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(54) INTANK OIL COOLER

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(57) ABSTRACT

An intank oil cooler assembly comprises a plurality of manifold end connected, vertically stacked, elongated tubular panel subassemblies, containing structurally enhancing header manifold connector end post with external circular wide flanges, manifold intermediate spacer disc washers, and a base plate subassembly placed in a supporting bottom base position. Each thin-walled, tubular panel subassembly has header manifold inlet and outlet end sections, an internal central longitudinal flow channel region designed for conducting internal fluid flow, and also, has a turbulizer subassembly installed therein for causing internal fluid turbulization to optimize heat transfer. Each tubular panel subassembly is fabricated by laminating together paired, thin-walled plate elements having sidewalls embossed with dimpled exterior surface projections on their outer convex surface and axially corresponding reverse side dimpled depressions on their inner concave surface. Opposing tubular panel dimple surface projections are top end flattened and brazed externally together to position and form a geometrically desired fluid passageway between each thin-walled, tubular panel subassembly.

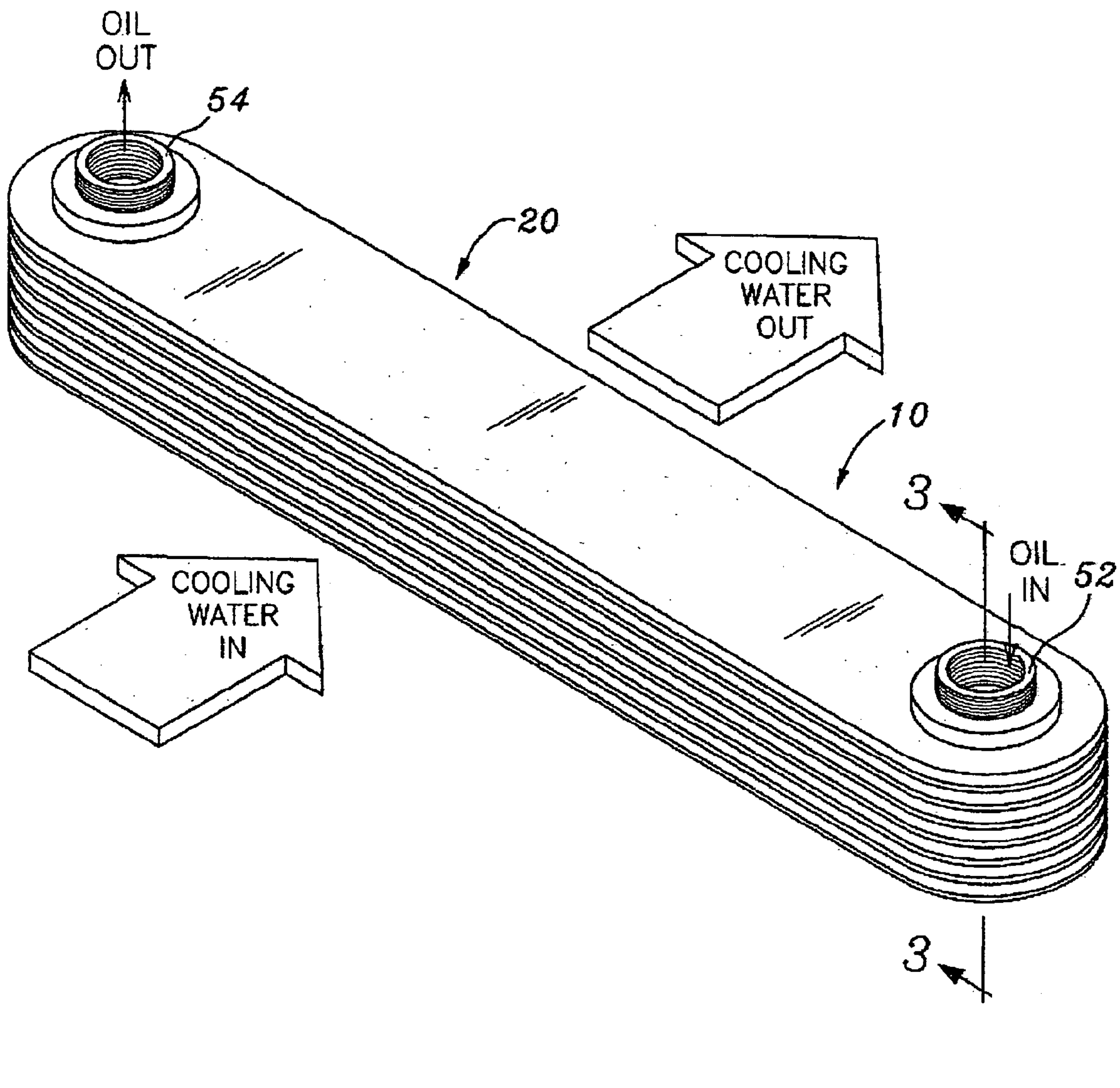
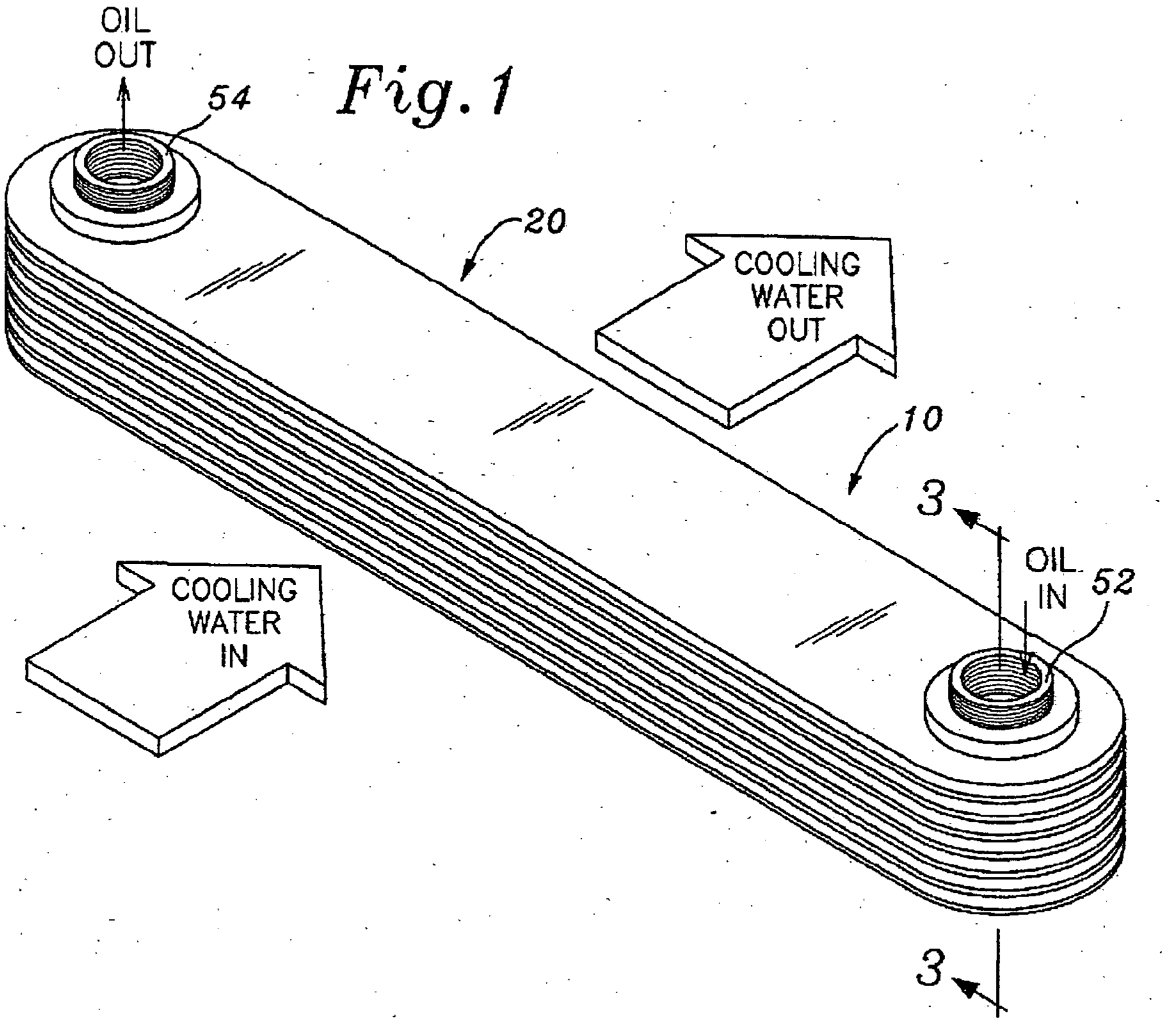


