Aug. 10, 1965 C. B. HOOD, JR., ETAL **3,199,583**

SPIRAL TUBE HEAT EXCHANGER

Filed Aug. 10, 1962 3 Sheets-Sheet 1

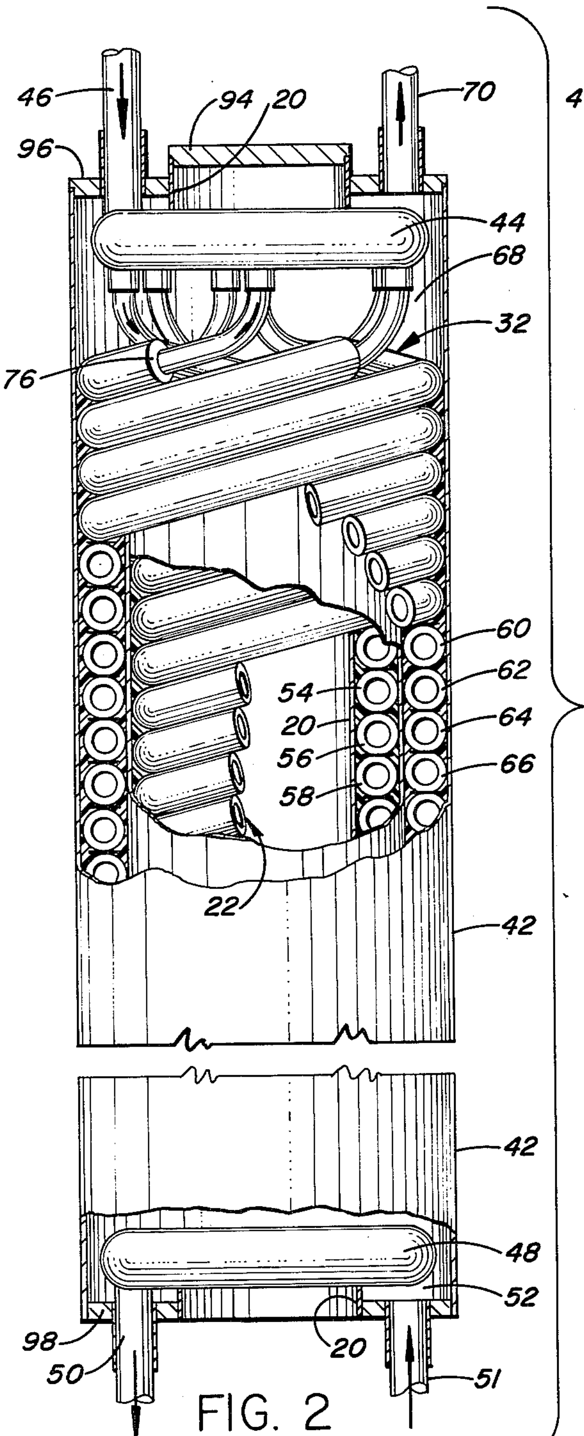

FIG. 2

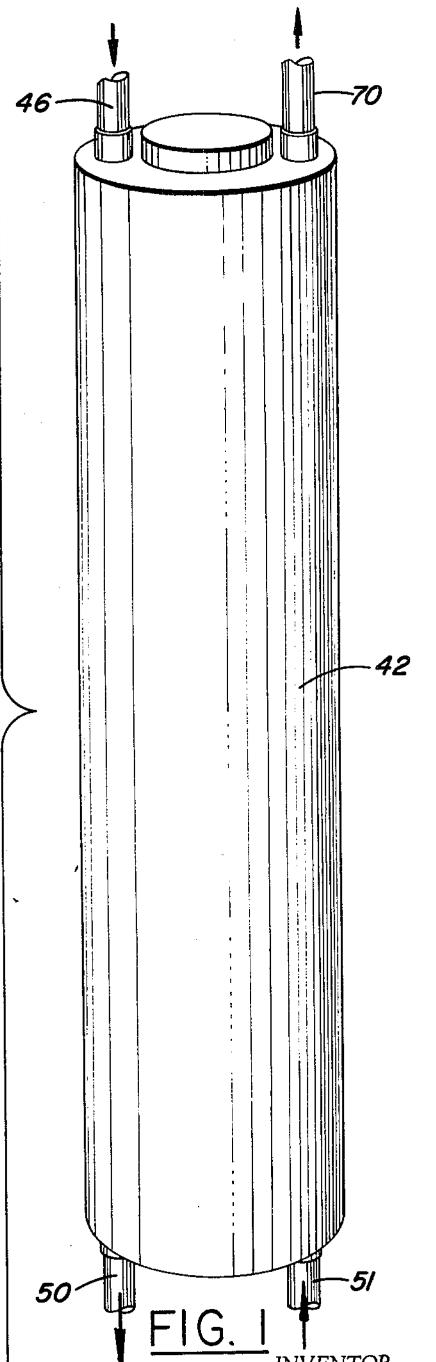

