

Oct. 22, 1968

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3,406,747

HEAT EXCHANGER HAVING CONCENTRIC SUPPLY AND EXHAUST CONDUITS

Filed Jan. 18, 1966

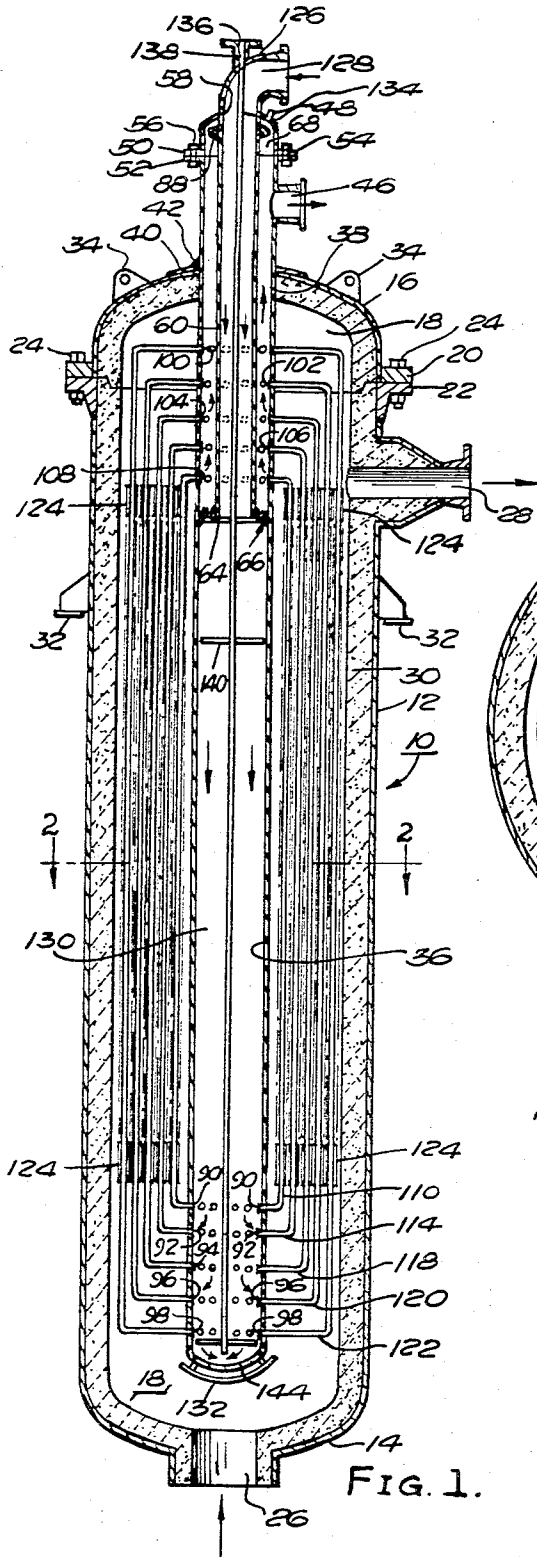


FIG. 1.

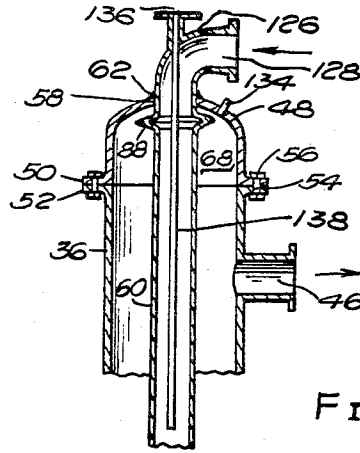


FIG. 4.

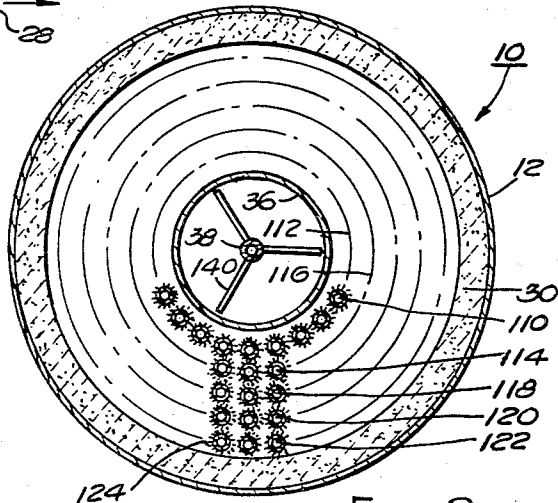


FIG. 2.

