US 20020162649A1

(19) United States
(12) Patent Application Publication
Fineblum
(10) Pub. No.: US 2002/0162649 A1
(43) Pub. Date: Nov. 7, 2002

(54) DOUBLE VORTEX HEAT EXCHANGER

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(21) Appl. No.: **09/846,901**

(22) Filed: **May 1, 2001**

Publication Classification

(51) **Int. Cl.**[7] **F28F 13/12**; F28D 7/10
(52) **U.S. Cl.** **165/154**; 165/109.1

(57) **ABSTRACT**

An improved heat exchanger with two counter-flow passages, a first passage through a round, central tube and a second passage which is annular to the first flow passage. The fluids enter the passages tangentially or past swirl-generating foils at the tube entrance such that fluids are driven to flow in a vortex. The central tube contains a swirling flow of cooler fluid. The annular passage contains warmer swirling fluid flowing in the opposite axial direction from the cooler fluid. The purpose of the heat exchanger is to heat the cooler swirling fluid as it flows through the central tube or to cool the warmer swirling fluid as it flows through the annulus. In some embodiments, fins or other projections on the wetted surfaces of the tubes will be oriented to sustain vortex flow throughout the passages. In some embodiments the outlets may be tangential to recover the some of the kinetic energy of the vortex flow. The tangential outlets may be enlarged for still greater kinetic energy recovery. Heat transfer between the two fluids is stimulated because warmer portion of warm fluid in the annular passage will be driven inward toward the inner surface between annular passage and the inner tube and wherein colder, denser, portion of the colder fluid is forced outward by centrifugal force against the outer wall of the central tube to maintain the maximum temperature difference across the tube wall. Thus, heat transfer is enhanced in an energy efficient manner.

