United States Patent

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[54] **HEAT EXCHANGE MEANS**
24 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **165/159,** 165/125, 165/160, 165/162
[51] **Int. Cl.** **F28d 7/00**
[50] **Field of Search** 165/125, 145, 155, 162

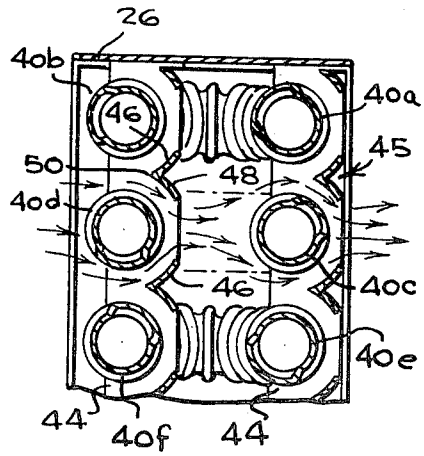
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ABSTRACT: A heat exchanger is provided with horizontally and vertically aligned exchange tubes through which a heat exchange liquid or gas flows with the tubes being of thin-walled construction in the form of a through-the-wall spiral and with a plurality of elongated slats connecting the tube segments to maintain fixed relative spacing with baffle means extending between the slat members on the downstream side of the tubes with respect to a fluid flowing over the exterior of the tubes with the baffles being formed of two arcuately shaped wedge components for directing the fluid flow around the downstream side of the tubes to provide heat flow through substantially the entire tube body with the tubes being arranged in circular array and linear array in two embodiments; in another embodiment the tubes are supported in parallel vertical array so that the external fluid flows along the length of the tubes and a plurality of wave-shaped baffles are mounted between the tubes to direct the gas flow back and forth over the tubes as the flow moves generally along the length of the tubes.