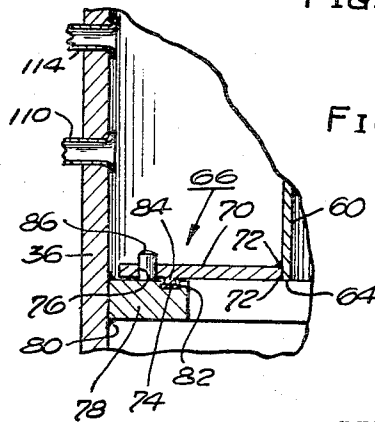


FIG. 3.

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HEAT EXCHANGER HAVING CONCENTRIC SUPPLY AND EXHAUST CONDUITS

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Filed Jan. 18, 1966, Ser. No. 521,278

2 Claims. (Cl. 165-74)

ABSTRACT OF THE DISCLOSURE

A heat exchanger having concentric conduits forming inlet and outlet conduits for a heat exchange fluid. The outer conduit extends into and through a major portion of the shell and has a closed end portion within the shell and an open end portion externally of the shell. The inner conduit is concentrically positioned in the outer conduit and extends through a minor portion of the shell. The inner conduit has an open end portion internally of the shell that serves as an inlet for the heat exchange fluid and an open other end portion within the outer conduit. An annular seal member closes the opening between the inner wall of the outer conduit and the outer wall of the inner conduit adjacent the other end portion of the inner conduit. Heat exchange tubes are connected at one end to the outer conduit adjacent the closed end of the outer conduit and at the other end above the annular seal member.

This invention relates to a heat exchanger and more particularly to a heat exchanger in which the heat exchange tubes are supported by a central fluid supply conduit that extends through a major portion of the heat exchange chamber.

In industrial processes, especially where high temperatures are required, a substantial portion of the heat generated in the processes is carried away by the waste gases or by the gaseous products of the process. Special heat exchange devices such as waste heat boilers have been employed in the past to recover a portion of the heat from the gases and transfer the recovered heat to the fluids used in the industrial processes. It is common practice to design the heat exchangers for the particular operating conditions to which the heat exchanger will be subjected in the industrial process. This limits the use of the particular heat exchanger to the operating conditions of the industrial process.

There are many heat exchanger designs wherein a plurality of heat exchange tubes are used to provide the desired surface area between the respective heat exchange fluids. The conventional parallel tube heat exchangers have a cylindrical shell forming a heat exchanger chamber with inlet and outlet ports for a first heat exchange fluid, usually a gas at an elevated temperature. Headers are formed in the cylindrical shell, usually at opposite ends, and are connected by means of a plurality of heat exchange tubes that are arranged in parallel relation to each other within the heat exchange chamber. Other openings are provided in the shell for the flow of a second heat exchange fluid, usually a liquid, through the tubes in heat exchange relation with the first heat exchange fluid.

Where the components within the heat exchange chamber are subjected to relatively high temperatures, as for example temperatures of about 1600° F., expensive bellows type expansion joints must be provided between the various elements within the heat exchange chamber to compensate for the differential expansion therebetween. Also, where the elements are subjected to a substantial pressure differential due to the difference in pressure between the two heat exchange fluids, the headers and tube sheets must be fabricated of relatively thick expensive

material capable of withstanding the high pressure differential. Where the heat exchange fluid passing through the tubes is a liquid and contains foreign material such as dirt particles or the like, special provisions must be made to prevent the foreign material from accumulating in the headers and heat exchange tubes. Heat exchangers have also been constructed in the form of one or more banks of U-shaped tubes supported in an enclosed heat exchange chamber. The upper portion of the heat exchange chamber is divided by means of a vertical wall into adjacent headers for directing the heat exchange fluid through the U-shaped tubes in heat exchange relation with the usually gaseous other heat exchange fluid. The above discussed problems are more acute with this type of heat exchanger and difficulties are encountered in spacing the U-shaped tubes and joining the tubes to the tube plate. Foreign material in the heat exchange fluid collects in the curved portions of the tubes and restricts the flow of the fluid therethrough. This frequently causes premature failure of the U-shaped tubes. The herein described heat exchanger has a novel arrangement of components that overcome the above discussed disadvantages and permits the exchanger to be used in a variety of applications and not restricted to a narrow range of operating conditions as had been the practice in the past.