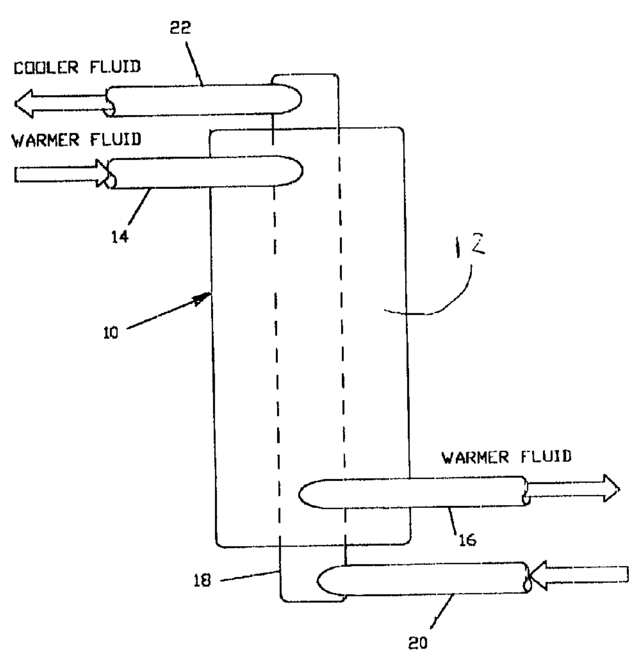


FIG. 2

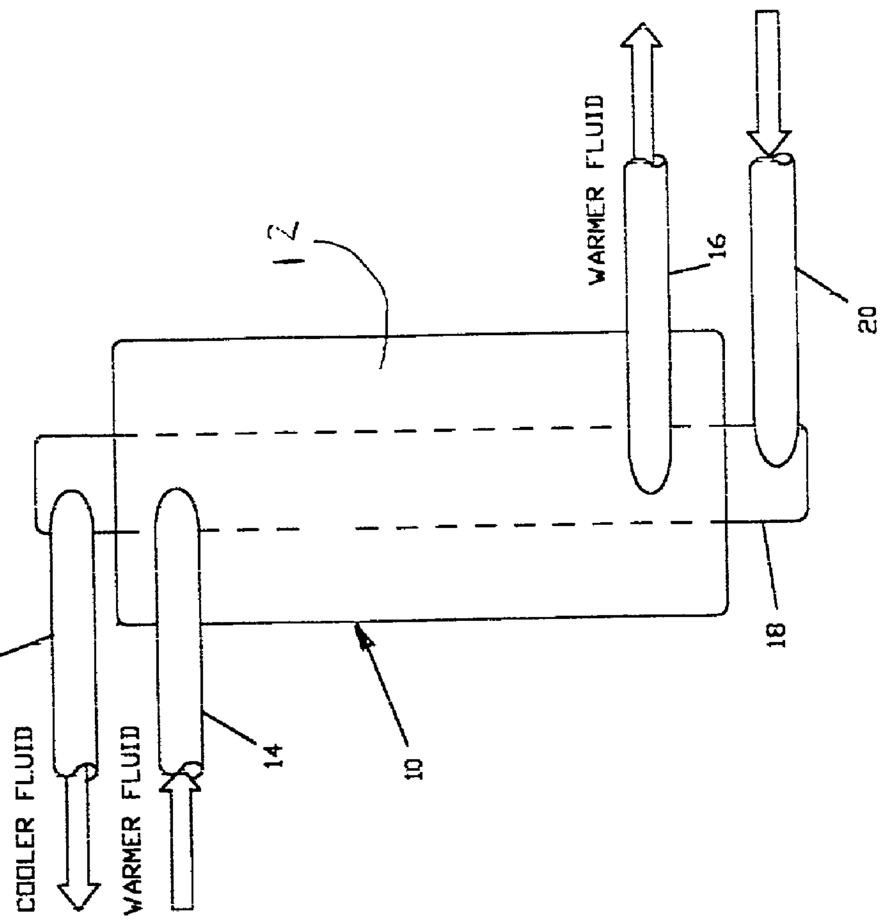
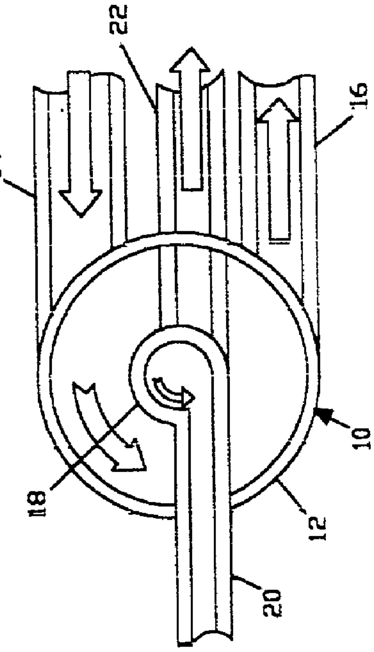
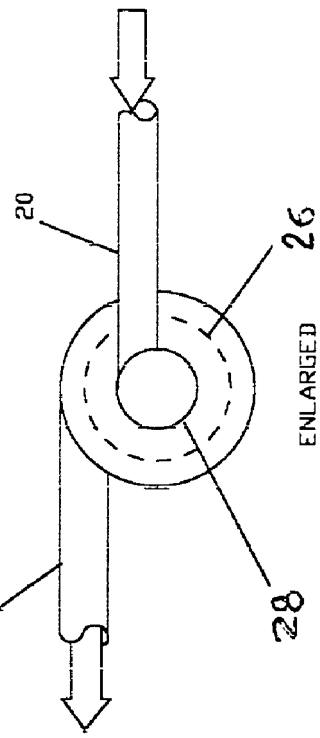

