given heat exchangers. The seals according to the present invention may be installed into the aperture by hand or by suitable instrument so as to seat the seal into a given location in the aperture. In use, seal 50 is compressed a predetermined amount to provide a proper seal between the tube 4 and the header plate aperture. Seal 50 is held in place by shoulders

34 and 38, with shoulder 34 providing support for seal 50 to resist the pressure incurred at the high pressure side of upper header plate 10, and shoulder 38 providing support for seal 50 during the angled installation of tube 4. Aperture 16 is preferably designed to hold seal 50 captive within upper header plate 10 during installation and removal of tube 4. That is, seal 50 is contained entirely within aperture 16 and does not extend above the tank side of the header plate 10 into the upper tank 17 or below the tube side of the header plate 10. Aperture 16 must be able to accommodate tube 4 being positioned at angle α with respect to longitudinal axis L, which is necessary in order for lower end 12 to clear lower header plate 14 or heat exchange frame during installation and removal without dismantling the frame of the heat exchanger.

[0024] The actual dimensions of diameters A, B, C, and D, as well as the depth of each portion, that is, its dimensional length along longitudinal axis L, will be determined by the specific application of a given heat exchanger and the desired insertion angle α required for insertion or removal of a heat exchanger tube. Certain factors that will affect the desired insertion angle α include such factors as the diameter of the flow tube, the length of the flow tube, the dimensions of the fin elements of the flow tube, the operating pressure of the heat exchanger, the type of seal used, and beveling of the portions of the aperture, if desired. Diameter A must be large enough to allow tube 4 to be inserted at insertion angle α to axis L without binding the tube within the portion 30 of the header plate and preventing its proper insertion into the header plate, but small enough to provide proper support to retain the seal under system operating pressure. At the limiting tube angle α for a given heat exchanger as shown in Fig. 4, the left side of tube 4, contacts, and its range of motion is limited by, the tube side edge 31 of first portion 30. The right side of tube 4, as seen in Fig. 4, contacts, and its range of motion is limited by, tank side edge of first portion 30 at shoulder 34.

[0025] Diameter B must be larger than diameter A in order to provide for seal 50 and shoulder 34 between first and second portions 30, 32. Diameter B and corresponding shoulders fixedly retain seal 50 and is sized to allow seal 50 to be compressed to a designed compression level when tube 4 is in its normal approximately vertical orientation, seen as the left most tube 4 in Fig. 2.

[0026] Diameter C must be smaller than diameter B in order to provide for shoulder 38 between second and third portions 32, 36. Diameter C is sized to provide clearance for tube 4 when it is oriented at angle α , as well as providing proper support for Seal 50 during tube installation and removal as well as low pressure operation. Low pressure operation refers to a condition in which the pressure sides of upper header plate 10 are reversed. That is, the pressure within upper tank 17 is lower than that portion of the heat exchanger between upper and lower header plates 10, 14 which is typically exposed to air. In such a reverse pressure condition, shoulder 38 would provide support against the source of higher pressure. Diameter C may be, in certain preferred embodiments, approximately equal to diameter A.

[0027] In certain nonlimiting embodiments, diameter D is larger than diameter C. Diameter D is sized to provide clearance for tube 4 when tube 4 is at insertion angle α with respect to longitudinal axis L to prevent binding of tube 4. In other embodiments, diameter D is approximately equal to diameter C or the fourth portion 40 may gradually increase in a beveled manner toward the tank side surface of the heat exchanger plate.

[0028] The depths of each portion may vary as well based on operating conditions of the heat exchanger. Specifically, for example, the depth of first portion 30 and third portion 36 must be sized to provide a sufficient thickness for shoulder 34 and shoulder 38 which can withstand the pressures incurred by Seal 50.

[0029] In the illustrated embodiments, aperture 18 has the same construction as aperture 16. It is to be appreciated that in other embodiments, aperture 18 may have a constant diameter, or, alternatively, have a single channel containing a groove incorporating a seal to provide a seal between tube 4 and aperture 18.