The invention herein disclosed comprises a vertical shell forming a heat exchange chamber that has inlet and outlet ports for one heat exchange fluid. A first conduit extends through a major portion of the shell and has a closed end portion that is spaced from the inner surface of the shell. The first conduit has an open end portion outside of the shell that forms an outlet port for a second heat exchange fluid. The first conduit is suitably secured to and supported by the vertical shell. A second conduit is concentrically positioned within the first conduit and extends through a minor portion of the heat exchange chamber. The second conduit is supported by the first conduit in a manner that an annular space is formed between the outer surface of the second conduit and the inner surface of the first conduit. There is an annular seal means closing the annular space adjacent the end portion of the second conduit to thereby form two chambers within the first conduit. One chamber communicates with the second conduit and extends downwardly below the lower edge of the second conduit. The annular space between the first and second conduits forms the second chamber. The first conduit has a plurality of spaced apertures adjacent the lower end thereof and other spaced apertures adjacent the upper end above the lower edge of the second conduit. A plurality of vertical tubes are connected to preselected spaced apertures in the side walls of the first conduit and provide a flow path for the second heat exchange fluid from the first chamber to the second chamber.

It is, therefore, the primary object of this invention to provide heat exchange apparatus wherein the heat exchange tubes are supported from a central conduit that extends through a major portion of the heat exchange chamber.

Another object of this invention is to provide a heat exchanger that has a pair of concentric conduits supported by the shell to provide for opposite and parallel flow paths for one of the heat exchange fluids within the heat exchange chamber.

Another object of this invention is to provide a heat exchanger that has a first conduit extending through a major portion of the heat exchange chamber formed by a vertical shell and a second conduit concentrically positioned within the first conduit to provide a flow path for a heat exchange fluid through the first conduit and a plurality of heat exchange tubes connected thereto.

These and other objects and advantages of this invention will be more completely disclosed and described in the following specification, the accompanying drawings and the appended claims.

In the drawings:

FIGURE 1 is a longitudinal section through my heat exchanger illustrating the arrangement of the concentric conduits and the parallel heat exchange tubes.

FIGURE 2 is a transverse section of the heat exchanger taken along the line 2—2 and partially illustrating the circular arrangement of the banks of tubes within the vertical shell.

FIGURE 3 is an enlarged view in section illustrating the seal arrangement between the concentric conduits.

FIGURE 4 is an enlarged fragmentary view in section illustrating the flanged connection of the external conduit for assembly and removal of the internal concentric conduit.

In the drawings, my heat exchanger, generally designated by the numeral 10, has an outer cylindrical shell or body portion 12 with a dish shaped bottom portion 14 and a dish shaped top portion 16, and forms therein a heat exchange chamber 18. The lower dish shaped end portion 14 may be formed integrally with the cylindrical body portion 12 or, where desired, may be separately fabricated and secured thereto by suitable means. The upper dish shaped portion 16 has a radially extending annular flange 20 that mates with a radially extending flange 22 formed adjacent the upper edge of the cylindrical body portion 12. A plurality of aligned passageways extend through the respective flange members 20 and 22 and bolts 24 extend through the passageways and secure the upper dish shaped portion 16 to the upper edge of the cylindrical body portion 12. As will be later discussed, the upper dish shaped portion 16 may be removed from the cylindrical body portion 12 to permit other elements of the heat exchanger to be positioned within the chamber 18.