WARMER FLUID
COOLER FLUID
WARMER FLUID
12
16
20
18
22
14
10

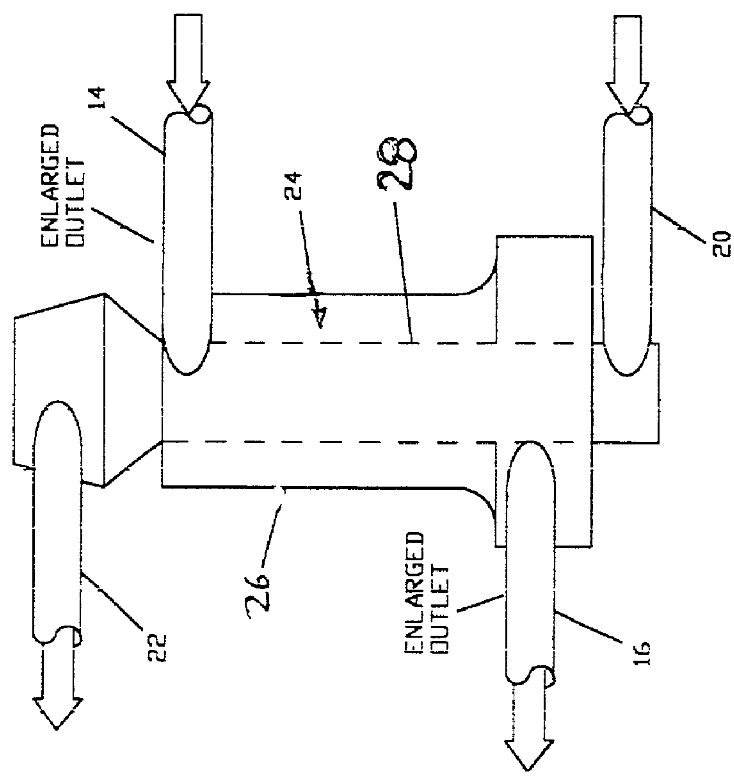
FIG. 1


22
14
16
18
10
12
20



20
26
ENLARGED OUTLET
28
16

FIG. 3B



ENLARGED OUTLET
14
24
28
20
26
22
ENLARGED OUTLET
16

FIG. 3A

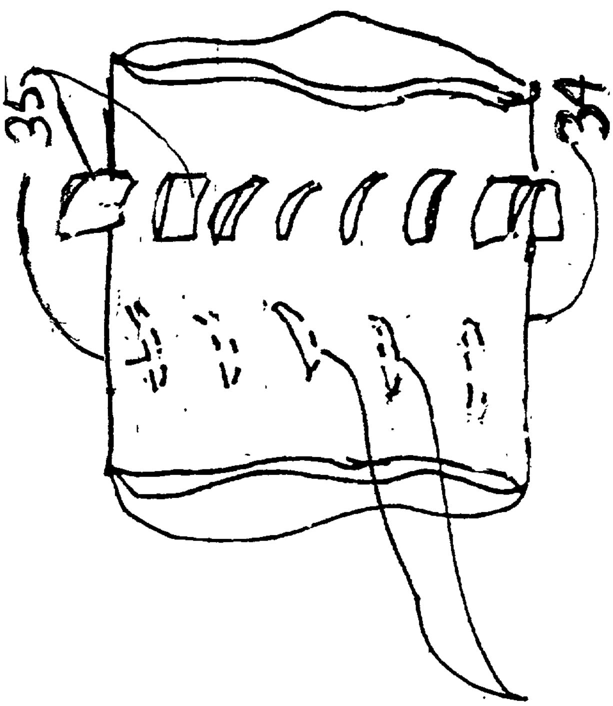


FIG. 5

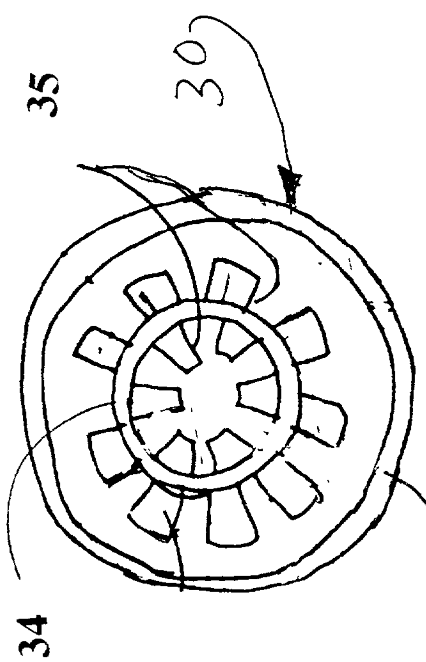
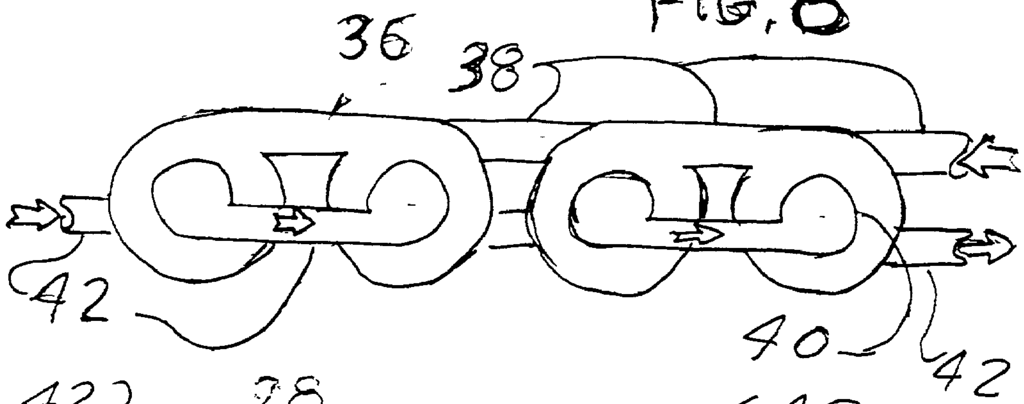