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SHEET 1 OF 3

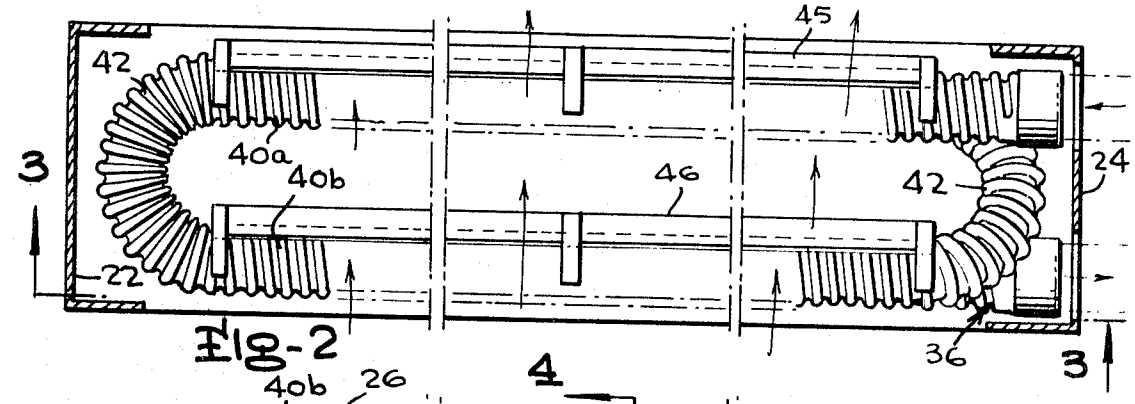


Fig-2

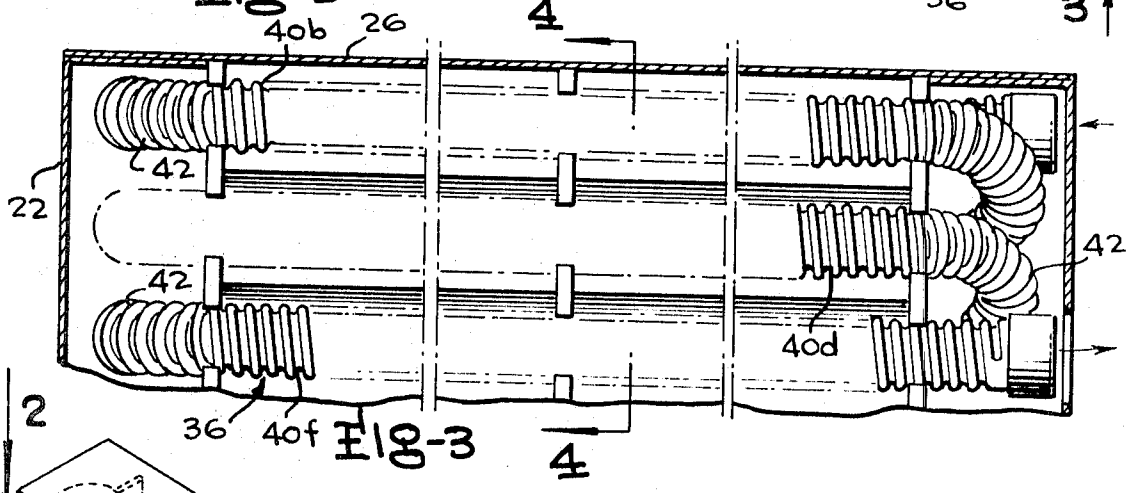


Fig-3

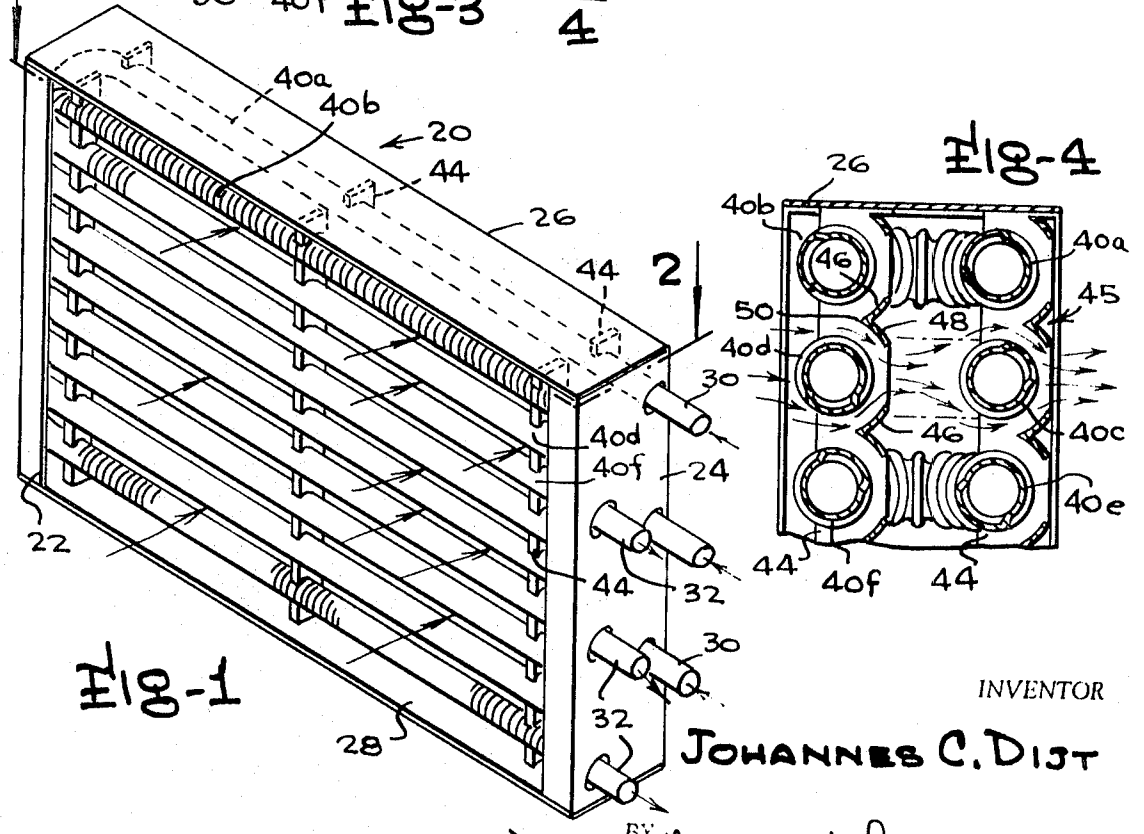


Fig-1

Fig-4

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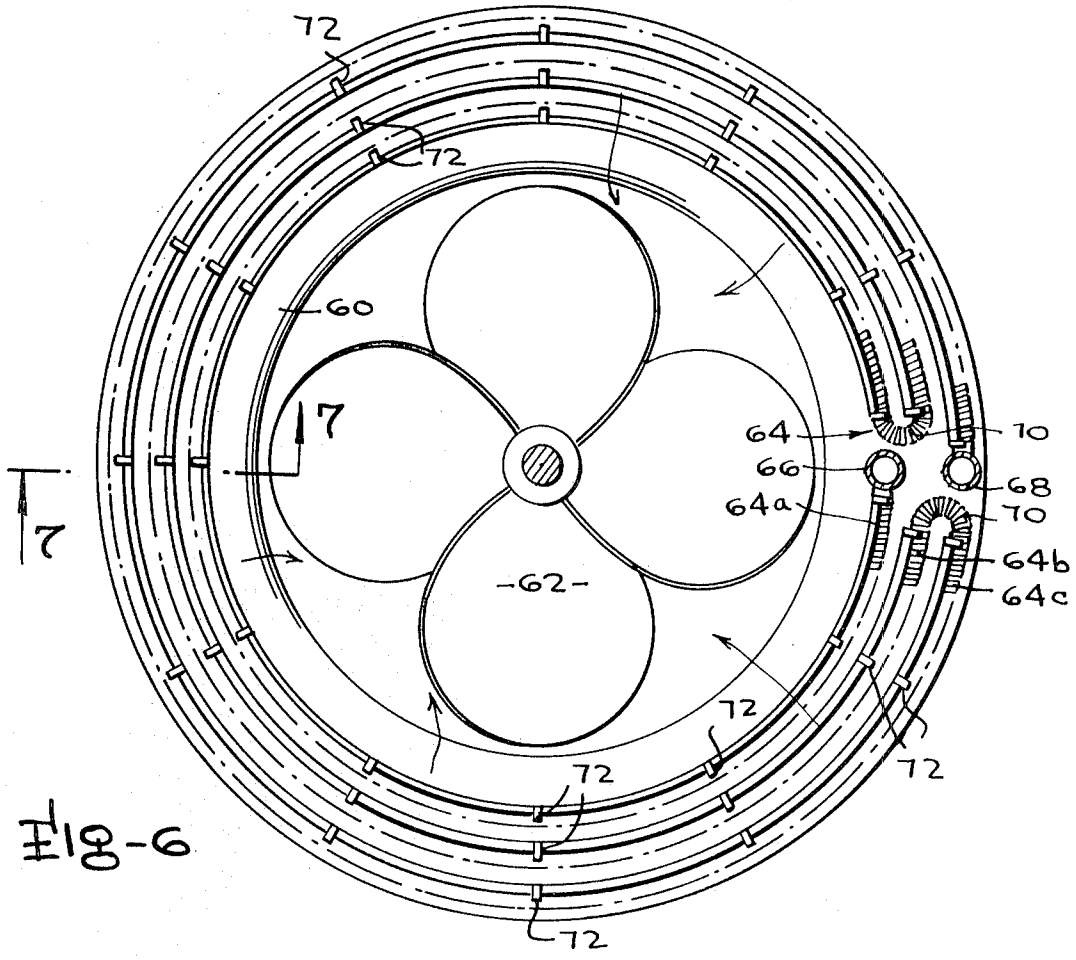