FIG. I

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SPIRAL TUBE HEAT EXCHANGER

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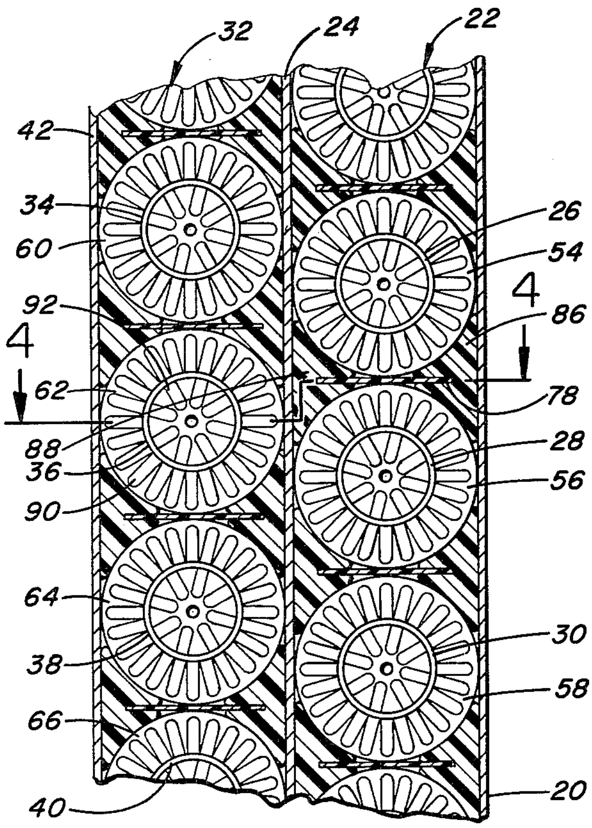