FIG 4

FIG. 6



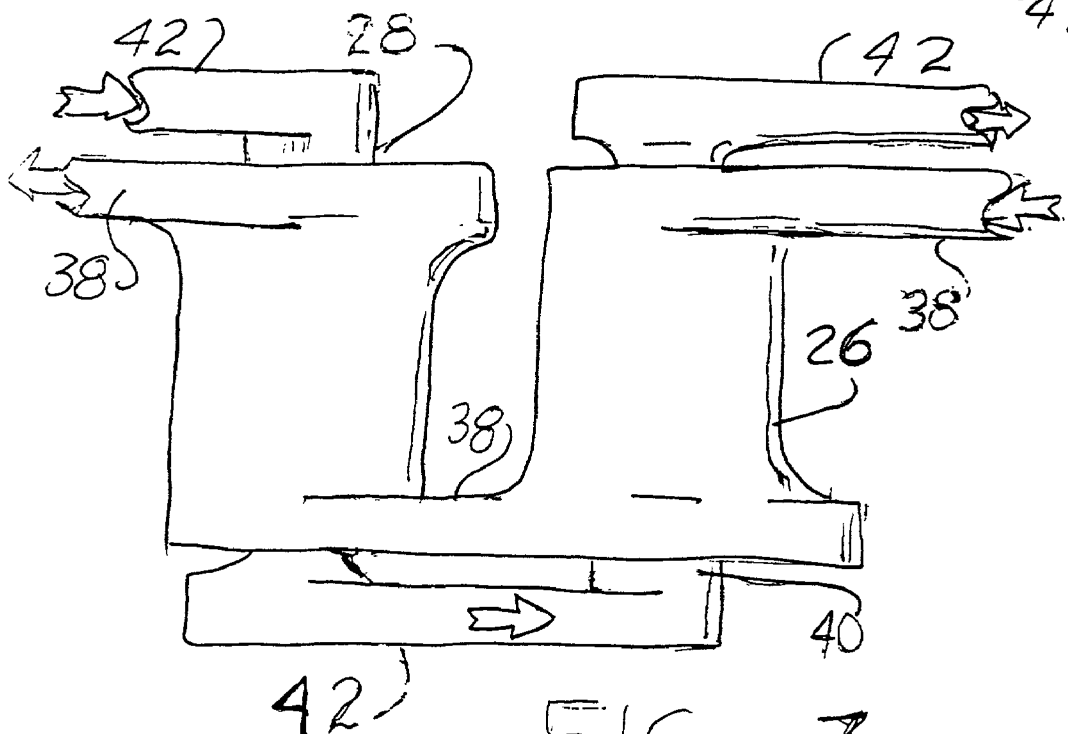


FIG. 7

DOUBLE VORTEX HEAT EXCHANGER

FIELD OF IMPROVEMENT

[0001] A fluid-fluid heat exchanger, in general, and a fluid-fluid heat exchanger with fluid paths in the form of a concentric double vortex, in particular. REFERENCE: DISCLOSURE DOCUMENT 472208, APR. 7, 2000

PRIOR ART

[0002] Present heat exchangers use fins and convolutions to increase the heat transfer area to augment heat transfer. Additionally, fins and other protrusions in the flow path of the fluids are shaped to stimulate increased turbulence which, in turn, stimulates heat transfer. However all such present measures for heat transfer augmentation, fins, convolutions and turbulence generators, increase the pumping work at approximately the same or greater rate at which heat transfer is augmented. Thus, the energy advantage of improved heat transfer is lost due to the additional energy required for increased pumping.

[0003] Some heat transfer devices have benefited from vortex flow within single tubes. The heat transfer on the inner surface is augmented by a factor of three or so. [1]Andrews, M. J., Fletcher L. S., "Comparison of Several Heat Exchangers", *J. Heat Transfer* November 1996 Vol 118, pg 901. [2] Blum, H. A. "Heat Transfer in a Decaying Vortex System" with L. R. Oliver, 1966 *ASME Winter Annual Meeting,* Paper 66-WA/HT-62, pg 5. [3] Ginwala, K. "Engineering Study of Vapor Cycle Cooling Equipment for Zero Gravity Environment" Senaha, I., "Augmentation of Heat Transfer in a Tube With an Inlet Blade Wheel"*Heat Transfer-Japanese Research,* v 23 n 5, 1994, pp 440-455

SUMMARY OF THE INVENTION