Fig. 1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OUT
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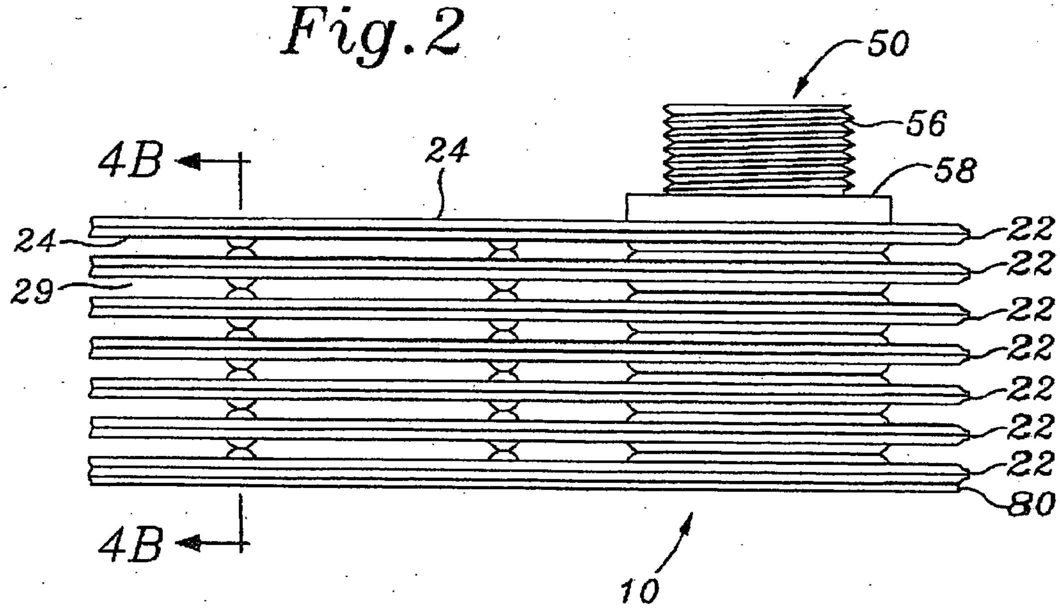
20
COOLING
WATER
OUT
10
3
OIL
IN
52
COOLING
WATER
IN
3

Fig. 2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56
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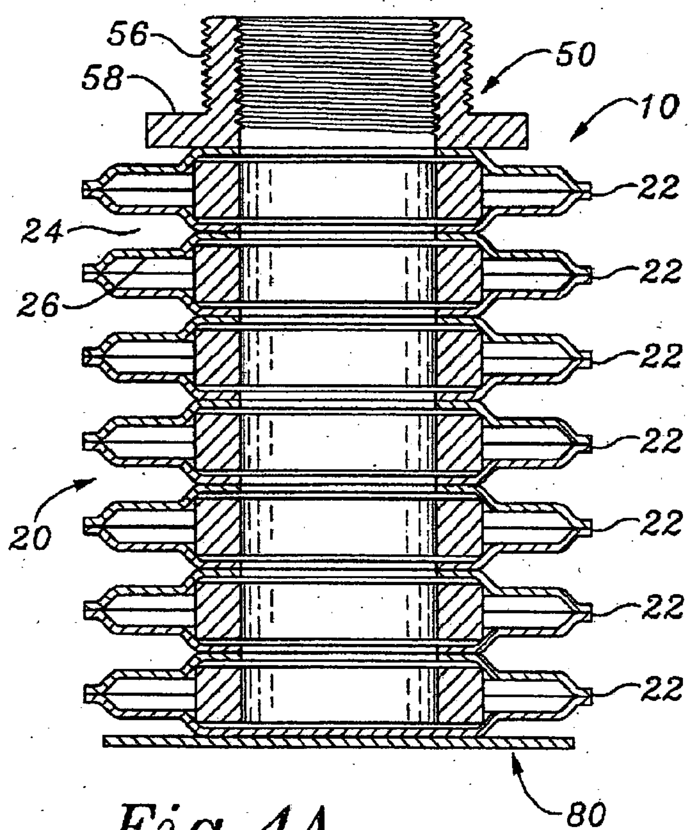
4B
24
24
29
22
22
22
22
22
22
22
80
4B
10