FIG. 3

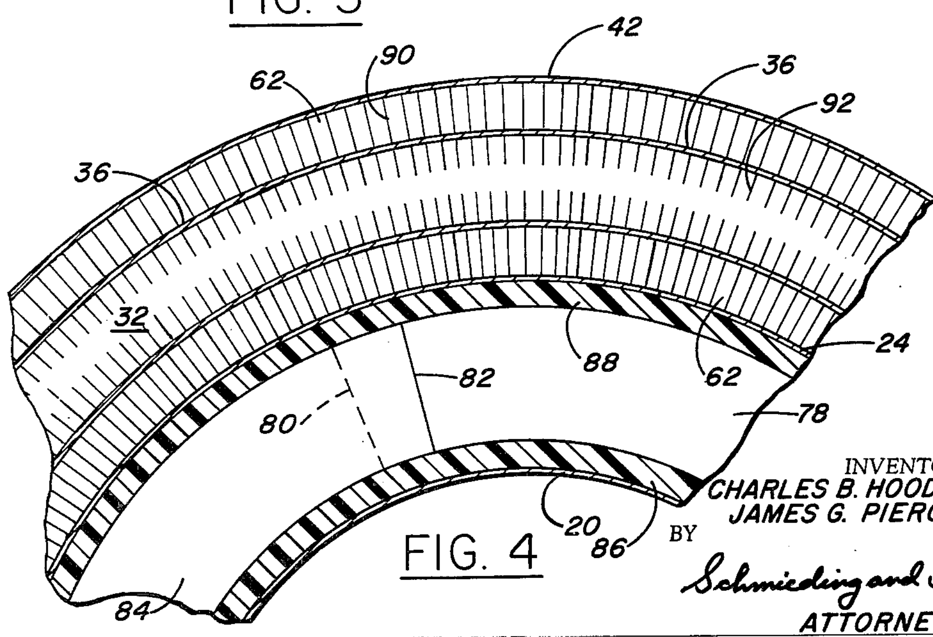

FIG. 4

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SPIRAL TUBE HEAT EXCHANGER

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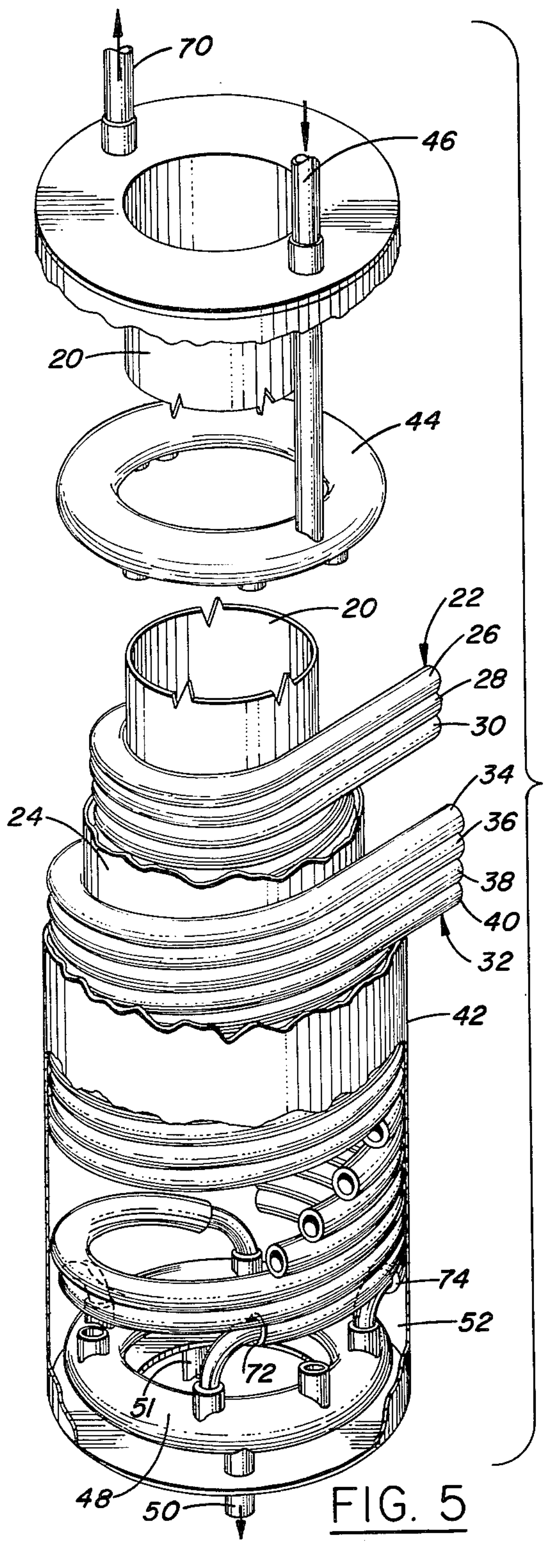