[0004] The heat exchanger augments the heat transfer between two counter flow passages; one passage through a round, central tube and a second passage which is annular to the first flow passage. The fluids enter the passages tangentially or past swirl-generating vanes at the tube entrance such that fluids are driven to flow in a vortex. The central tube contains a swirling flow of cooler fluid. The annular passage contains swirling warmer fluid flowing in the opposite axial direction from the cooler fluid. The purpose of the heat exchanger is to heat the cooler swirling fluid as it flows through the central tube and/or to cool the warmer swirling fluid as it flows through the annulus. In some embodiments fins or other projections on the one or both surfaces of the inner tube or the inner surface of the outer tube will be shaped and oriented to sustain vortex flow throughout the passages. In some embodiments the outlets may be tangential, and these tangential outlets may may be placed at enlarged tube ends. These enlargements in the exit plane permit the conversion of some of the kinetic energy of the swirl in into pressure energy which reduces pumping requirements.

[0005] Heat transfer between the two fluids is stimulated because warmer, less dense, portion of warm fluid in the annular passage will, by the effect of centrifugal fore, selectively flow inward toward the inner surface between annular passage and the inner tube and wherein colder, denser, portion of the colder fluid is forced outward by centrifugal force against the outer wall of the central tube to, thus, maintain the maximum temperature difference across the tube wall whereby heat transfer is enhanced.

[0006] If the ordinary fluid flow heat transfer coefficient for a tube 1 times the value of the Dittus-Boelter Equation with no heat transfer augmentation,

$$1/(1/1+1/1)=V_2=0.5$$

[0007] With vortex flow on both sides of a tube however,

$$1/(1/3+1/3)=1/(2/3)=1.5$$

[0008] where the the vortex flow stimulates a heat transfer rate three times that for straight flow. The tangential inlets and outlets may be at any angle. Thus, exterior elbows and the pressure losses of such elbows may be avoided.