Fig.3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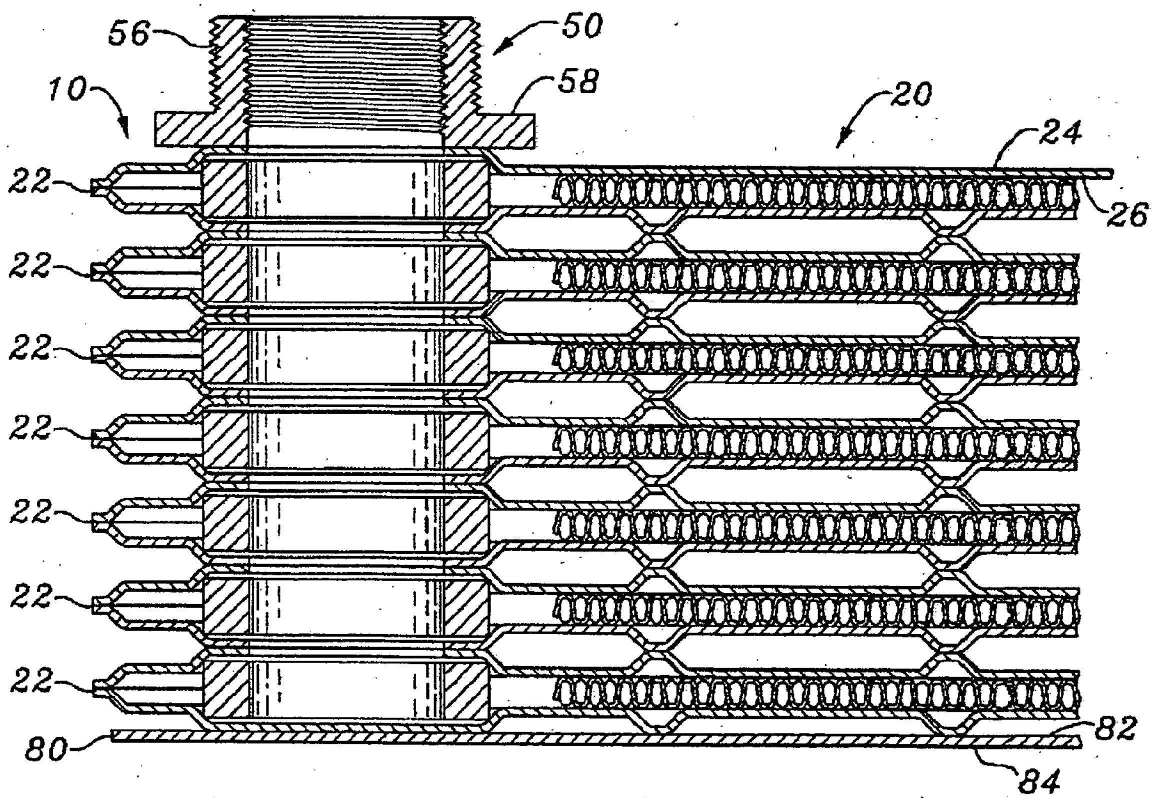
22
24
26
22
22
22
20
22
22
22
80

Fig.4A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10
58
20
24
22
26
22
22
22
22
22
22
80
82
84

Fig.4B

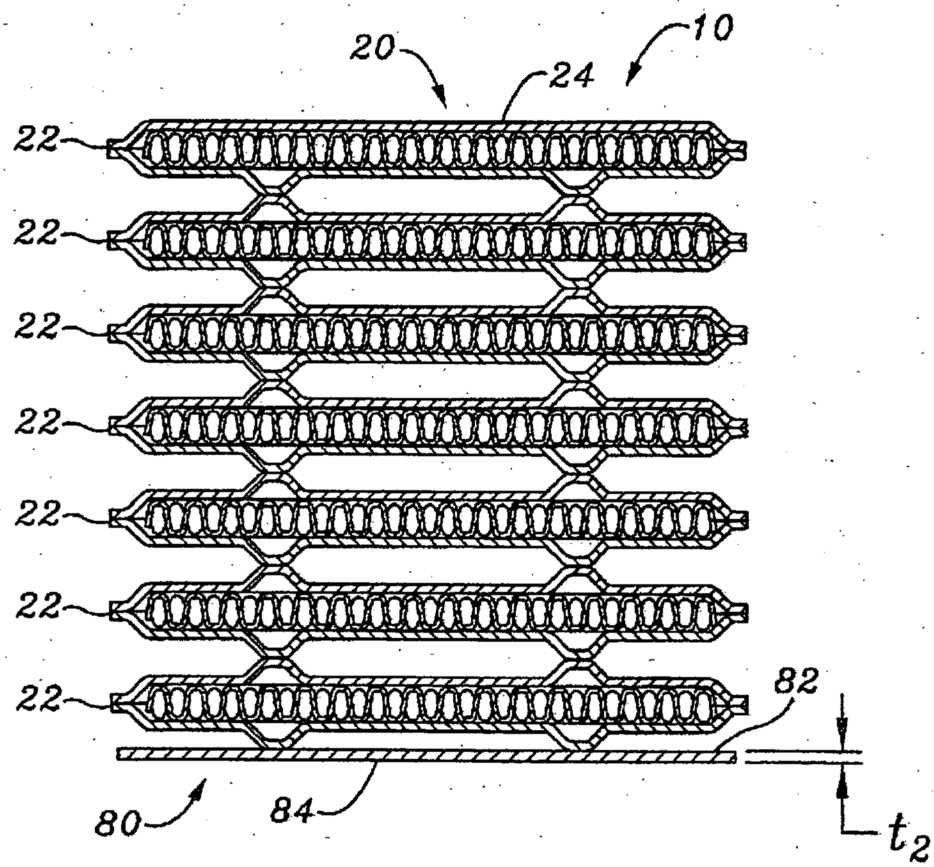
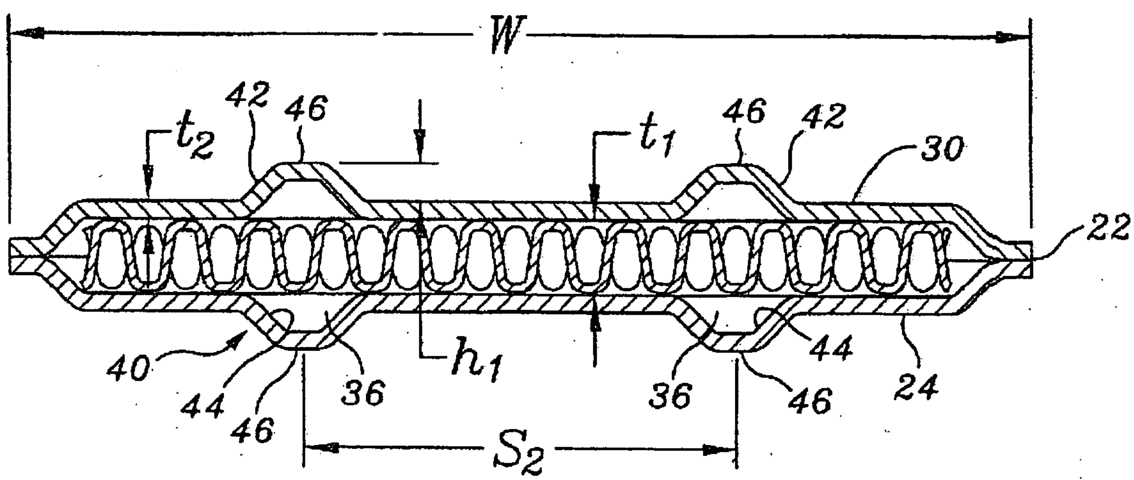