[0030] In another preferred embodiment, shown in Fig. 5, a cupped washer 60 is provided on tube 4 between upper header plate 10 and an uppermost fin 6. Cupped washer 60 has a substantially C-shaped cross-section forming a concave surface 62 which faces upper header plate 10. A contamination seal 64 is positioned between upper header plate 10 and concave surface 62. Contamination seal 64 is formed of a first portion 66 having a substantially rectangular cross-section and a second portion 68. Second portion 68 extends upwardly and radially outwardly from an upper and radially inner edge of first portion 66, terminating in a lip 70 which extends radially outwardly. In other preferred embodiments, contamination seal 64 may have other constructions, e.g., a substantially rectangular cross section. Contamination seal 64 acts to protect seal 50 from dust and other contaminants which may be encountered in some applications. Cupped washer 60 protects contamination seal 64 and/or apertures 16, 18 from large objects, high-pressure water washers, and other items which may damage contamination seal 64 and/or apertures 16, 18 or otherwise impair the functionality of heat exchanger 2. It is to be appreciated that contamination seal 64 may, in certain preferred embodiments, be used without cupped washer 60. A similar cupped washer 60 and contamination seal 64 may be placed on lower end 12 of tube 14 adjacent lower header plate 14.

[0031] In light of the foregoing disclosure of the invention and description of the preferred embodiments, those skilled in this area of technology will readily understand that various modifications and adaptations can be made without departing from the true scope and spirit of the invention. All such modifications and adaptations are intended to be covered by the following claims.

Claims

1. A heat exchanger having a frame comprising:

a plate (10) having a tube side and a tank side;
a plurality of apertures (16) extending through the plate (10); and a plurality of tubes (4) inserted in the apertures and sandwiched between the plate on one side and an element (14) on the other side;
each aperture (16) having a longitudinal axis L and a wall of nonuniform diameter at at least three locations; and
a seal (50) fixedly engaged within the aperture (16) by shoulders (34,38) formed by differing diameters of the wall and wherein the seal (50) is configured to engage the flow tube (4) after insertion of the flow tube (4) into the aperture (16);

characterized in that:

the diameter at each location is sufficiently large enough to accommodate insertion of the flow tube (4) into the aperture (16) at an insertion angle α to the longitudinal axis L to allow insertion and removal of a flow tube (4) from the heat exchanger (2) without disassembling the frame of the heat exchanger (2), where α is greater than zero degrees.

2. The heat exchanger of claim 1 wherein each aperture (16) includes a first portion (30) to accept a flow tube (4), the first portion (30) adjacent the tube side and having a first diameter (A) to accommodate insertion of the flow tube (4) into the first portion (30) and into the aperture (16) at the insertion angle α .

3. The heat exchanger of claim 2 wherein the seal (50) is fixedly engaged in a second portion (32) of the aperture (16), the second portion (32) adjacent the first portion (30) and having a second diameter (B) larger than the first diameter (A) of the first portion (30) with the second portion (32) having shoulders (34, 38) for retaining the seal (50) during insertion and removal of the flow tube (4).

4. The heat exchanger of claim 3, wherein the aperture (16) includes a third portion (36) adjacent the second portion (32), the third portion (36) has a third diameter (C) smaller than the second diameter (B) of the second portion (32), and the third diameter (C) is larger than the first diameter (A) of the first portion (30).

5. The heat exchanger of claim 4, wherein the third portion (36) extends to the tank side of the plate (10).

6. The heat exchanger of claim 4, wherein the aperture (16) includes a fourth portion (40) adjacent the third portion (36), the fourth portion (40) having a fourth diameter (D) larger than the third diameter (C) of the third portion (36).

7. The heat exchanger of claim 1, wherein the first portion (30) has a beveled or rounded edge (31) at the tube side of the plate (10).

8. The heat exchanger of claim 6, wherein the fourth portion (40) has a beveled or rounded edge (44) at the tank side of the plate (10).