Fig-6

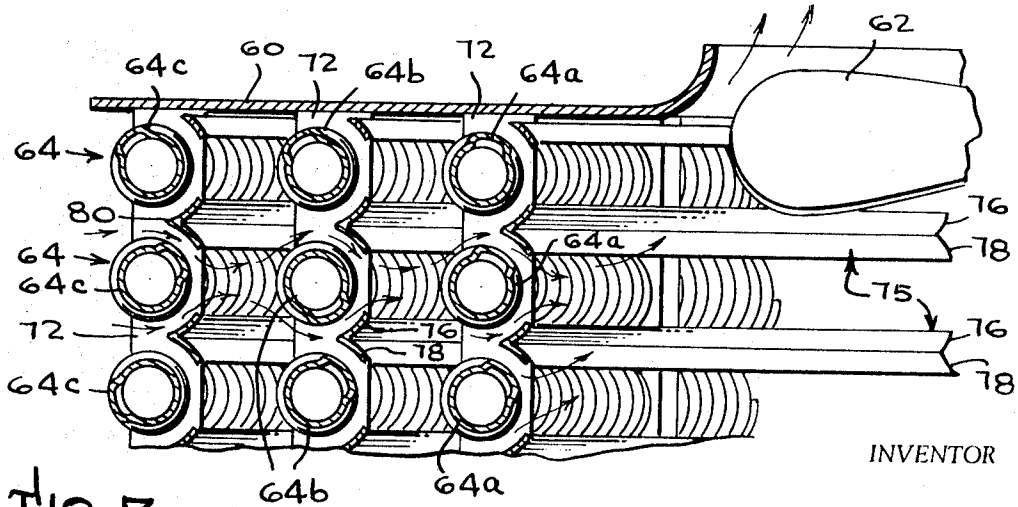


Fig-7

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Fig-9

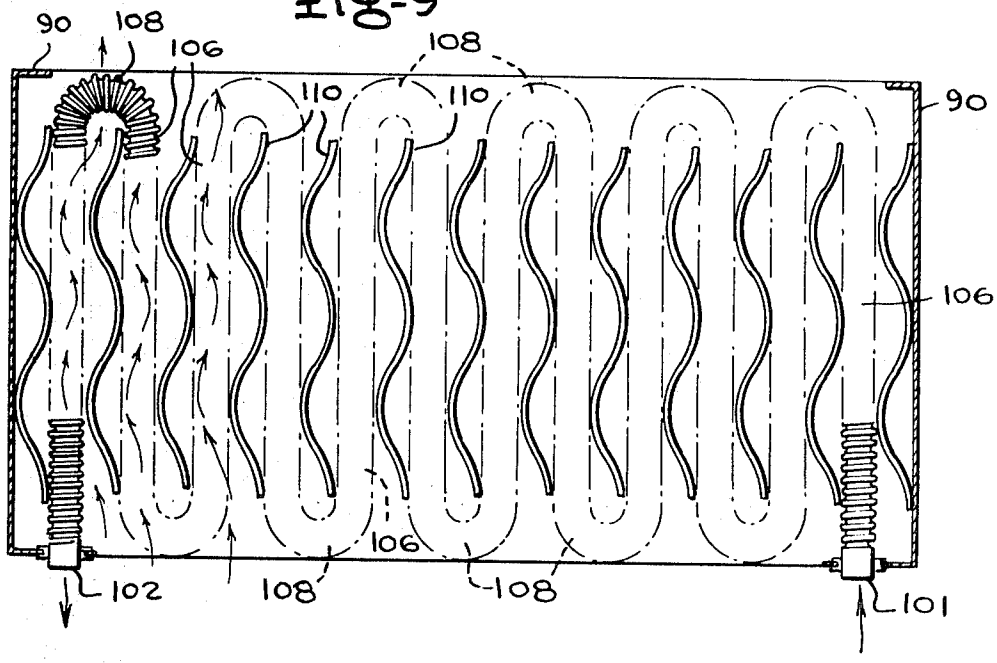
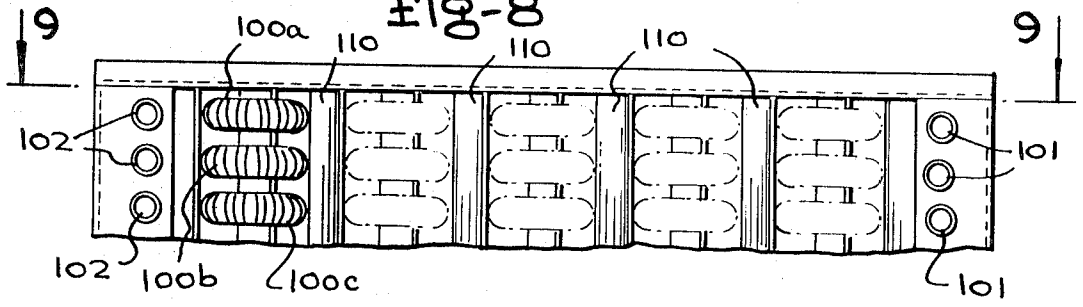