20
24
10
22
22
22
22
22
22
22
82
80
84
t_2

Fig.5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t_1
46
42
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22
40
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46
36
h_1
36
46
44
24
S_2

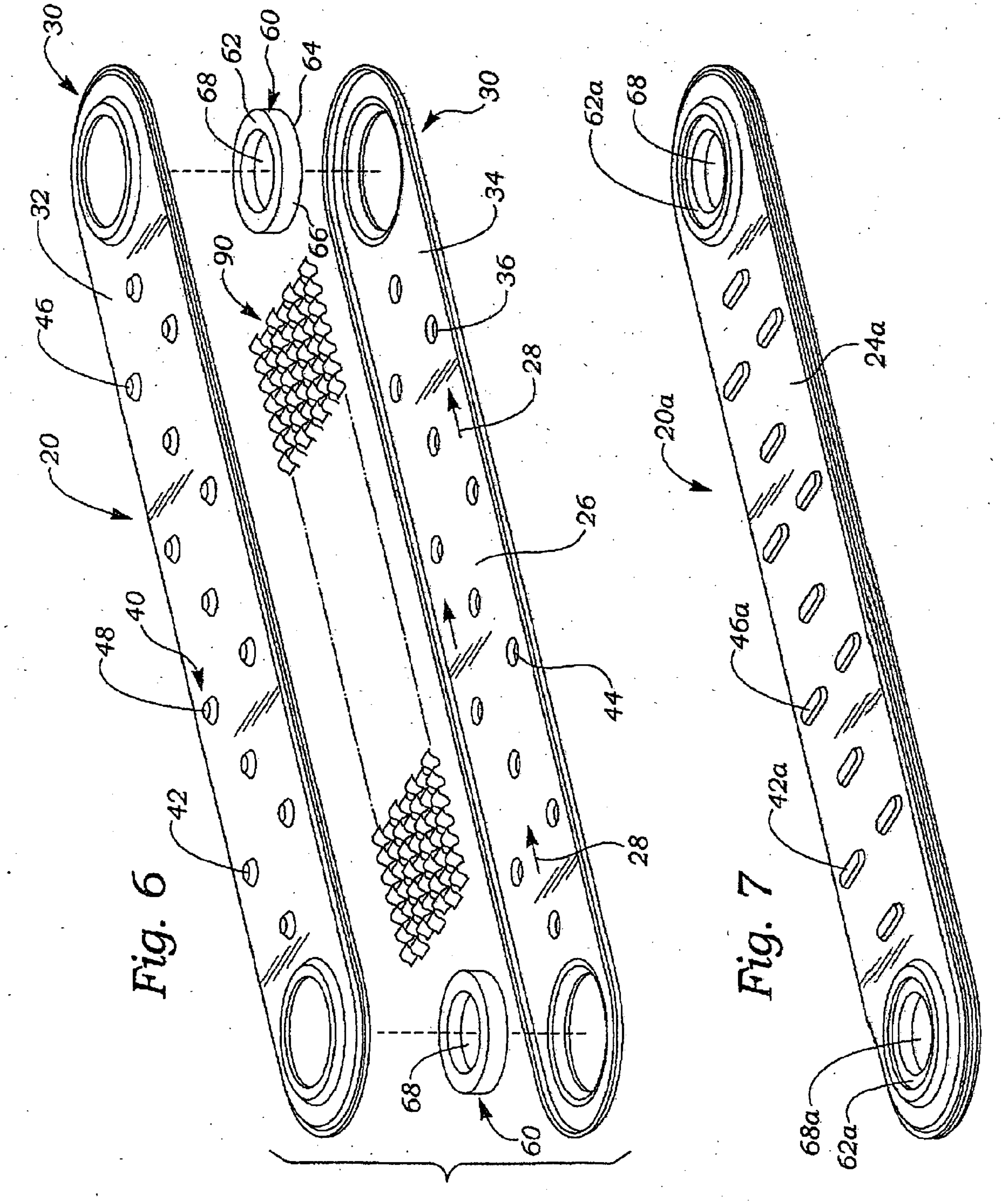
30
60
62
64
68
30
32
34
66
90
36
46
28
20
26
40
48
44
42
28
68
60
62a
68
24a
20a
46a
42a
68a
62a

Fig. 6

Fig. 7

INTANK OIL COOLER

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates generally to the field of heat exchangers, and more particularly to intank coolers.