The dish shaped lower end portion 14 has an opening 26 therein that serves as an inlet port for a heat exchange fluid and the cylindrical body portion has an opening 28 that serves as an outlet opening to withdraw the heat exchange fluid from the chamber 18. It should be understood that although it is preferred to position the inlet and outlet openings 26 and 28 as illustrated in the drawings, the relative location of the inlet and outlet openings may be changed without departing from the invention herein described. With the arrangement illustrated in FIGURE 1, the first heat exchange fluid, which under usual circumstances is a gas at an elevated temperature of about 1600° F., enters the chamber 18 through the inlet 26, flows upwardly through a major portion of chamber 18 and exhausts through outlet opening 28. A suitable refractory liner 30 may be provided along the inner surface of chamber 18 to reduce radiation losses through the walls of chamber 18 and to reduce the metal temperature of the outer shell. Support members 32 may be secured to the external wall of the cylindrical body portion 12 and provide support pads for the heat exchanger 10. There also are provided suitable lugs 34 secured to the external wall of dish shaped portion 16 for removing the top dish shaped portion 16 from the cylindrical body portion 12. A conduit 36 extends through an opening 38 in the top dish shaped portion 16 into the heat exchange chamber 18 and is secured to the top dish shaped portion 16 by means of a suitable flange 40 and suitable weldments 42. With this arrangement, the conduit 36 is supported by the top dish shaped portion 16 and extends into and through a major portion of the heat exchange chamber 18. The conduit 36 has a preferably integral closed end portion 44 that is spaced from the heat exchange chamber end portion 14 and an outlet opening 46 extending laterally therefrom externally of the heat exchange chamber 18. An upper dish shaped end portion 48 has an annular external flange 50 that is

in overlying relation with a mating annular flange 52 on the upper edge of the conduit 36. The flanges 50 and 52 have a plurality of aligned apertures 54 through which bolts 56 extend and secure the upper dish shaped end portion 48 to the conduit 36. The upper dish shaped end portion 48 has a central aperture 58 therethrough through which a second conduit 60 extends and is secured to the upper dish shaped portion 48 by means of weldments 62.

The second conduit 60 is coaxially positioned within the conduit 36 and extends into the heat exchange chamber 18 within the conduit 36. Conduit 60 has a lower end portion 64 with seal means generally designated by the numeral 66 between the external wall of the inner concentric conduit 60 and the internal wall of the outer conduit 36. The concentric conduits 36 and 60 are so dimensioned that an annular space 68 is formed therebetween. The annular seal means 66 encloses the lower portion of the annular space 68 to form an annular chamber. Throughout the specification the annular space 68 between concentric conduits 36 and 60 will also be referred to as chamber 68.

The seal means 66 is illustrated in detail in FIGURE 3 and includes a radially extending flange 70 secured to the inner concentric conduit end portion 64 by means of weldments 72. The radial flange 70 has an annular depending flange 74 extending downwardly from the lower surface and a plurality of apertures 76 therethrough. The inner wall of the outer conduit 36 has an inwardly extending flange 78 secured thereto by weldments 80. The upper surface of flange 78 has an annular recess 82 in which the annular depending flange 74 is positioned. A suitable gasket 84 is positioned in the recessed portion 82 and provides an annular resilient seal therein. A plurality of vertical pins 86 are secured to the inwardly extending flange 78 and extend through the apertures 74 in flange 70 to position the inner concentric conduit 60 within the outer conduit 36.

The inner concentric conduit 60 has a bellows type expansion joint 88 that compensates for the differential expansion between the concentric pipes and affects a mechanical seal between the respective flanges 70 and 78 on inner and outer conduits 60 and 36. As will be later discussed, the above described arrangement allows access to the internal surface of the outer conduit 36 by removal of the inner conduit 60. Access to the internal portion of outer conduit 36 is desirable both in assembly and in maintenance of the heat exchanger.

The outer conduit 36 has formed in the side wall adjacent the lower end a plurality of regularly spaced apertures 90 arranged in a circle in substantially the same horizontal plane around the periphery of the conduit. A second circle of regularly spaced apertures 92 are formed in the outer conduit side wall 36 and are spaced below the apertures 90. Other circles of regularly spaced apertures 94, 96, and 98 are formed in the side wall of conduit 36 in vertical spaced relation to each other, as illustrated in FIGURE 1. Similarly, adjacent the upper end of outer conduit 36 within the heat exchange chamber 18 there are a series of circles of apertures 100, 102, 104, 106 and 108 regularly spaced about the periphery of outer conduit 36 and vertically from each other. A plurality of tubes 110 have their lower end portions extending through apertures 90 and their upper end portions extending through apertures 108 adjacent the top of the chamber 18. The tubes 110 form circular banks about conduit 36 as is illustrated in FIGURE 2. The circular arrangement is indicated by the dash-dot circular line 112. Tubes 114 have their lower end portions extend through apertures 92 in conduit 36 adjacent the lower portion of heat exchange chamber 18 and their upper end portions extend through apertures 106 adjacent the upper portion of the chamber 18. The tubes 114 encircle the tubes 110 as is indicated by the dash-dot line 110. Similarly, tubes 118, 120 and 122 have their end portions extend through apertures 94, 96 and 98 respectively in