Fig-8



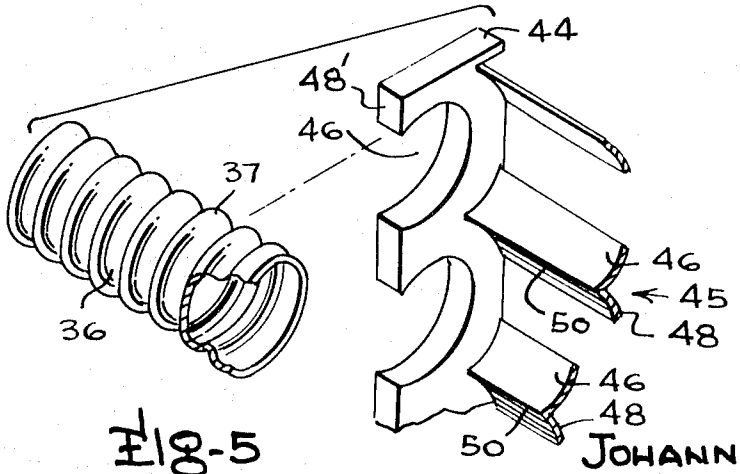


Fig-5

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HEAT EXCHANGE MEANS

BACKGROUND OF THE INVENTION

This invention is in the field of heat exchangers and is specifically directed to improved systems of heat exchange in which heat flow is effected through heat exchange tubes in which an internal heat transfer liquid medium is flowing with a second fluid flow moving past the tubes externally for exchange of heat through the tube wall between the internal fluid and the external fluid.

Prior known heat exchangers have assumed a wide variety of forms and have consequently provided wide variations in reliability, thermal efficiency, volumetric efficiency and cost of construction and operation. One measure of a heat exchanger's efficiency is the cost of construction of the unit per thermal unit of transfer capability which is usually expressed in terms of cost per ton of refrigeration. Many varying designs have been proposed in a continuing effort to lower the cost per ton. Additionally, there has been a never ending quest for heat exchangers having a high degree of thermodynamic heat transfer efficiency regardless of the dollar cost per thermal flow capacity. Such units are required in specialized fields such as in aircraft and other vehicles or devices having space or weight limitations.

Probably the greatest demand for heat exchangers having a low dollar cost per thermal flow capacity is in the field of air conditions for automobiles, buildings and the like. Moreover, it is particularly desirable that heat exchangers employed in automobile air-conditioning systems be of as small a size as is practically possible while maintaining the required thermal flow capacity.

By far the most common form of heat exchanger currently employed is the plain tube construction in which a plurality of thin fins are attached to the exterior surface of the tube to increase the contact area with fluid flowing over the exterior surface of the tubes and the associated fins. The capacity of systems of this type is increased by the area of the fins which provide a substantially large surface for the absorption and transfer of heat. Such finned tubes devices have assumed a wide variety of forms; for example, many exchangers employ individual circular fins on each tube each fin being individually associated with only one tube. Other finned heat exchangers have employed continuous plate fins connecting and extending between a plurality of tubes extending substantially perpendicular to the plates. Heat exchangers of the last-mentioned type require that the fluid flowing over the external surface of the tubes flow perpendicular to the tubes and are of substantial difficulty to clean when the plates are closely spaced and fins are corrugated to improve capacity.

The great majority of refrigerant cooling coils as used in air-conditioning units are constructed of copper tubes with which aluminum fins are associated. However, a number of the more recently developed systems have employed aluminum tubes and aluminum fins due to the increased cost of copper. The heat flow capacity of heat exchanger depends on several variably factors. One such factor is turbulence both inside and outside of the tube surface. In the finned tube heat exchanger construction external turbulence is accomplished by making the fins of corrugated material which expedient has been found to increase the capacity over flat fins by as much as 10 percent in exchangers having the same surface dimensions and tube spacing operated under identical conditions. Additionally, internal turbulence can be achieved in plain tube constructions by the employment of inserts mounted on the inside of the tube to increase the turbulence of the fluid flowing through the tube. Unfortunately, such inserts create an additional impediment to fluid flow on the inside of the tube and consequently result in additional pumping power requirements.

One of the factors in the cost of constructing conventional copper tube and aluminum baffle heat exchangers is caused by the fact that the tubes cannot be bent from a unitary piece of tubing to provide several parallel linear tube sections connected to provide a continuous flow path. Consequently, parallel linear tube sections must be welded to U-shaped connections on the ends of the copper tubes to provide a continuous flow path. Such connections are necessitated by virtue of the fact that the copper tubes must be open ended in order to allow assembly to the aluminum fins and expansion of the copper tubes by means of mechanical or hydraulic expanders, necessary to provide a permanent bond between the tubes and fins.