[0003] 2. Background Discussion

[0004] Many different types of intank oil coolers are constructed comprising a vertical stack of individual, tubular panel subassemblies. These intank oil coolers, in general use, are used for heat transfer purposes in applications internal to a primary fluid system. This invention is applicable to intank oil cooler assemblies where the primary design consideration includes providing good heat transfer characteristics obtained from the in-series stacking of individual tubular type, paired plate, panel subassemblies, each having an interior longitudinal fluid flow channel containing therein an internal turbulizer subassembly for enhancing heat transfer. In these intank oil cooler assemblies, the individual tubular panels are vertically stacked parallel together in a series arrangement, and are fabricated with opposing inlet and outlet header sections end manifold ports and the inlet and outlet end header manifold port sections are interconnected, so that one end manifold port header region defines the fluid port inlet end for the acceptance of inlet fluid flow and the opposing header manifold fluid port set defines the fluid port outlet end for the discharge of the fluid flow.

[0005] In intank oil cooler applications having tubular type paired plate subassemblies, performance is optimized by increasing the heat exchanger effective surface area and decreasing tubular wall thickness to enhance heat transfer. Prior to lamination, the panel element surface is embossed with dimples which project externally outward in each of the embossed single panel elements and, in the past, usually required the heat exchanger paired plate panels to be thickened in sidewall thickness to withstand high fluid flow capacity and fluid pressure as required to effect the desired heat dissipation rate demanded by the heat generating source.

[0006] The novelty of the herein disclosed intank oil cooler assembly invention is that the subject intank oil cooler assembly is fabricated with comparatively thinner walled, tubular panel sidewalls to enhance heat transfer characteristics, without the inherent resulting structural weakness of thin-walled tubular panels. The structural design weakness of thin-walled tubular panels is overcome by providing structural enhancing manifold external circular wide retention flanges, manifold intermediate disc spacer washers, and a base stiffening plate to impart greater sufficient structural strength to the individual tubular panel subassemblies that are fabricated and stacked in vertical sequence, so that the series of minimized thin-walled paired plate tubular panel subassemblies optimize heat transfer, while the mounting connector end post, external circular wide retention flanges, manifold intermediate spacer disc washers, and the base plate overcome distortion, thereby minimizing intank oil cooler assembly size and weight, and further, reducing fabrication costs and installation space.

[0007] The inventor has determined for specific heat exchanger applications the proper design of the plate element thin-wall width thickness, the dimension of the external circular wide retention flanges, the dimensions of the manifold intermediate spacer disc washers, and the structural base plate dimensions, that in combination with the stacked individual tubular type, paired plate panel subassemblies achieve optimum performance from the intank oil cooler assembly design parameters. The placement of the manifold intermediate spacer disc washers in the manifold subassemblies decreases intank oil cooler assembly height, thereby minimizing cooler size, while providing the desired intank oil cooler heat dissipation design without comprising overall structural strength for each specific cooler application.

[0008] Furthermore, an internal turbulizer subassembly of varied construction types and design configurations can be installed internally within the tubular panel subassembly to achieve the desired degree of turbulation of internal fluid flow in the tubular panel interior channel region, thereby further improving customizing the intank cooler heat transfer characteristics.

SUMMARY

[0009] This intank oil cooler invention is fabricated with embossed paired sets of dimpled elongate, single thin-walled plate elements that are perimeter laminated together to form longitudinal elongate tubular plate panels having opposing header manifold end sections that are placed in parallel relationship in a vertical stack. The header manifold end sections are aligned with manifold intermediate spacer disc washers and sealed hermetically together, so that the proximal ends form a header manifold inlet port for accepting input fluid flow and the opposing distal ends form a header manifold outlet port header for discharging fluid flow discharge.

[0010] The mounting top connector end post, external circular wide flange, and the manifold intermediate spacer disc washers in combination with the support base plate subassembly are designed in proportional relationship to the sidewall thickness of the plate elements to provide structural integrity with the combined effect of the external flange of the intank oil cooler connection post, the manifold intermediate spacer disc washer, the support base plate, and the vertically stacked, thin-walled, tubular plate panel subassemblies. The laminated, paired set of single, thin-walled plate elements that form the tubular plate panel subassembly are each longitudinally embossed on their face surface to produce exterior dimpled convex projections that have an axially corresponding, opposing interior concave dimpled surface on their reverse side surface, the surface of the top tubular panel subassembly in the stack having a flattened surface with no exterior dimpled convex projections.

[0011] The dimpled exterior convex projections are of equal vertical height and are flattened on their top end surface to be joined together by brazing along a common horizontal plane, the co-joined flat top surfaces acting as tubular plate panel subassembly divider spacing elements for maintaining a fluid passageway region equidistant vertical distance spacing between opposing parallel tubular plate panel subassemblies in the vertical stack of tubular plate panel subassemblies, the dimple projections partially defining the external fluid flow parallel passageways and providing uniform distance spacing between adjacent external surfaces of the tubular panel subassemblies.

[0012] The intank oil cooler dimpled external fluid flow passageway regions, that are uniformly spaced apart by the dimple shaped vertical projection embossments, are positioned uniformly in a geometric flow configuration in the external fluid flow channel region to cause the fluid flowing through the external central flow channel sub-region to intermix both longitudinally and circularly around the dimple projections to improve heat transfer. The structural support base plate is fastened to the bottom surface of the lowest tubular plate panel subassembly in the vertical stack to provide the intank oil cooler panel with structural integrity in the bottom area of the header manifold region for distortion resistance to high operating pressures, thereby minimizing the tubular panel single plate element wall thickness to obtain a corresponding weight reduction and size reduction of the intank oil cooler.

[0013] It is, therefore, a principal object of the present invention to provide an improved structurally rigid, vertically stacked, intank oil cooler assembly composed of thin-walled plates that are constructed by laminating thin-walled, paired plate panel subassemblies together to produce an efficient intank oil cooler assembly requiring relatively small installation space while meeting the same or greater heat transfer and quantitative fluid flow capacity of a larger intank oil cooler assembly.