9. The heat exchanger of claim 1, further comprising:

a plurality of flow tubes (4) having a first end (8) and a second end (12);

a second header plate (14) having a plurality of apertures (18) sized to receive a second end (12) of a flow tube (4), and each flow tube (4) engaging corresponding apertures (16, 18) of the first and second header plates (10, 14).

10. The heat exchanger of claim 9, further comprising a plurality of contamination seals (64), each contamination seal (4) engaging a corresponding flow tube (4) and contacting the tube side of a corresponding header plate (10, 14).

11. The heat exchanger of claim 10, wherein the contamination seal (64) further includes a washer (60).

Patentansprüche

1. Wärmetauscher mit einem Rahmen, der Folgendes aufweist:

eine Platte (10) mit einer Rohrseite und einer Behälterseite;
eine Vielzahl von durch die Platte (10) verlaufenden Öffnungen (16) und eine Vielzahl von Rohren (4), die in die Öffnungen eingesteckt sind und zwischen die Platte auf einer Seite und einem Element (14) auf der anderen Seite geschichtet sind, wobei jede Öffnung (16) eine Längsachse L und eine Wand mit einem uneinheitlichen Durchmesser an mindestens drei Stellen hat; und
eine Dichtung (50), die mittels durch unterschiedliche Durchmesser der Wand ausgebildete Schultern (34, 38) fest in die Öffnung (16) eingerastet ist, wobei die Dichtung (50) so konfiguriert ist, dass sie nach dem Einstecken des Durchflussrohrs (4) in die Öffnung (16) in das Durchflussrohr (4) einrastet,

dadurch gekennzeichnet, dass der Durchmesser an jeder Stelle groß genug ist, um das Durchflussrohr (4) in die Öffnung (16) in einem Einsteckwinkel α zur Längsachse L einstecken zu können, sodass ein Durchflussrohr (4) in den Wärmetauscher (2) eingesteckt und aus diesem herausgezogen werden kann, ohne den Rahmen des Wärmetauschers (2) zu demontieren, wobei α größer als Null Grad ist.

2. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, dass** jede Öffnung (16) einen ersten Teil (30) zum Aufnehmen eines Durchflussrohrs (4) aufweist, wobei der erste Teil (30) an die Rohrseite angrenzt und einen ersten Durchmesser (A) hat, der so groß ist, dass das Durchflussrohr (4) in den ersten Teil (30) und in die Öffnung (16) in dem Einsteckwinkel α eingesteckt werden kann.

3. Wärmetauscher nach Anspruch 2, **dadurch gekennzeichnet, dass** die Dichtung (50) in einen zweiten Teil (32) der Öffnung (16) fest eingerastet ist, wobei der zweite Teil (32) an den ersten Teil (30) angrenzt und einen zweiten Durchmesser (B) hat, der größer als der erste Durchmesser (A) des ersten Teils (30) ist, wobei der zweite Teil (32) Schultern (34, 38) zum Festhalten der Dichtung (50) während des Einsteckens und Herausziehens des Durchflussrohrs (4) hat.

4. Wärmetauscher nach Anspruch 3, **dadurch gekennzeichnet, dass** die Öffnung (16) einen an den zweiten Teil (32) angrenzenden dritten Teil (36) aufweist, wobei der dritte Teil (36) einen dritten Durchmesser (C) hat, der kleiner als der zweite Durchmesser (B) des zweiten Teils (32) und größer als der erste Durchmesser (A) des ersten Teils (30) ist.

5. Wärmetauscher nach Anspruch 4, **dadurch gekennzeichnet, dass** der dritte Teil (36) zur Behälterseite der Platte (10) verläuft.

6. Wärmetauscher nach Anspruch 4, **dadurch gekennzeichnet, dass** die Öffnung (16) einen an den dritten Teil (36) angrenzenden vierten Teil (40) aufweist, wobei der vierte Teil (40) einen vierten Durchmesser (D) hat, der größer als der dritte Durchmesser (C) des dritten Teils (36) ist.

7. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, dass** der erste Teil (30) eine abgeschrägte oder abgerundete Kante (31) an der Rohrseite der Platte (10) hat.