Additionally, prior known heat exchangers of the type in which heat exchanger tubes extend across a fluid flow path are arranged with the tubes being staggered in unaligned relationship so that no tube would be immediately behind the tube immediately upstream from it in order to improve fluid contact with the tube surface. Yet most of the heat transfer effected by the fluid passing over the finned tube surface is transmitted through the fins as said fluid has more contact with the fin area than with the tubes. Since the fluid inside the tube must transfer its thermal energy to the fluid passing over the outside of the finned tubes, or vice versa, the quantity of such transfer is related to the metal thermal resistance of the fin and tube assembly. Thermal resistance in turn is directly related to the length of heat transfer travel and to heat transfer quantity. The ineffective use of the heat exchange surface in the prior known designs has caused the necessity of providing more surface and the use of expensive metals in order to obtain better volumetric capacity.

The present invention provides a heat exchanger system in which low-cost tube materials can be employed while retaining, and actually improving upon, the thermal efficiency of prior known systems employing expensive materials having high thermal conductivity (k) factor. Such employment has been made possible by the combination of very thin corrugated metal tubes in combination with baffles so directing the fluids that effective use of all the surface provided is obtained and turbulence is provided to cause maximum heat transfer efficiencies.

Additionally, the subject invention provides a heat exchanger system that is easily assembled with a minimum of labor and a consequent savings in final cost. The instant invention thus provides a system which has high thermal efficiency as well as an improved cost efficiency as compared to the prior known devices.

SUMMARY OF THE INVENTION

It is the primary object of this invention to provide new and improved heat exchange means.

Obtainment of the object of this invention is enabled in one embodiment through the provision of a heat exchanger in which a unique continuous heat exchange tube is formed of extremely thin-walled metal such as stainless steel alloys having a high modulus of elasticity and a suitable k factor. The tube is in the form of a continuous helical through-the-wall spiral construction extending from the external wall to the internal wall of the tube. A long unitary section of the tube can be bent back and forth across a gaseous flow path to provide long sections that are horizontally and vertically aligned with plastic support elements being provided for maintaining the tubes in aligned relationship. Adjacent ones of the support elements are provided with flow baffles extending parallel to the long tube sections and downstream of the tube sections with respect to the external fluid flow with each one of the flow baffles being in the form of two arcuate baffle plates which intersect at an apex extending along a line equidistant from each of the tubes with which that particular baffle is associated. The arcuate baffles serve to direct the fluid flow around the downstream side of each of the tubes so that efficient heat exchange between fluid flowing through the tubes and fluid flowing around the tubes is enabled through substantially the entire surface of the tubes. The convoluted external surface of the tube provides substantial turbulence and heat exchange capability fully equivalent to conventional prior tube and fin

assemblies. Moreover, the internal convolutions provide internal liquid turbulence without the necessity of employing separate inserts and the like. The elongated tube sections and their associated arcuate baffle members can be either linear or curved along their length as the case may be in different embodiments.

Additionally, the convoluted tube is employed in another embodiment with the gaseous flow being along the length of the tube elements and wave-type baffle members being located between adjacent tube portions for directing the gaseous flow back and forth across the tube as the gas generally traverses along the length of the tube sections. Here again, substantial improvements in cost and thermal efficiencies are enabled by the inventive construction.

Probably the most significant aspect of the subject inventive concept is the realization that greater thermal and cost efficiency can be achieved with low-cost thin-walled tube materials which have sufficient strength by virtue of the material employed and the continuous body wall spiral geometric configuration of the tube than is possible with prior tube materials having greater thermal transfer capacity but which require a greater wall thickness. Another significant aspect of the subject inventive concept resides in the combination of such tube constructions with the per se inventive baffling means which enables a heat flow through substantially the entire area of aligned tubes both on the upstream and downstream sides of the tube with respect to the fluid flowing transversely across the tubes.

It has been found that the subject invention, when employing a tubing having 6.5 square feet of area, is capable of providing heat flow capacity equal to the capacity of a prior conventional copper tube-aluminum fin system having 58.5 square feet of total transfer area (the total of the tubing surface and the fin surface). Therefore, it is readily apparent that the subject invention provides substantial volumetric efficiency over the prior known designs. Additionally, the low weight inventive tubing of the invention enables the construction of heat exchangers which weigh only 2 pounds per ton of capacity as compared to 7 pounds per ton of prior known copper tubing-aluminum fin constructions. Therefore, there can be no doubt that the subject invention represents a vast improvement over the prior known heat exchange devices in volumetric weight and thermal efficiency. Moreover, vast savings in cost are enabled by the subject invention which can be constructed much more economically than can conventional copper tubing and aluminum baffle heat exchangers since there is a great savings in material and manufacturing costs by the elimination of welding and other assembly operations. For these reasons, there can be no doubt that the instant invention truly represents a giant step forward in the art of heat exchangers.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one embodiment of this invention;

FIG. 2 is a sectional view taken along lines 2—2 of FIG. 1;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2;

FIG. 4 is a sectional view taken along lines 4—4 of FIG. 3;

FIG. 5 is an exploded perspective view illustrating a tube section and associated supporting and baffle means;

FIG. 6 is a top view of another embodiment of the inventive concept;

FIG. 7 is a sectional view taken along lines 7—7 of FIG. 6;

FIG. 8 is an elevational view of another embodiment of the inventive concept; and

FIG. 9 is a sectional view taken along lines 9—9 of FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Attention is initially invited to FIG. 1 of the drawings which illustrates a first embodiment 20 of the subject invention. This embodiment is in the form of a generally rectangular heat exchanger with a plurality of linear tube sections shown illustrated in a horizontal orientation.