OBJECTS OF THE INVENTION

[0009] A. Provide for the heat transfer augmentation of swirl flow to both hotter and cooler flow passages.

[0010] B. To provide for improved pressure recovery of fluid exiting flow passages.

[0011] C. To maintain vortex flow and heat transfer augmentation throughout the passages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **FIG. 1** is a cross-sectional view of a double vortex heat exchanger

[0013] **FIG. 2** is an exterior view of a double vortex heat exchanger.

[0014] **FIG. 3** contains two exterior views of a double vortex heat exchanger with tubes enlarged at the outlet ends.

[0015] **FIG. 4** is a cross-sectional view of a double vortex heat exchanger with turning vanes on wall of inner tube.

[0016] **FIG. 5** is a partial view of an inner tube of a double vortex heat exchanger with turning vanes on wall of inner tube.

[0017] **FIG. 6** is an end view of double vortex heat exchangers in series

[0018] **FIG. 7** is a side view of double vortex heat exchangers with enlarged outlet ends in series

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] **FIG. 1** is a cross-sectional view of a double vortex heat exchanger. A double vortex heat exchanger **10** comprises an outer tube **12**, an annulus inlet tube **14**, an annulus outlet **16**. an inner tube **18**, an inner tube inlet **20** and an inner tube outlet **23**. These components interact such that warmer fluid tangentially enters the annulus within outer tube **12** through annulus inlet **14** such the fluid in the annulus within outer tube **12** is swirled. The resulting vortex flow generates a centrifugal force within the annulus within outer tube **12** such that the cooler denser portion of the fluid is directed outward and the warmer portion of the fluid is directed inward toward the cooler inner tube **18**.

[0020] Cooler fluid enters inner tube **18** through inner tube inlet **20** and is swirled such that the resulting vortex drives the cooler portion outward towards tube wall which is being heated by the warmer fluid within outer tube **12**. As a result the cooler portion of the cool stream and the warmer portion of the warm stream are in thermal contact for improved heat transfer as desired.

[0021] **FIG. 2** is a view of a double vortex heat exchanger. Double vortex heat exchanger **10** consists of a outer tube **12**, an annulus inlet tube **14**, an annulus outlet tube **16**, an inner tube (only the ends of which are visible) **18**, an inner tube inlet tube **20** and an inner tube outlet tube **22**. As a result of the centrifugal force within the vortex flows, the cooler portion of the inner cool stream and the warmer portion of the outer warm stream are in thermal contact for improved heat transfer as desired.

[**0022**] **FIG. 3** contains two exterior views of a double vortex heat exchanger **24** with tubes enlarged at the outlet ends. Higher temperature fluid enters the outer tube **26** through annulus inlet tube **14**, and leaves through the annulus outlet tube **16**. The lower temperature fluid swirls within the inner tube (only the ends of which are visible) **28** through an inner tube inlet **20** and leaves through inner tube outlet **22**. As a result of the centrifugal force within the vortex flows, the cooler portion of the inner cool stream and the warmer portion of the outer warm stream are in thermal contact for improved heat transfer as desired. In addition, the swirling fluid decelerates as it enters the enlarged outlets to the outer tube **26** and the inner tube **28** and, as a result, pressure will be recovered as in the diffuser of centrifugal pumps and blowers.

[**0023**] **FIG. 4** is a cross-sectional view of a double vortex heat exchanger **30** with outer tube **32** and inner tube **34** having attached turning vanes **35** on the inner wall of inner tube **34** and on the outer wall of inner tube **34**. The vanes add to effective heat transfer surface and also stimulate vortex flow so that such vortex flow and resultant heat transfer augmentation is maintained throughout the passages within the double vortex heat exchanger. Within very long tubes the vortex motion is gradually dampened unless maintained by turning vanes.

[**0024**] **FIG. 5** is a partial view of inner tube **34** with attached turning vanes **35**.

[**0025**] **FIG. 6** is an end view of double vortex heat exchanger assembly **36** with double vortex exchangers in series. Warm transfer tubes **38** transmit the warmer fluid between the outer tubes while cooler fluid circulates between inner tubes **40** through cool transfer tubes **42**.