8. Wärmetauscher nach Anspruch 6, **dadurch gekennzeichnet, dass** der vierte Teil (40) eine abgeschrägte oder abgerundete Kante (44) an der Behälterseite der Platte (10) hat

9. Wärmetauscher nach Anspruch 1, der weiterhin Folgendes aufweist:

eine Vielzahl von Durchflussrohren (4) mit einem ersten Ende (8) und einem zweiten Ende (12) und eine zweite Kopfplatte (14) mit einer Vielzahl von Öffnungen (18), die so dimensioniert sind, dass sie das zweite Ende (12) eines Durchflussrohrs (4) aufnehmen können, wobei jedes Durchflussrohr (4) in entsprechende Öffnungen (16, 18) der ersten und zweiten Kopfplatten (10, 14) einrastet.

10. Wärmetauscher nach Anspruch 9, der weiterhin eine Vielzahl von Verunreinigungsdichtungen (64) aufweist, die jeweils in ein entsprechendes Durchflussrohr (4) einrasten und die Rohrseite einer entsprechenden Kopfplatte (10, 14) berühren.

11. Wärmetauscher nach Anspruch 10, **dadurch gekennzeichnet, dass** die Verunreinigungsdichtung (64) weiterhin eine Dichtungsscheibe (60) aufweist.

5 Revendications

1. Echangeur de chaleur comportant un cadre comprenant :

une plaque (10) ayant un côté tubes et un côté réservoir,
une pluralité d'ouvertures (16) s'étendant au travers de la plaque (10), et une pluralité de tubes (4) insérés dans les ouvertures et pris en sandwich entre la plaque d'un côté et un élément (14) de l'autre côté, chaque ouverture (16) ayant un axe longitudinal L et une paroi de diamètre non uniforme en au moins trois emplacements, et
un joint (50) engagé fermement dans l'ouverture (16) grâce à des épaulements (34, 38) formés par des diamètres différents de la paroi, et où le joint (50) est configuré pour être en contact avec le tube de circulation (4) après insertion du tube de circulation (4) dans l'ouverture (16),

caractérisé en ce que :

le diamètre en chaque emplacement est suffisamment grand pour prendre en compte une insertion du type de circulation (4) dans l'ouverture (16) à un angle d'inclinaison α par rapport à l'axe longitudinal L afin de permettre l'insertion et l'enlèvement d'un tube de circulation (4) par rapport à l'échangeur de chaleur (2) sans démontage du cadre de l'échangeur de chaleur (2), où α est supérieur à zéro degré.

2. Echangeur de chaleur selon la revendication 1, dans lequel chaque ouverture (16) comprend une première partie (30) pour recevoir un tube de circulation (4), la première partie (30) étant adjacente au côté tubes et ayant un premier diamètre (A) pour permettre une insertion du tube de circulation (4) dans la première partie (30) et dans l'ouverture (16) à l'angle d'insertion α .

3. Echangeur de chaleur selon la revendication 2, dans lequel le joint (50) est engagé de façon fixe dans une seconde partie (32) de l'ouverture (16), la seconde partie (32) étant adjacente à la première partie (30) et ayant un second diamètre (B) plus grand que le premier diamètre (A) de la première partie (30), la seconde partie (32) ayant des épaulements (34, 38) pour retenir le joint (50) durant l'insertion et l'enlèvement du tube de circulation (4).

4. Echangeur de chaleur selon la revendication 3, dans lequel l'ouverture (16) comprend une troisième partie (36) adjacente à la seconde partie (32), la troisième partie (36) présente un troisième diamètre (C) plus petit que le second diamètre (B) de la seconde partie (32), et le troisième diamètre (C) est plus grand que le premier diamètre (A) de la première partie (30).

5. Echangeur de chaleur selon la revendication 4, dans lequel la troisième partie (36) s'étend vers le côté réservoir de la plaque (10).

6. Echangeur de chaleur selon la revendication 4, dans lequel l'ouverture (16) comprend une quatrième partie (40) adjacente à la troisième partie (36), la quatrième partie (40) ayant un quatrième diamètre (D) plus grand que le troisième diamètre (C) de la troisième partie (36).