Heat exchanger 20 comprises a rectangular tube supporting frame formed of first and second vertically oriented end channels 22 and 24 which are connected by a top plate 26 and a bottom plate 28. The end frame members 22 and 24 and the top and bottom plates 26 and 28 are connected to each other by any conventional means such as welding, riveting of the like when said elements are formed of metal. Moreover, in some installations, the frame can be formed of plastic or the like and the parts could be adhesively or other wise conventionally secured together. In any event, end frame member 24 is provided with a plurality of apertures through which fluid inflow lines 30 and fluid outflow lines 32 extend for connection to heat exchange tube members 36 supported on the interior of the frame members.

The heat exchange tubular members 36 are of thin-walled flexible construction and are preferably formed of material having a high modulus of elasticity in the order of at least 29×10^6 and having a heat transfer k factor in the order of at least 14.4 with the walls having a thickness of less than 0.012 inch ranging down to the order of 0.004 inch. It is necessary that the modulus of elasticity be sufficiently large to enable the tube to be constructed with sufficiently thin walls as will enable obtainment of the required heat flow capacity for the particular wall. In other words, the heat flow capacity per unit area of the tube and per dollar cost is increased by using very thin walls of strong material but relatively low thermal conductivity rather than through the use of highly conductive material which requires much thicker and heavier walls due to its low strength characteristics. Therefore, the high-heat conductivity desired is achieved by the use of thin walls of moderate heat transfer capability as opposed to the use of a material of high-heat transfer capability which requires thicker and heavier wall construction. For example, series 400 stainless steel (as defined in the American Society For Testing & Material definition A 240–67) having a thickness in the order of 0.005 inch provides a heat flow capacity far in excess of that possible with prior known copper tube and aluminum fin systems which tubes have a minimum wall thickness of 0.016 inch. Each of the tubular members 36 is in the form of a continuous through-the-wall spiral convolution 37 (FIG. 5) extending along its entire length which strengthens the tubing to enable the use of the extremely thin walls. The convolution extends from the exterior to the interior of the tubing member so that ridges on the outer surface correspond to the troughs on the inner surface and vice versa. While stainless steel of the aforementioned type has proven to be extremely satisfactory for practice of the invention, the tubing material is not limited to such material and other alloys could be employed. Moreover, galvanized or copper coated carbon steel would also function satisfactorily.

Each unitary tubular member 36 is in the form of a plurality of linear sections 40 extending across the width of the exchanger and which are connected on their ends by U-shaped bent portions 42. It will be noted that each unitary tubing member 36 of the embodiment of FIGS. 1–4 comprises two linear sections 40*a* and 40*b* in the uppermost horizontal plane, two intermediate sections 40*c* and 40*d* in an intermediate horizontal plane and two bottom sections 40*e* and 40*f* in a lower plane with the end of one of the bottom sections being connected to the outflow line 32. Therefore, it will be seen that each unitary tubing member 36 provides a total of six horizontal linear tube sections that are connected by five U-shaped portions 42. The tubing construction is such that a unitary member can be bent to assume the shapes illustrated in FIG. 2 and 3 with there being no need for welding, brazing or the like for connecting the respective linear portions 40. Additionally, it should be noted that the upstream sections 40*b*, 40*d* and 40*f* lie and the downstream sections 40*a*, 40*c* and 40*e* are respectively oriented in common vertical planes as shown in FIG. 4. Similarly, the linear sections 40*a* and 40*b* lie in a common upper horizontal plane as to the sections 40*c* and 40*d* which lie in a common intermediate horizontal plane and the sections 40*e* and 40*f* which lie in a lower horizontal plane. Therefore, it will be readily apparent that all of the tube sec-

tions are in aligned array in a manner to enable an easy cleaning of the outer surface thereof.

It should be understood that any number of linear sections 40 can be provided from unitary tubing members 36 in accordance with the desired functional characteristics of the particular heat exchange system. Moreover, it should also be understood that the terms "horizontal plane" and "vertical plane" are directional only in the sense as they are applied to the orientation of the preferred embodiment as shown in the drawings and these planes could actually be any two mutually perpendicular planes if the illustrated exchanger should be reoriented at an angle different from that shown in the drawings.

Positioning means is provided for maintaining the flexible tubing 36 in the illustrated position shown in FIGS. 1–4. The positioning means comprises a plurality of elongated slats 44 (FIG. 5) which extend between the top plate 26 and the bottom plate 28 and each of which includes a plurality of circular apertures 46 which intersect the forward edge 48' of the slat. Apertures 46 are dimensioned so that the tubing 36 can be snapped into the apertures and retained therein with the minimum of difficulty. Baffle members 45 in the form of elongated horizontally extending arcuate sections 46 and 48 joined along an apex line 50 extend between the respective slat members 44. The baffle members 45 and slats 44 are of unitary plastic construction and are dimensioned so that the juncture of the elements 46, 48 at line 50 is positioned horizontally parallel to the axes of the linear tubing sections 40 with line 50 being vertically positioned in a plane midway between the axes of the two sections 40 mounted immediately upstream of the baffle member. The foregoing orientation will be readily apparent from inspection of FIG. 4.