FIG. 5

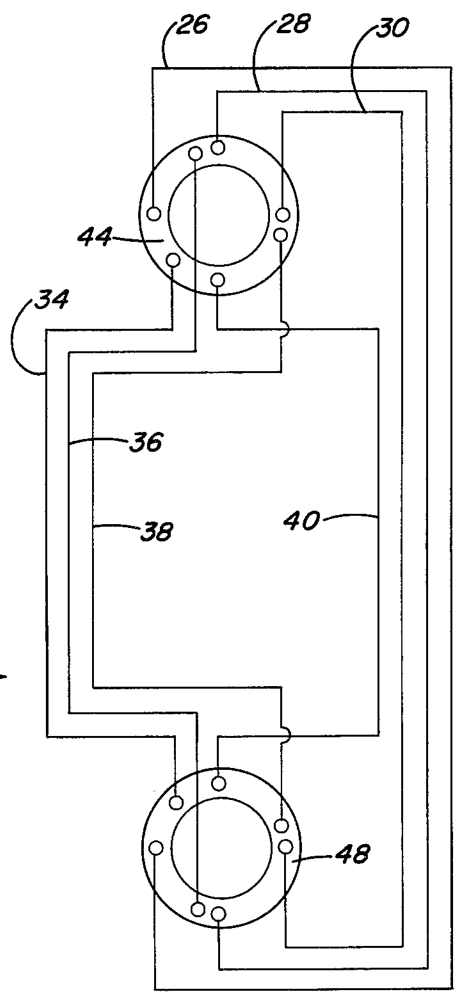

FIG. 6

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SPIRAL TUBE HEAT EXCHANGER

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18 Claims. (Cl. 165—135)

This invention relates to gas counterflow type heat exchangers primarily for cryogenic applications.

In general, the present invention relates to improvements in Hampson heat exchangers of the type wherein a first gaseous flow is passed through a plurality of layers of coaxially disposed spirally wound tubes and a counterflow of a second gas is passed through the heat exchanger housing in heat exchange relationship with the outer surfaces of the spirally wound tubes.

In accordance with the present invention, the heat exchanger is provided with a novel outer passage construction that conducts the previously mentioned outer counterflows in spiral paths in heat exchange relationship with the outer surfaces of spirally wound tubes.

This novel passage construction is highly advantageous in that it forces the counterflowing gas to follow relatively long spiral paths as compared to passing the flows along uncontrolled paths extending longitudinally through the exchanger.

As another advantage, the novel spiral outer passage construction is assemblied in a novel manner from materials of low thermal conductively which insulate, one from another, the adjacently positioned outer paths and thereby eliminate tube to tube heat migration.

As another advantage, the novel spiral path construction is uniquely formed by a series of overlapping arcuate segments which, when assembled, form spirally extending spaced ribbons in combination with flexible filler strips that form mounts for the overlapping spiral segments and which also form an arcuate outer wall for outer passages surrounding the spiral tubes.

It is, therefore, an object of the present invention to provide a compact heat exchanger of increased efficiency for any given physical length that incorporates a spirally extending outer passage construction which forces the counterflowing gas to follow spirally extending and thence longer heat exchange paths for any given heat exchanger length.

It is another object of the present invention to provide a spiral tube heat exchanger that includes a novel outer spiral passage construction which conducts the counterflowing gas through relatively long spiral passages that are thermally insulated, one from another, whereby intertube heat migration is substantially eliminated.

It is another object of the present invention to provide a spiral tube type heat exchanger that combines a maximum in fluid to metal contact with a minimum of pressure drop.

It is another object of the present invention to provide a spiral tube heat exchanger that includes a novel spiral outer passage construction formed of overlapping arcuate segments mounted by resilient filler strips which provide a spirally extending inter passage thermal insulation that can be readily installed in surrounding relationship with tubes of spiral configuration.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein

a preferred form of embodiment of the invention is clearly shown.

In the drawings:

FIG. 1 is a perspective view of a heat exchanger constructed in accordance with the present invention;

FIG. 2 is a broken sectional view, partially in section of a heat exchanger constructed in accordance with the present invention, the section being taken along the vertical plane through the axial centerline of the apparatus;

FIG. 3 is a typical partial sectional view showing in detail the outer spiral passage construction of the present invention, the section being taken along a vertical plane through the axial centerline of the exchanger;

FIG. 4 is a partial top sectional view of the heat exchanger of the preceding figures, the section being taken along the line 4—4 of FIG. 3;

FIG. 5 is an exploded broken perspective view showing the construction of the heat exchanger of the preceding figures; and

FIG. 6 is a diagrammatic view showing the parallel circuitry for the spiral tubes of the present heat exchanger.