7. Echangeur de chaleur selon la revendication 1, dans lequel la première partie (30) comporte un bord chanfreiné ou arrondi (31) du côté tubes de la plaque (10).

8. Echangeur de chaleur selon la revendication 6, dans lequel la quatrième partie (40) comporte un bord chanfreiné ou arrondi (44) du côté réservoir de la plaque (10).

9. Echangeur de chaleur selon la revendication 1, comprenant en outre :

une pluralité de tubes de circulation (4) ayant une première extrémité (8) et une seconde extrémité (12), une seconde plaque de collecteur (14) ayant une pluralité d'ouvertures (18) dimensionnées pour recevoir une seconde extrémité (12) d'un tube de circulation (4), et chaque tube de circulation (4) s'engageant dans des ouvertures correspondantes (16, 18) des première et seconde plaques de collecteurs (10, 14).

EP 1 097 347 B1

10. Echangeur de chaleur selon la revendication 9, comprenant en outre une pluralité de joints contre l'encrassage (64), chaque joint contre l'encrassage (4) étant en prise avec un tube de circulation correspondant (4) et en contact avec le côté tubes d'une plaque de collecteur correspondante (10, 14).

5 **11.** Echangeur de chaleur selon la revendication 10, dans lequel le joint contre l'encrassage (64) comprend en outre une rondelle (60).

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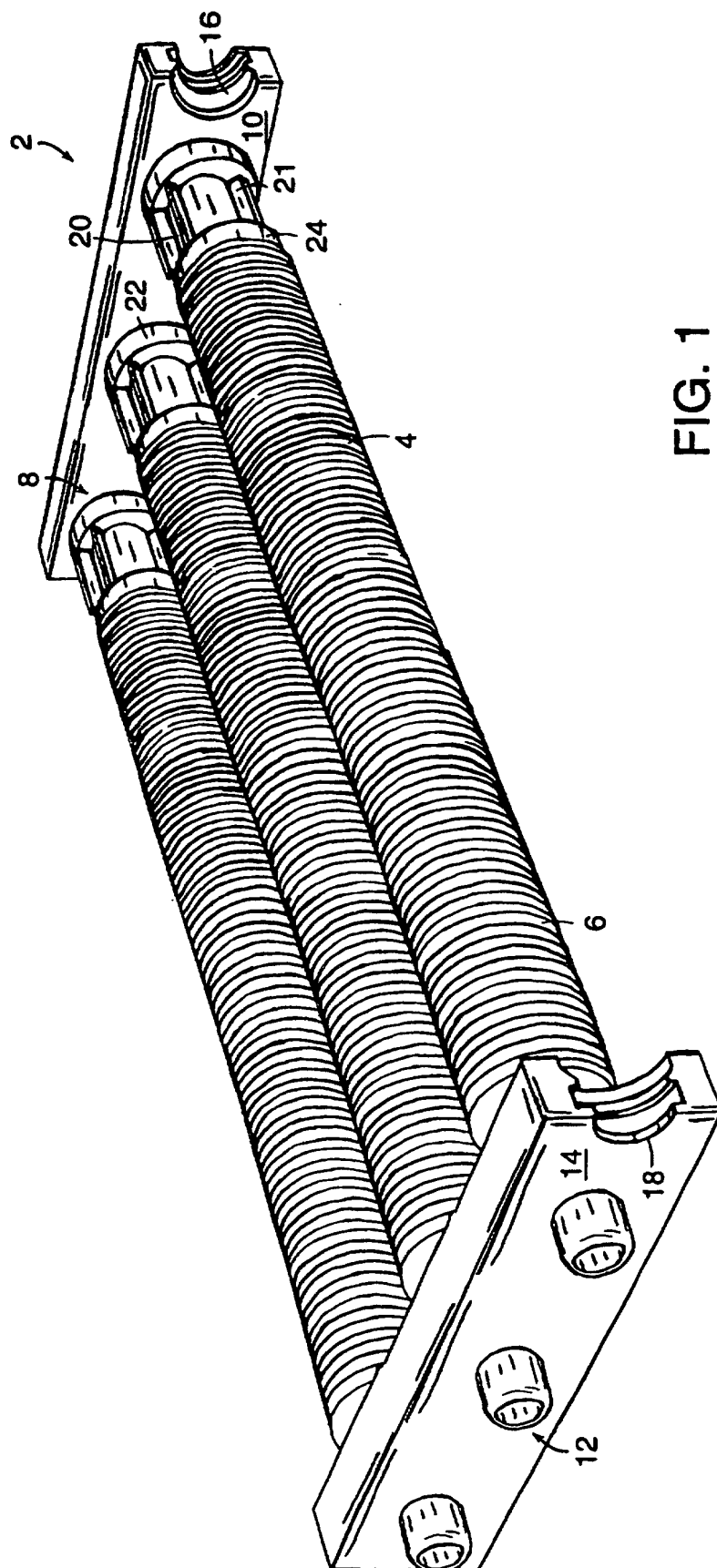
35