conduit 36 adjacent the lower portion of the heat exchange chamber 18 and through apertures 104, 102 and 100 respectively adjacent the upper portion of heat exchange chamber 18. The tubes form, in transverse section, concentric circular banks, as is clearly illustrated in FIGURE 2. The vertical portions of the tubes have fins 124 along their external surface to increase the heat exchange surface between the respective heat exchange fluids. The tubes 110, 114, 118, 120 and 122 have substantially right angled end portions that extend into the respective apertures. The tubes may be secured in the apertures by means of external weldments and internal flanging of the tubes, as is illustrated in FIGURE 3, or by other conventional methods such as rolling in the tubes. With this arrangement, fluid-tight connections between the tubes and the conduit 36 are provided.

The internal conduit 60 has an elbow end portion 126 forming an inlet 128 for the second heat exchange fluid which, under ordinary circumstances, is a liquid at a relatively low temperature and relatively high pressure, as for example, 1500 p.s.i. The liquid heat exchange fluid enters through inlet opening 128 into the concentric conduit 60 and flows downwardly through the conduit 60 into the first conduit 36 below the seal means 66. The external conduit 36 below seal means 66 forms a receiver or chamber 130 for the heat exchange fluid entering through inlet 128. The chamber 130 extends through a major portion of the heat exchange chamber 18 so that fluid entering through inlet 128 flows to the bottom of the chamber 130 and enters the circular banks of tubes and flows upwardly therethrough and into the annular chamber 68. The fluid leaves chamber 68 through outlet opening 46 formed in outer conduit 36. The second fluid entering through inlet 128 is heated in the tubes by the hot gases flowing through chamber 18 from inlet opening 26 to outlet 28. It should be understood that although parallel flow of the respective heat exchange fluids has been described, countercurrent flow also could be obtained where desired.

The conduit 36 has a heat shield 132 adjacent the dish shaped lower end portion 44 and a vent 134 in the upper dish shaped end portion 48. The inner concentric conduit 60 has an opening 136 in the elbow portion 126 and a third conduit 138 is positioned concentrically within conduits 60 and 36. The conduit 138 extends downwardly through the conduit 36 and terminates adjacent the closed end portion 44. Suitable spacer means 140 maintain the conduit 138 in concentric relation to conduit 36. The conduit 138 serves as a blow down means to remove the foreign particles that might accumulate in the dish shaped lower portion of the outer conduit 36. It should be noted that the apertures 98 are spaced above the dish shaped end portion 44 of conduit 36 to minimize the flow of impurities through the tubes 122. To remove the accumulation of solid impurities from the bottom of the conduit 36, a suitable vacuum or suction is applied to conduit 138 to withdraw the accumulation of solid particles adjacent the bottom of conduit 36.

The outer concentric pipe or tube 36 is secured to the upper dish shaped portion 16 and suspended in the chamber 18. The other elements of the heat exchanger, that is the inner concentric conduit 60 and the circular banks of tubes are supported by the conduit 36. With this arrangement, the elements of the heat exchanger may be quickly removed from the chamber 18 by removal of the upper dish shaped portion 16. It should be noted that the conduit 36 is secured to the upper dish shaped portion 16 at what may be termed the cold end of the heat exchange chamber 18 where minimum temperature stresses are exerted on the support provided for the conduit 36.

It should also be noted that the arrangement of the elements above described provides for inexpensive and relatively simple fabrication of the heat exchanger. The inner concentric pipe 60 is removable from the outer

concentric pipe 36 by removal of bolts 56 and upper concentric end portion 48 so that access may be had to the inner portion of pipe or conduit 36 for both assembly and maintenance. During assembly, where desired, the end portions of the heat exchange tubes may be rolled or flared from the inside of conduit 36 to provide a fluid-tight seal between the conduit 36 and the heat exchange tubes. Where necessary for maintenance, access can also be gained to the internal portion of pipe 36 by removing the upper concentric end portion 48 and the internal concentric pipe 60 supported thereby. The seal means 66 is so constructed that the inner concentric pipe 60 may be easily removed and again repositioned with the desired fluid-tight seal.