Referring in detail to the drawings, FIG. 1 illustrates a heat exchanger constructed in accordance with the present invention that includes in FIG. 2, an inner tubular core 20 around which is wound an inner layer of three parallel spiral tubes indicated generally at 22.

An inner layer cover 24 surrounds inner layer 22, the later comprising three individual tubes 26, 28 and 30, best seen in FIG. 5 and diagrammatically illustrated in FIG. 6.

A second or outer layer of four parallel tubes is generally indicated at 32 and includes individual tubes 34, 36, 38 and 40, said tubes being surrounded by an outer layer cover 42.

Each of the upper ends of the tubes in the inner layer 22 and outer layer 32 are connected to an inlet manifold 44 that is in turn connected to the exterior of the exchanger by an inlet tube 46 and the lower ends of the tubes are connected to an outlet manifold 48 which is in turn connected to the exterior of the exchanger by an outlet tube 50.

The counterflow of gas enters intake tube 51 in chamber 52, said chamber being formed by cover 42. The flow next enters a plurality of passages 54, 56 and 58 surrounding each of the inner tubes 26, 28 and 30 and a plurality of outer passages 60, 62, 64 and 66 surrounding each of the outer tubes 34, 36, 38 and 40.

The gaseous counterflow leaves the outer passages via an upper chamber 68 and an outlet tube 70.

Some of the inlets for the outer passages are shown at 72 and 74 in FIG. 5 and one of the outlets for these passages is shown at 76 in FIG. 2.

Reference is next made to FIGS. 3 and 4 which illustrate in detail the outer passage construction of the present invention which is formed by a spirally extending assembly of overlapping arcuate segments formed of micarta sheet material or other suitable material having low thermal conductivity, such as a suitable fabric impregnated with a resinous composition. One of these arcuate micarta segments is indicated at 78 in FIGS. 3 and 4 and includes an end portion 80 in overlapping relationship with an adjacent arcuate micarta segment 84. The inner edge of the segment is mounted in a slot formed in an inner flexible filler strip 86 and an outer edge of the strip is mounted in a slot in an outer flexible filler strip 88. Two such filler strips 86 and 88 are required between adjacently positioned tubes and are formed of synthetic rubber, extruded plastic, or other suitable low thermal conductivity material.

With continued reference to FIGS. 3 and 4, each of the spiral tubes, such as tube 36 illustrated in section in FIG. 4, includes a plurality of radially outwardly extending fins 90 and a plurality of radially inwardly extending fins 92 which serve to increase the gas to metal surface contact area, said outer fins 90 serving the additional function of centering the spiral tubes within their respective outer annular passages.

In general, it should be pointed out that in the particular example illustrated, the inner layer of tubes 22 comprises three individual tubes and the outer layer of tubes 32 comprises four individual tubes, each of the outer tubes being of higher pitch, since the outer spiral is of greater diameter in order to provide substantially equal axial lengths for all of the inner and outer tubes. With this arrangement, it will be understood that all of the inner and outer heat exchange paths, extending between the manifolds 44 and 48 will be substantially the same length. Hence, all of the spiral paths will have substantially the same resistance to flow, and the heat exchange load will be equally distributed between the individual tubes.

The heat exchanger of the present invention is fabricated by first prewinding each of the inner spiral tubes 26–30 and each of the spiral outer tubes 32–40 around a metal form which is smaller in diameter, by a calculated amount, than the final spiral diameter to allow for springback of the tubing. One of the inner spiral tubes 30 is next mounted on inner tubular cord 20 and one of the inner filler strips 86 is laid in place, in spiral configuration for the entire length of tube 30.

The outer inner tubes 26 and 28 are next screwed into a place around core 20 with respective filler strips 86 being successively laid in place between the two.

The overlapping arcuate segments of sheet micarta, or the like, are inserted between the inner tubes with the inner edges of the segment 78 pressed down into the spiral grooves in the inner filler strips 86.