Slats 44 serve to position the tubing in a horizontal flow of fluid such as air illustrated by the arrows in FIGS. 1, 2 and 4. It should be noted that the air flowing over section 40*d* engages the upstream side of the tubing as illustrated in FIG. 4 and is then directed around the rear or downward side of the tubing by the arcuate member 46 and 48 of the baffles 45 immediately above and below the rear side (downstream) of the section 40*d*. The flow then continues downstream to engage linear section 40*c* in the same manner with the baffle members immediately above and below the downstream side of the section 40*c* serving to direct the fluid against the rear or downstream side of that section in an obvious manner.

Therefore, it will be seen that the embodiment illustrated in FIGS. 1–5 provides a heat exchanger in which there is no necessity for welding or the like in the assembly of the exchanger and which provides parallel tube orientation in horizontal and vertical planes for enabling an easy cleaning of the exchanger. Moreover, the baffle members 45 direct the fluid flow about the exterior of the tubing on the downstream side of each of the linear sections so that effective heat flow is enabled through substantially the entire tubing portion. It should be noted that the embodiment illustrated in FIG. 1 employs three unitary tubing members 36 with three fluid inlets and outlets but that the number of such sections can be varied in accordance with the particular heat exchange characteristics desired.

FIGS. 6 and 7 illustrate a second embodiment of the invention in which flexible heat exchange tubes of identical construction to those of the previous embodiment are arranged in a circular manner with a central fan providing a flow of air radially with respect to the tubes. Specifically, a cowling 60 is provided to define the periphery of the exchanger and to guide air through same. A fan 62 serves to pull air radially inward across the tubing in the manner shown in FIG. 7. A unitary tubing member 64 is provided in an upper horizontal plane with connections being provided to an inlet header 66 and an outlet header 68 extending in a vertical manner. Tubing 64 is oriented in a plurality of circular sectors 64*a*, 64*b* and 64*c* which are concentric with respect to each other and which are oriented in a common horizontal plane as was noted previously. Connection between the various sectors of the tube elements 64 is enabled by a plurality of U-shaped bent portions 70 essentially identical to the previously discussed U-shaped bent portions 42.

Retention of the arcuate sectors 64*a*, 64*b* and 64*c* in position is enabled by a plurality of vertically extending support slats 72 which are essentially identical to the slats 44 previously discussed. However, baffling means 75 extending between the slats are provided in a manner analogous to the previously discussed baffling 45 with the baffling element 75 being arcuately curved along its axis to follow the arcuate curvature of the tubing sectors 64*a*, 64*b* and 64*c*. Specifically, the baffling comprises an upper arcuate sector 76 and a lower sector 78 which join each other at a common apex 80. It should be noted that the apex 80 is positioned midway in a vertical direction between the arcuate sectors lying in vertical alignment in adjacent horizontal planes.

A plurality of tubing elements 64 extend in stacked vertical alignment in spaced horizontal planes as shown in FIGS. 6 and 7 with the number of tubing elements being employed dependent upon the desired heat flow characteristics of the particular installation. It should also be noted that the arrangement shown in FIG. 7 consists of three horizontal planes in each of which a unitary tubing element 64 is mounted with each of the unitary tubing elements being provided with three arcuate sectors 64*a*, 64*b* and 64*c* with all of the sectors 64*c* having their axes lying in a common outer cylindrical surface, the sectors 64*b* having their axes in a common intermediate cylindrical surface and the sectors 64*a* having their axes in a common inward or smaller cylindrical surface.

The flow of air around the exterior of the tube sectors is radially inward and is consequently perpendicular to the orientation of the tube sectors. Additional arcuate sectors could be employed in each horizontal plane if such should be desired.

In any event, the curved baffle members 75 direct the flow of air about the upstream and downstream sides of each of the arcuate sectors in a manner analogous to the first embodiment so that heat transfer occurs throughout the entire wall portion of each of the sectors.

FIGS. 8 and 9 illustrate another embodiment of the invention in which a frame 90 supports a plurality of vertically aligned unitary tube members 100*a*, 100*b*, 100*c* etc. respectively oriented in stacked spaced horizontal planes in a flow of air or other fluid illustrated by the arrows in FIG. 9. The unitary tube members 100 include an inlet 101 and an outlet 102 for internal fluid and are formed of a plurality of linear portions 106 extending with their axes parallel to the direction of external fluid flow and connected by U-shaped bent connector portions 108. A plurality of wave-shaped spring type baffle members 110 are mounted between adjacent linear sections 106 and cooperate to direct the air flow back and forth across the linear sections as the air progresses generally along the length of the linear sections as shown in FIG. 9. Any number of linear sections can be employed in each unitary tube element 100 and any number of unitary tube members oriented in vertically spaced horizontal planes can be employed in accordance with the heat flow capacity desired of the particular installation.

The tubing elements employed in the embodiments of FIGS. 8 and 9 are formed of the same material and in the same manner as the previously discussed embodiments.

It should be understood that various modifications of the subject invention will occur to those skilled in the art but which will not depart from the spirit and scope of this invention as defined by the appended claims. For example, while the preferred tubing is formed of series 400 stainless steel, the tubing does not necessarily have to be formed of a stainless steel alloy and could be formed of other materials such as galvanized or copper coated carbon steel or other corrosion resistant metals with a sufficiently high modulus of elasticity to enable the material to be formed with sufficiently thin walls to give the required heat flow capacity and to be bent into the proper desired shape. Along these lines, it is noted that a plain

surface tube formed of the same material and having a wall thickness of the same order as that of the tubing employed in the instant invention would be incapable of being bent in the manner of the U-shaped portions of the subject invention. This is true because such plain tubing easily crimps when bent to any substantial degree. However, the formation of the tubing with the continuous spiral wall construction enables the tubing to be easily bent to remarkably acute angles without damage to the tube. Therefore, the combination of the particular material having a desired elasticity and thermal flow characteristics formed in the continuous spiral wall results in the superior performance of the instant inventive concept. Additionally, the employment of the support and baffle means in the various embodiments serves to enhance the functional characteristics of the tube concept.