[0014] Another object of this invention is to provide an intank oil cooler being structurally enhanced to effect structural stability by having a mounting top connector end post with an external circular wide flange, manifold intermediate spacer disc washers, and a base plate to minimize the wall thickness of the tubular panel subassembly, thereby minimizing the size of the intank oil cooler assembly.

[0015] Another object of this invention is to provide a lightweight and low cost intank oil cooler assembly that is of a reduced total weight less than intank oil cooler assemblies presently commercially available for heat transfer applications.

[0016] Another object of this invention is to reduce the manufacturing cost of the intank oil cooler assembly by reducing the wall material thickness of the thin-walled tubular panel subassemblies.

BRIEF DESCRIPTION OF DRAWINGS

[0017] For a better understanding of the invention, reference is made to the following description taken in connection with the accompanying drawings, wherein:

[0018] **FIG. 1** is a perspective view of the improved intank oil cooler assembly.

[0019] **FIG. 2** is a partial side elevational view showing the improved intank oil cooler assembly.

[0020] **FIG. 3** is a cross-sectional view of the improved intank oil cooler assembly with structural reinforcing components including the header manifold external mounting post, circular wide flange; the header manifold intermediate spacer washers; and, the base support plate.

[0021] **FIG. 4***a* is a header manifold cross-sectional side view along line **4-4** of **FIG. 2**.

[0022] **FIG. 4***b* is a header manifold cross-sectional view along the line **4-4** of **FIG. 2** containing a turbulizer subassembly.

[0023] **FIG. 5** is an enlarged cross-sectional view of a turbulizer subassembly having a corrugated truncated triangular cross-section.

[0024] **FIG. 6** is an exploded view of the thin-walled panel with structurally reinforcing embossed disc dished dimples in combination with the other structurally reinforcing components.

[0025] **FIG. 7** is an alternative embodiment with cylindrical rod shaped dimples.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0026] With reference to **FIGS. 1 and 2**, an intank oil cooler assembly **10** comprises a series of vertically stacked, elongate thin-walled tubular panel subassemblies **20**. These tubular panel subassemblies **20** are assembled in a stack face-to-face, in spaced-apart relationship to form uniform external passageway regions **29** between opposing exterior sidewall faces of the vertically stacked, tubular panel subassemblies **20**. As shown in **FIGS. 3, 4,** and **5**, each thin-walled tubular panel subassembly **20** has at least one internal channel longitudinal flow region **28** within the tubular panel subassembly **20**, and are fabricated from a paired set of plate element members **30** having embossed dimples **40** on their convex outer sidewall surface **32** and axially corresponding concave inner sidewall surface **34**.

[0027] Referring to **FIG. 2**, each tubular panel subassembly **20** is constructed by first assembling together a paired set of plate element members **30** that are fixedly paired for subsequent lamination in face-to-face hermetically sealed contact. These paired set of plate element members **30** are laminated together with their convex outer surfaces **32** in corresponding longitudinal parallel alignment. After lamination, each embossed dimple **40** has an exterior convex projection **42** and an interior concave depression **44**, and is of equal vertical height with a truncated flattened top **46** in common lateral alignment along a horizontal plane with respect to each other. The dimpled projection flattened peaks **46** are brazed together along the dimpled projection flattened peaks contact surface **48**. These exterior convex projection surfaces **42** are positioned on the exterior surface of each tubular panel subassembly **20** and are uniformly located with respect to each other, and thereby, after being brazed together, form the spaced-apart, tubular panel subassembly **20**, having a convex outer sidewall surface **24** that defines the sidewalls of external passageway regions **29**, wherein exterior fluid flows between each adjacent tubular panel subassembly **20** for heat transfer. The horizontal external passageway regions **29** are defined by the opposite facing, adjacent external outer sidewall surfaces of the parallel aligned, tubular panel subassemblies **20**.

[0028] Coolant fluid entering the tubular panel subassembly **20**, internal longitudinal flow channel region **28**, first enters the inlet header manifold **52**, and then flows through the intank oil cooler assembly **10**, vertically stacked series of tubular panel subassemblies **20**. The header manifold subassemblies **50** are comprised of a fluid flow inlet defining a proximal inlet port end section **52** and a fluid flow outlet defining a distal outlet port end section **54** from which fluid flow is discharged. Surrounding the intank oil cooler assembly **10**, proximal inlet port end section **52** opening, is an inlet header manifold embossed concave disc shaped depression area **36** in the plate element member **30**, and surrounding the intank oil cooler assembly **10**, distal outlet port end section **54** opening is a similar outlet header manifold embossed concave dish shaped depression area **36**. Each plate element member **30** embossed depressed area forms a bell-shaped depression and is located at each manifold end to accommodate a manifold intermediate spacer disc washer **60** having a top disc surface **62**, a bottom disc surface **64**, a sidewall surface **66**, and a central aperture **68**.

[0029] With reference to **FIGS. 3 & 4**, each plate element member **30** has a substantially similar header inlet and outlet manifold subassembly **50** with an interconnecting axial fluid channel that after laminating are aligned by a manifold intermediate spacer disc washer **60** with that of a succeeding embossed plate element member **30** to form each header manifold proximal inlet port end section **52** and distal outlet port end section **54**. Each header manifold subassembly **50**, except the one on the upper surface of the outer plate element member **30** of the uppermost tubular panel subassembly **20**, is an integral portion of the header manifold opening of each tubular panel subassembly **20**. Header manifold embossments of adjacent tubular panel subassemblies **20** are disposed axially in abutting relationship by the header manifold intermediate spacer disc washers **60** and are brazed together around their outside perimeter surfaces to define an annular region where they are permanently brazed together. The respective header manifold subassemblies **50** of each adjacent tubular panel subassembly **20** is manifold intermediate spacer disc washers **60** interconnected, preferably by brazing at their outermost end surfaces to the succeeding header manifold subassembly **50** of the innermost panel, thus joining each successive manifold subassembly **50** to the next succeeding tubular panel subassembly **20**. Each intank oil cooler assembly **10** header manifold subassembly **50** is aligned with the internal flow channel by the manifold intermediate spacer disc washers **60** connectively joined to the brazed header manifold subassembly **50** having an external circular wide flange **56**, top connector post **58**.