The outer filler strips 88 are next wound in between the inner tubes, with the outer edges of segments 78 disposed in the inwardly facing slots in the outer filler strips 88.

The inner layer cover 24 is next positioned over the inner tubes and the above described assembly steps are next carried out for the outer layer 32 comprising the individual spiral tubes 34–40.

The manifolds 44 and 48, and plates 94, 96 and 98 and the inlet and outlet tubes 50, 51, 46 and 70 are next mouted in place and the outer layer cover 42 is wrapped around the outer layer to complete the assembly.

In operation, the first gaseous flow enters the exchanger at inlet tube 46 and passes through manifold 44 where it is distributed to the seven inner passages formed by the seven spiral tubes. The inner flow leaves the exits of the seven inner passages via manifold 48 and outlet conduit 50.

The counterflow enters the exchanger at inlet conduit 51, passes through chamber 52 and then enters the outer annular passage surrounding the outer tubes. This outer flow is released from the exchanger via chamber 68 and outlet conduit 70.

The exchange of heat between the two flows occurs through the walls of the spiral tubes with the flexible strips and spiral micarta segments serving to substantially eliminate heat transfer between the adjacent outer annular passages.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

We claim:

1. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration; a plurality of outer tubes in parallel spiral configuration; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means between each adjacent pair of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the outer surfaces of said inner tubes; spiral insulating wall means between each adjacent pair of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the outer surfaces of said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages, each of said spiral insulating wall means being formed by two coextensive flexible filler strips disposed in confronting edge to edge relationship.

2. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration, each of said inner tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a plurality of outer tubes in parallel spiral configuration, each of said outer tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means between the fin ends of each adjacent pair of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the fins on said inner tubes; spiral insulating wall means between the fin ends of each adjacent pair of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the fins on said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages, each of said spiral insulating wall means being formed by two coextensive flexible filler strips disposed in confronting edge to edge relationship.

3. In a heat exchanger the combination of a plurality of tubes surrounding an inner wall in parallel spiral flow configuration; spiral insulating wall means between each pair of said plurality of separate tubes and forming a plurality of spirally extending annular passages each of which surrounds a respective one of said spiral tubes; and an outer wall surrounding said tubes and insulating wall means, each of said spiral insulating wall means being formed by two coextensive flexible filler strips disposed in confronting edge to edge relationship.

4. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration; a plurality of outer tubes in parallel spiral configuration; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between each adjacent pair of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the outer surfaces

of said inner tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between each adjacent pair of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the outer surfaces of said outer tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots; a first manifold operatively connected to said inner and outer spiral tube for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

5. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration, each of said inner tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a plurality of outer tubes in parallel spiral configuration, each of said outer tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between the fin ends of each adjacent pair of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the fins on said inner tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between the fin ends of each adjacent pair of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the fins on said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

6. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration; a plurality of outer tubes in parallel spiral configuration; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between each adjacent pair of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the outer surfaces of said inner tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots and comprising a plurality of arcuate segments having overlapping ends; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between each adjacent pair of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the outer surfaces of said outer tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots and comprising a plurality of arcuate segments having overlapping ends; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

7. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration, each of said inner tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a plurality of outer tubes in parallel spiral configuration, each of said outer tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between the fin ends of each adjacent pair of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the fins on said inner tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots and comprising a plurality of arcuate segments having overlapping ends; spiral insulating wall means formed by spaced resilient spiral filler strips provided with fronting open ended slots and being interposed between the fin ends of each adjacent pair of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the fins on said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

8. In a heat exchanger the combination of a plurality of tubes surrounding an inner wall in parallel spiral flow configuration; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between each pair of said plurality of tubes and forming a plurality of separate spirally extending annular passages each of which surrounds a respective one of said spiral tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots; and an outer wall surrounding said tubes and insulating wall means.