[**0026**] **FIG. 7**. is a view of an assembly of double vortex heat exchangers with enlarged tube ends. The outer tubes **26** with enlarged tube ends are connected by warm transfer tubes **38** while the inner tubes **28** with enlarged tube ends are connected by cool transfer tubes **42**.

I claim:

1. A double vortex heat exchanger comprising an outer tube and an inner tube within said outer tube with tangential inlet to said outer tube with tangential inlet to said inner tube and with higher temperature fluid flowing tangentially into said outer tube and flowing in a swirling motion toward the outlet of said outer tube such that swirling motion generates a centrifugal force to drive the cooler, denser portion of the higher temperature fluid outward and which permits the warmer portion of the higher temperature fluid to flow inward toward the outer wall of said inner tube, and with lower temperature fluid flowing tangentially into said inner tube and flowing in a swirling motion toward the outlet of said inner tube such that swirling motion generates a centrifugal force to drive the cooler, denser portion of the lower temperature fluid outward toward outer wall of said inner tube and which permits the warmer portion of the lower temperature fluid to flow inward away from outer wall of said inner tube such that cooler portion of lower temperature fluid and the warmer portion of higher temperature fluid to both flow toward the outer wall of said inner tube whereby a maximum temperature difference and, consequently, a maximum rate of heat transfer is established between the two fluids as desired.

2. A double vortex heat exchanger as claimed in claim 1 further including tangential outlets from said tubes whereby some of kinetic energy of swirling fluid is and pumping energy is conserved as desired.

3. A double vortex heat exchanger as claimed in claim 1 further including fins on surfaces of said inner tube whereby heat transfer surface is increased and heat transfer is augmented as desired.

4. A double vortex heat exchanger as claimed in claim 2 with said tubes being enlarged in vicinity of said tangential outlets.

5. A double vortex heat exchanger as claimed in claim 3 with said fins being so oriented and so shaped as to divert fluid into a swirling flow path within said tubes.

6. A double vortex heat exchanger as claimed in claim 1 wherein the fluids within said tubes flow in relative counterblow.

7. A method of augmenting heat transfer between two fluids whereby the higher temperature fluid flows in a spiral path within an annulus around a circular tube or pipe wherein a lower temperature fluid is also flowing in a spiral path wherein centrifugal force in higher temperature fluid flowing in annulus causes cooler, denser portion of higher temperature fluid to flow outward away from outer surface of said tube or pipe and which permits warmer portion of higher temperature fluid to flow inward toward outer surface of said tube or pipe and such that lower temperature fluid flowing within said tube or pipe by reason of spiral flow path experiences centrifugal force which causes cooler, denser portion of lower temperature fluid to flow outward toward surface of said tube or pipe such that cooler portion of lower temperature fluid and warmer portion of higher temperature are adjacent on opposite sides of said tube or pipe whereby temperature difference is maximized and, heat transfer between higher temperature fluid and lower temperature fluid is maximized as desired.

8. A double vortex heat exchanger comprising an exterior circular duct, an interior circular duct centrally placed within said exterior circular duct, a vortex generating means at entrance of said exterior circular duct, a vortex generating means at entrance of said interior circular duct, a means of supply of higher temperature fluid to entrance of said exterior circular duct, a means of supply of lower temperature fluid to said interior circular duct, a means of removing cooled fluid from said exterior circular duct and a means of removing heated fluid from said interior circular duct.

9. A double vortex heat exchanger as claimed in claim 8 with said vortex generating means being in the form of turning vanes at entrance of said exterior circular duct and at entrance of said interior circular duct.

10. A double vortex heat exchanger as claimed in claim 8 with additional vortex generating means within said exterior circular duct and within said interior circular duct such that vortex flow is reenergized within said exterior circular duct and within said interior circular duct whereby vortex flow generated heat transfer augmentation will persist throughout double vortex heat exchanger as desired.

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