40

45

50

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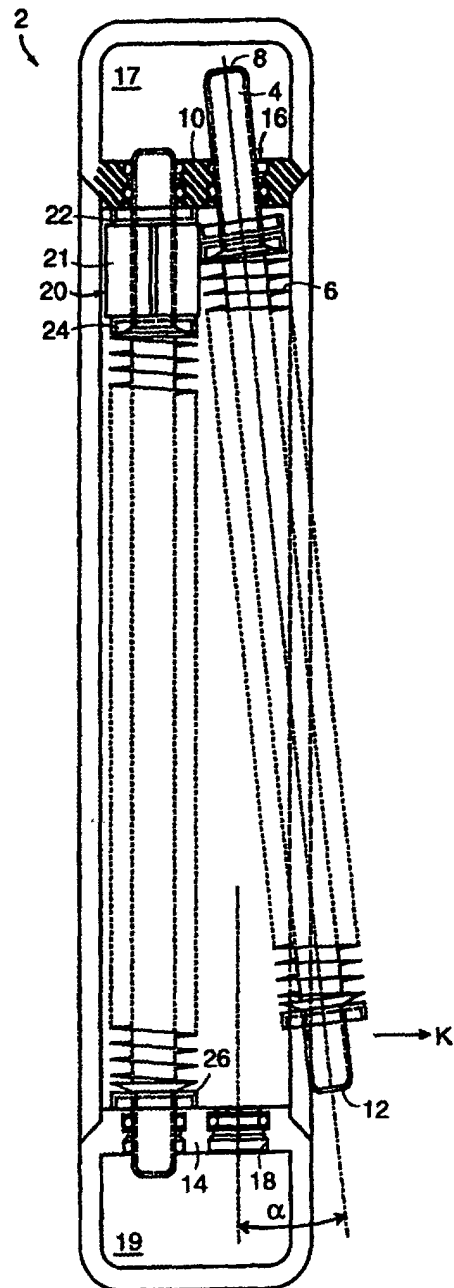