9. In a heat exchanger the combination of a plurality of tubes surrounding an inner wall in parallel spiral flow configuration; spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between each pair of said plurality of tubes and forming a plurality of separate spirally extending annular passages each of which surrounds a respective one of said spiral tubes; a thin spiral layer of low thermal conductivity material mounted in said open ended slots and comprising a plurality of arcuate segments having overlapping ends; and an outer wall surrounding said tubes and insulating wall means.

10. In a heat exchanger the combination of a pair of parallel spiral tubes each of which includes fins on the outer surface thereof; and a spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between confronting ends of said fins and forming separate spirally extending annular passages each of which surrounds a respective one of said spiral tubes; and a thin spiral layer of low thermal conductivity material mounted in said open ended slots.

11. In a heat exchanger the combination of a pair of parallel spiral tubes each of which fins on the outer surface thereof; and a spiral insulating wall means formed by spaced resilient spiral filler strips provided with confronting open ended slots and being interposed between confronting ends of said fins and forming separate spirally extending annular passages each of which surrounds a respective one of said spiral tubes; and a thin spiral layer of low thermal conductivity material mounted in said open ended slots and comprising a plurality of arcuate segments having overlapping ends.

12. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration; a plurality of outer tubes in parallel spiral configuration; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means between each adjacent pair of said inner tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the outer surfaces of said inner tubes; spiral insulating wall means between each adjacent pair of said outer tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the outer surfaces of said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

13. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration, each of said inner tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a plurality of outer tubes in parallel spiral configuration, each of said outer tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means between the fin ends of each adjacent pair of said inner tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said inner tubes and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the fins on said inner tubes; spiral insulating wall means between the fin ends of each adjacent pair of said outer tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said outer tubes and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the fins on said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

14. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration; a plurality of outer tubes in parallel spiral configuration; a tubular wall interposed between said inner tubes and

said outer tubes; spiral insulating wall means between each adjacent pair of said inner tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said inner tubes, said thin spiral layer comprising a plurality of arcuate segments having overlapping ends, and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relation-insulating wall means between each adjacent pair of said outer tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said outer tubes, said thin spiral layer comprising a plurality of arcuate segments having overlapping ends, and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the outer surfaces of said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

15. A heat exchanger comprising, in combination, a plurality of inner tubes in parallel spiral configuration, each of said inner tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a plurality of outer tubes in parallel spiral configuration, each of said outer tubes including a plurality of fins extending radially outwardly from the outer surface thereof; a tubular wall interposed between said inner tubes and said outer tubes; spiral insulating wall means between the fin ends of each adjacent pair of said inner tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said inner tubes, said thin spiral layer comprising a plurality of arcuate segments having overlapping ends, and forming separate spirally extending annular passages for conducting return flows of fluid in heat exchange relationship with the fins on said inner tubes; spiral insulating wall means between the fin ends of each adjacent pair of said outer tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said outer tubes, said thin spiral layer comprising a plurality of arcuate segments having overlapipng ends and forming separate spirally extending annular passages for conducting a return flow of fluid in heat exchange relationship with the fins on said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the flows from said inner and outer spiral tubes; a first chamber open to one end of said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages.

16. In a heat exchanger the combination of a plurality of tubes surrounding an inner wall in parallel spiral flow configuration; spiral insulating wall means between each pair of said plurality of tubes including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said tubes and forming a plurality of separate spirally extending annular passages each of which surrounds a respective one of said spiral tubes; and an outer wall surrounding said tubes and insulating wall means.

17. In a heat exchanger the combination of a pair of parallel spiral tubes each of which includes fins on the outer surface thereof; and a spiral insulating wall means interposed between confronting ends of said fins including

a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said tubes and forming separate spirally extending annular passages each of which surrounds a respective one of said spiral tubes.

18. In a heat exchanger the combination of a pair of parallel spiral tubes each of which includes fins on the outer surface thereof; and a spiral insulating wall means interposed between confronting ends of said fins including a thin spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between each of said tubes, said thin spiral layer comprising a plurality of arcuate segments having overlapping ends and forming separate spirally extending annular passages each of which surrounds a respective one of said spiral tubes.

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