[0030] Each intank oil cooler assembly **10** has an inlet constructed manifold subassembly substantially identical to the opposing outlet constructed manifold subassembly. Internal coolant fluid, after flowing through any of the tubular panel subassemblies **20** returns to the fluid coolant source by discharging through the header manifold distal outlet port end section **54**. The header manifold distal outlet port end section **54** is constructed to provide a fluid discharge exit opening at the distal end of each tubular panel subassembly **20**, through which fluid can be discharged from each tubular panel subassembly **20** after having initially flowed therethrough.

[0031] For improving convection through both the outer and inner thin sidewalls of the tubular panel subassembly **20**, each of the plate element members **30** is constructed with external, vertically spaced apart, exterior convex dimple projections **42** arranged geometrically on the convex outer sidewall surface **24** of each plate element member **30** in a generally uniform staggered geometric pattern. As shown in **FIGS. 2, 3** and **4**, the embossed outer sidewall surface **24** has individual exterior convex projections **42** that are butt end, braze connected; and extend vertically to form a dimple common contact plane area **74**.

[0032] These exterior convex projection **42** of the tubular panel subassembly **20**, convex surface **32** are embossed on the exterior surface portions of the thin sidewalls of each tubular panel subassembly **20** external passageway region **29**, and the external dimples **40** project individually vertically outward from the upper and bottom exterior sidewall surfaces of the tubular panel subassembly **20**.

[0033] On both the upper and bottom exterior thin sidewall surfaces **24** & **26** of the tubular panel subassembly **20**, the exterior convex projections **42** function is to improve heat transfer performance by directing movement of the external fluid coolant passing over the exterior surface of the tubular panel subassembly **20** toward the longitudinal, center of the tubular panel subassembly **20**, where there is usually less unimpeded fluid flow than at the tubular panel subassembly **20** edge regions. On the concave channel inner sidewall surface **26**, the increased effective width, because of the embossed dimples **40**, provides a path of reduced flow resistance directed toward the outer internal edge of the tubular panel subassembly **20**, where this effect causes the internal fluid to flow toward the more effective cooling edge tubular panel region to create greater fluid flow mixing action within the internal channel longitudinal flow region **28** of the tubular panel subassembly **20**.

[0034] The embossed dimpled **40**, exterior convex projection **42**, thus constructed, also contributes to improved heat transfer by providing additional heat transfer surface area on both the outer sidewall surface **24** and the inner sidewall surface **26** of the tubular panel subassembly **20**.

[0035] Before fabrication, each plate element member **30** has been machine embossed between suitably shaped dies. It is technically well established that the thinner the sidewall thickness with which the embossed plate element member **30** is fabricated, the more effective is the tubular panel subassembly **20** in transferring heat from the fluid flowing inside the tubular panel subassembly **20** to the outer sidewall surface **24** of the tubular panel subassembly **20**. But conversely, these plate element members **30**, when thinly fabricated for good heat transfer, are more susceptible to distortion by flow fluid heat and pressures that develop within the tubular panel subassembly **20**, and also by the thermal stresses imposed by the brazing operations used to fabricate the thin-walled, tubular panel subassembly **20**.

[0036] The exterior convex dimple projection **42** is dynamically well suited for also imparting the required additional structural strength to reduce or prevent undesirable tubular panel subassembly **20** warping and other distortion. When the tubular panel subassembly **20** is pressurized, tubular panel subassembly **20** distortion deflections tend to occur along pressure induced stress lines. The inclusion in the tubular panel subassembly **20** surfaces of the embossed dimple **40**, exterior convex projection **42**, increases the moment of inertia along these lines, resulting in significant added desirable panel stiffness in the tubular panel subassembly **20**.

[0037] Another alternative structural feature to increase heat transfer is by increasing the surface area of the tubular panel subassembly **20** intank oil cooler assembly **10** is shown in **FIG. 7**. In certain alternative intank oil cooler assembly **10** design applications, it has been necessary for the tubular panel subassembly **20** to be constructed with larger dimensions to provide greater surface area for promoting greater heat transfer, than is the case with the intank oil cooler assembly **10** present invention. A tubular panel subassembly **20** design constructed with larger dimples, or in the alternative, constructed with large semi-circular, rod-type ridges has been, in the past, to be found suitable for these applications. In prior art inventions, various shaped, flatenned dimples enable the tubular panel subassembly **20** to withstand high internal fluid pressures without distortion. A plurality of vertically spaced, dimpled semi-circular embossment vertical dimple projections are provided along vertical lines in the external passageways of the tubular panel subassembly **20** of the intank oil cooler assembly **10**, each horizontal external passageway centerline being formed approximately midway between vertical embossment projections and the vertical edges of the intank oil cooler assembly **10**. The aligned embossed dimples of the paired external tubular panel subassembly **20** plate element members **30** engage each other and are brazed at their upper flattened ends and are brazed together to produce the external passageway region **29**. These spaced apart, vertical dimples **40** impart added mechanical strength without greatly reducing fluid flow mixing between central regions of the tubular panel subassembly **20**.

[**0038**] In this alternate embodiment **FIG. 7**, the tubular panel subassembly **20** dimpled vertical embossments are fabricated as separate embossments **40** in the form of the semi-circular rod-shaped ridges. An advantage of the semi-circular rod type projection embossment of **FIG. 7** is that this type of metal tubular panel subassembly **20** promotes larger heat transfer surface area than dimpled circular cross-section vertical embossments.

[**0039**] In the preferred embodiment designs of **FIGS. 1-6**, it is to be noted that the reinforcing embossments are in the form of localized circular dimples, rather than dimples with semi-circular cylindrical ridge, as shown in **FIG. 7**. This has the advantage of allowing internal fluid to flow more freely and with less resistance through the external passageway region **29** of the tubular panel subassembly **20** and the panel edge regions, than would be the case if a vertically extending dimple semi-circular rod shaped ridge were designed in their location. This substantially unimpeded fluid flow promotes good uniform fluid mixing between the warmer fluid in the central regions of the internal system cooler assembly **10** and the fluid near the outer edges of the tubular panel subassembly **20**, thus counteracting the tendency for uneven cooling to occur as a result of the inherent extra cooling that tends to be present along the edges of each tubular panel subassembly **20**.