With the seal means 66 fabricated in the manner above described the expansion bellows 88 formed in internal concentric conduit 60 compensates for the difference in thermal expansion between the respective concentric conduits 36 and 60 and also urges the annular depending portion 74 on flange 70 into sealing relation with the gasket material 84 in the annular recess 82 of flange 78. The parallel arrangement of the tubes connected to the outer conduit 36 permits controlled expansion and contraction of the respective tubes.

Another advantageous feature of the arrangement of my heat exchanger is the low pressure differential between the second heat exchange fluid entering through inlet port 128 and leaving through outlet port 46 in the outer conduit 36. The pressure of the fluid entering the inner concentric conduit 60 is substantially the same as the pressure of the fluid leaving the heat exchanger through outlet 46, and the cylindrical wall of the inner concentric conduit 60 is thus subjected to substantially the same fluid pressure on its outer surface and its inner surface. Because of the low pressure differential, the conduit 60 may be fabricated of a relatively thin and inexpensive metal.

According to the provisions of the patent statutes, I have explained the principle, preferred construction, and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiments. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. A heat exchanger comprising a vertical shell forming a heat exchange chamber and having inlet and outlet ports for one heat exchange fluid,

a first conduit extending into and through a major portion of said heat exchange chamber, said first conduit having a closed end portion within said heat exchange chamber spaced from the inner surface of said shell and an open end portion externally of said heat exchange chamber and forming an outlet port for a second heat exchange fluid,

a second conduit extending into said first conduit and having an open end portion externally of said first conduit and forming an inlet port for said second heat exchange fluid, said second conduit extending through a minor portion of said heat exchange chamber and having an end portion positioned within said first conduit,

said second conduit spaced from said first conduit and forming an annular space between the outer surface of said second conduit and the inner surface of said first conduit,

seal means connecting said first conduit inner surface with said second conduit outer surface adjacent said second conduit end portion and forming a first chamber within said first conduit communicating with said second conduit and a second chamber of said annular space between said first and second conduits,

a plurality of heat exchange tubes communicating at one end with said first chamber and at the other

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end with said second chamber above said seal means and thereby forming a flow path for said second heat exchange fluid between said first chamber and said second chamber,
 said vertical shell including a cylindrical body portion having an annular top wall and a dish shaped closed bottom portion,
 a dish shaped member having a closed top portion and an annular bottom portion, said dish shaped member annular bottom portion positioned in abutting relation with said cylindrical body portion annular top wall and forming an enclosing heat exchange chamber,
 said dish shaped member having an aperture there-through,
 said first conduit extending through said aperture and secured to said dish shaped member so that said first conduit is suspended in said heat exchange chamber from said dish shaped member with said first conduit closed end portion spaced from the inner surface of said vertical shell dish shaped bottom portion,
 said heat exchange tubes extending through and secured to the wall of said first conduit so that said heat exchange tubes are removable from said heat exchange chamber with said first conduit,
 said first conduit having an annular end portion positioned externally of said heat exchange chamber,
 said first conduit having an opening therein below said annular end portion forming said outlet port for said second heat exchange fluid,
 a second dish shaped member having an annular bottom end wall secured to said first conduit annular end portion,
 said second dish shaped member having an aperture therethrough,
 said second conduit extending through said aperture in said second dish shaped member in concentric rela-

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tion with said first conduit and secured to said second dish shaped member,
 means to remove said second dish shaped member and said second conduit from said first conduit, and
 a third conduit extending through said second conduit into said first conduit and terminating adjacent the closed end portion of said first conduit,
 said third conduit arranged to convey a portion of said second heat exchange fluid containing solid impurities from said first chamber.
 2. A heat exchanger as set forth in claim 1 in which said seal means includes,
 a first annular ring member secured to the inner wall of said first conduit and extending radially inwardly therefrom,
 a second annular ring member secured to said second conduit end portion and extending radially outwardly therefrom,
 an annular seal member positioned on the upper surface of said first annular ring member,
 said second annular ring member positioned in overlying relation with said annular seal member, and
 means urging said second annular member into abutting relation with said annular seal member.

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