I claim:

1. A heat exchanger system comprising tube positioning means including elongated tube support members supporting a plurality of heat exchange tubes in a flow of a first fluid passing over the tubes in an upstream to downstream direction generally transverse to the tubes for effecting a heat transfer between the fluid passing over the heat exchange tubes and a second fluid in the interior of said tubes and flow directing baffle means extending between adjacent elongated tube support members generally parallel to two of said heat exchange tubes on the downstream side of said two tubes for directing a flow of gas around the downstream portions of said tubes whereby substantial heat flow will be obtained through the entire surface of said heat exchange tubes wherein each of said flow directing baffle means has two flow-directing surfaces each of which is arcuately cross-sectionally shaped and is curved concentrically with respect to one of said two tubes and intersect along an apex line equidistantly spaced from and parallel to the axes of said two tubes between which each respective baffle is spaced.

2. The invention of claim 1 wherein each of said elongated support members comprises a slat member of rectangular cross-sectional configuration which has a plurality of circular apertures extending inwardly from one edge for clampingly receiving respective ones of said tubes.

3. The invention of claim 2 wherein said elongated support members and baffle members are integrally formed of plastic construction.

4. The invention of claim 3 wherein said heat exchange tubes are formed of strong, flexible thin-walled metal in the form of a continuous spiral body wall convolution extending through the wall along substantially the entire length of the wall.

5. The invention of claim 4 wherein said heat exchange tubes are formed of metal having a high modulus of elasticity of at least 29×10^6 and a heat transfer k factor of at least 14.4.

6. The invention of claim 4 wherein the wall thickness of said heat exchange tubes is less than 0.012 inch and said tube is formed of stainless steel alloy.

7. The invention of claim 1 wherein said heat exchange tubes are in the form of at least one continuous unitary length of tubing extending in a plurality of vertically and horizontally aligned linear segments connected by bent U-shaped segments with said support members being connected to said linear segments.

8. The invention of claim 7 wherein said two flow-directing surfaces are arcuately cross-sectionally curved concentrically with respect to one of said linear segments and intersect along an apex line equidistantly spaced from and parallel to the axes of two of said linear segments between which each of said respective baffle members is mounted.

9. The invention of claim 8 wherein each of said elongated support members comprises a slat member of rectangular cross-sectional configuration which has a plurality of circular apertures extending inwardly from one edge for clampingly receiving respective ones of said linear segments.

10. The invention of claim 10 wherein said elongated support members and baffle members are integrally formed of plastic construction.

11. The invention of claim 10 wherein said heat exchange tubs are formed of strong, flexible thin-walled metal in the form of a continuous spiral body wall convolution extending through the wall along substantially the entire length of the wall.

12. The invention of claim 11 wherein said heat exchange tubes are formed of metal having a high modulus of elasticity of at least 29×10^6 and a heat transfer k factor of at least 14.4.

13. The invention of claim 12 wherein the wall thickness of said heat exchange tubes is less than 0.012 inch and said tube is formed of a stainless steel alloy.

14. The invention of claim 1 wherein said heat exchange tubes extend in vertically aligned arcuate circular concentric sectors in respective spaced horizontal planes and said heat transfer medium flows around said tubes in a generally radial direction with respect to said sectors.

15. The invention of claim 14 wherein said two flow directing surfaces are curved concentrically along their length with respect to one of said arcuate circular sectors and intersect along an arcuate apex line equidistantly spaced from and parallel to the axes of two of said arcuate circular sectors between which each respective baffle is spaced.

16. The invention of claim 15 wherein each of said elongated support members comprises a slat member of rectangular cross-sectional configuration which has a plurality of circular apertures extending inwardly from one edge for clampingly receiving respective ones of said arcuate sectors.

17. The invention of claim 16 wherein said elongated support members and said baffle members are integrally formed of plastic construction.

18. The invention of claim 17 wherein said circular sectors lying in a common horizontal plane are connected by a plurality of U-shaped connector portions with said connector portions and said circular sectors being formed of a unitary piece of tubing.

19. The invention of claim 15 wherein said heat exchange tubes are formed of a strong, flexible thin-walled metal in the form of a continuous spiral body wall convolution extending through the wall along substantially the entire length of the wall.

20. The invention of claim 19 wherein the wall thickness of said heat exchange tubes is less than 0.012 inch and said tube is formed of stainless steel alloy.

21. The invention of claim 1 wherein said heat exchange tubes are formed of a strong, flexible thin-walled metal in the form of a continuous spiral body wall convolution extending through the wall along substantially the entire length of the wall.

22. The invention of claim 21 wherein said heat exchange tubes are formed of metal having a high modulus of elasticity of at least 29×10^6 and a heat transfer k factor of at least 14.4.

23. The invention of claim 20 wherein the wall thickness of said heat exchange tubes is less than 0.012 inch and said tube is formed of stainless steel alloy.

24 The invention of claim 23 wherein said tubing is formed of series 400 stainless steel alloy.