FIG. 2

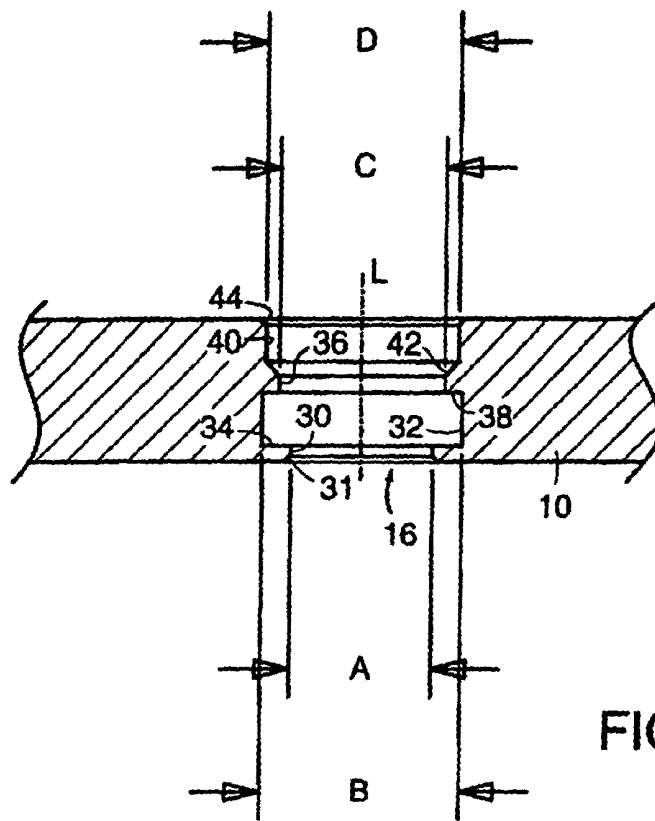


FIG. 3

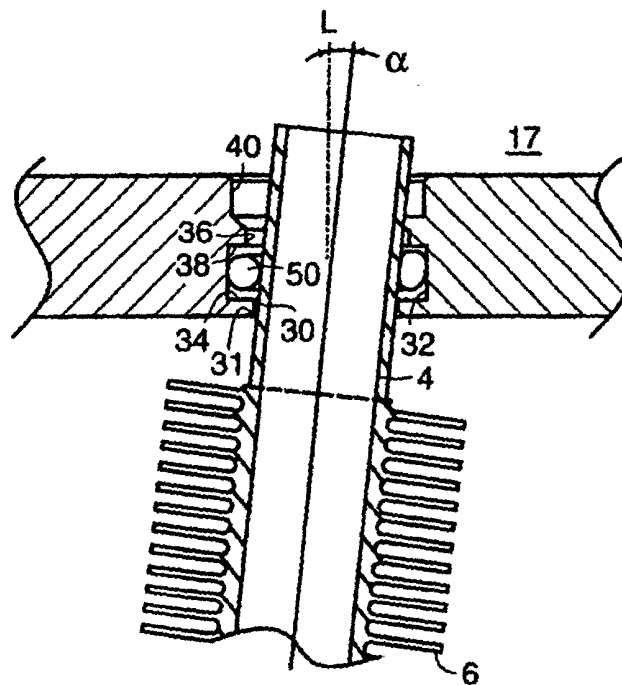


FIG. 4

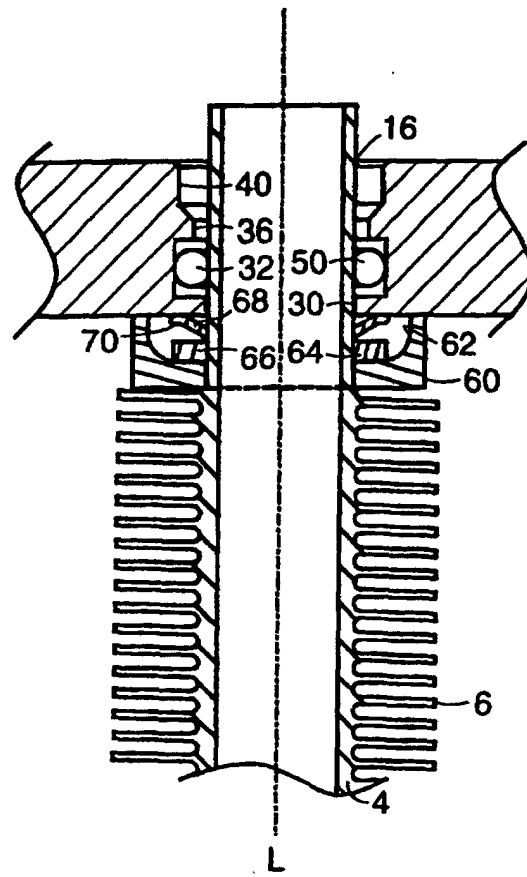


FIG. 5



POSSIBLE
PRESSURE SEAL
CROSS SECTIONS



POSSIBLE
DUST SEAL
CROSS SECTIONS

FIG. 6