[**0040**] With reference to **FIGS. 1 and 2**, a method is presented for fabricating an intank oil cooler assembly **10** to conduct internal fluid flow through a plurality of vertically stacked, elongated thin-walled, tubular panel subassemblies **20**. The thin-walled tubular panel subassemblies **20** are placed in face-to-face, spaced-apart relationship to form vertically spaced external passageway regions **29** between the exterior surface faces of the tubular panel subassemblies **20**. The thin-walled tubular panel subassembly **20**, convex exterior **32** are pre-embossed with a dimpled exterior convex projection **42** having a corresponding axial concave surface **34** on the reverse corresponding inner sidewall surface **26**.

[**0041**] Referring to **FIGS. 3 & 4**, each tubular panel subassembly **20** is fabricated by first pairing sets of plate element members **22**, with their perimeters aligned together, and then hermetically sealed by brazing them together to form internal channel flow regions **28** for conducting longitudinal flow of an internal fluid, the plate element member **30** have exterior convex projections **42** having been fabricated of equal vertical height, aligned axially with respect to each other, and their abutting truncated outer flattened ends are brazed together along a projection peak contact surface **48**, as seen in **FIGS. 4 and 6**. These projection flattened peak contact surfaces **48** are aligned with their exterior convex projection **42** uniformly dividing the tubular panel subassembly **20** into spaced-apart, side-by-side horizontal external passageway regions **29** to conduct fluid flow in the thus formed external passageway channels **29** disposed between adjacent tubular panel subassembly **20**, and that are defined by the opposing facing convex surfaces **32** of the perimeter aligned, laminated tubular panel subassembly **20**.

[**0042**] When coolant fluid enters the manifold of the tubular panel subassembly **20**, internal channel region for longitudinal flow **28**, the fluid flows through the vertically stacked, intank oil cooler assembly **10** series of tubular panel subassemblies **20**. As shown in **FIGS. 1, 2** and **3**, the manifold subassembly **50** has a proximal inlet port end section **52** and a distal outlet port end section **54**, that together define the internal fluid flow header manifold **50** intake and discharge ports.

[**0043**] The paired set of plate element members **22** are fabricated with substantially identical header manifold connecting embossments that are aligned by a manifold intermediate spacer disc washer **60** with a first embossed plate element member **30**. Each of these manifold subassembly **50** proximal inlet port end section **52** and the distal outlet port end section **54**, except the one on the outer plate element member **30** of the uppermost panel, is a portion of the header manifold opening to the tubular panel subassembly **20**. Fluid inlet and fluid outlet header manifold embossments of aligned adjacent thin-walled, tubular panel subassemblies **20** are disposed by the header manifold in abutting relationship, and then are brazed together with and to the manifold intermediate spacer disc washer **60** around the outside perimeter of the annular region, where fixed in location, they are braze mated together.

[**0044**] Internal fluid first flows through the first header manifold proximal inlet port end section **52** and then through the integrated interconnected header manifold section, and into the aligned internal channel region longitudinal flow region **28** of the tubular panel subassembly **20** that defines the external circular flange top connector end region **56** leading directly into the intank oil cooler assembly **10**.

[**0045**] Fluid flow through the internal system cooler assembly **10** lower header manifold constructed section is substantially identical to the upper header manifold construction section. Internal coolant fluid, after flowing through any of the tubular panel subassemblies **20** that are stacked in parallel, then returns to the fluid coolant source through the header manifold distal outlet port end section **54**.

[**0046**] The distal outlet port end section **54** is constructed to provide for fluid exit discharge at the header manifold distal outlet port end section **54** of each tubular panel subassembly **20**, whereby the fluid can subsequently exit each tubular panel subassembly **20** after first flowing through the tubular panel subassembly **20**.

[0047] Heat transfer convection is improved through the outer sidewall surface **24** and the inner sidewall surface **26** of the tubular panel subassembly **20** by each of the plate element members **30** by the spaced vertically projecting embossed dimples **40** on each plate element member **30** that are positioned in a generally staggered uniform pattern. As shown in FIGS. **2** thru **6**, the individual embossed dimples **40** extend transversely from the dimple vertically extending horizontal mating plane **48**. Embossed dimples on the exterior surface portions of each plate element member **30** form portions of the thin wall sections of the tubular panel subassembly **20**, external passageway regions **29**. The external dimples, project upward from the exterior surface of the tubular panel subassembly **20**, outer sidewall surface **24**. The embossed dimples **40** projections function to improve heat transfer conductance as the fluid coolant passes over the surface of the tubular panel subassemblies **20** causing fluid flow toward the axial center of the tubular panel subassembly **20**, where there is -usually less flow than at the edge regions. Internally, the fluid courses in a path of reduced flow resistance directed toward the outer edge of the tubular panel subassembly **20**.

[0048] Exterior convex projections **42**, contribute to improved cooling by providing additional heat transfer contact area surface for both the external and internal sidewalls of the tubular panel subassembly **20** and the embossed dimple **40** surfaces impart needed additional structural strength and resistance to distortion. During operation, pressurization of the fluid tubular panel subassembly **20** causes panel deflection from pressure along these pressure lines. In the tubular panel subassembly **20** of the exterior convex projection **42**, as the moment of inertia increases along these lines, this results in significant added stiffness to the tubular panel subassembly **20**.

[0049] The thin-walled construction of the tubular panel subassemblies **20** requires the addition to the intank oil cooler assembly of a bottom structural base support plate subassembly **80**, this base plate having a base plate lower surface **84** with a base plate thickness and top surface **82** for providing supporting structural strength to the intank oil cooler

[0050] The thin-walled tubular panel subassemblies **20** necessitate the structural additions of header manifold a external circular wide flanges, manifold intermediate spacer disc washers **60** and the bottom structural base support plate subassembly **80** having a base plate top surface **82** combination and a base plate lower surface **84** to provide structural strength reinforcement against fabrication and operational distortion in the intank oil cooler.

[0051] Thus, the method for fabricating an intank oil cooler assembly **10** comprises assembling at least two laminated paired set plate element members **22**, and then sealing the members peripherally in paired sets together to form elongated tubular panel subassemblies **20** having internal channel longitudinal flow regions **28**. The tubular panel subassemblies **20** are stacked vertically in series, the elongated tubular panel subassemblies **20** when end joined together, at a proximal inlet port end section **52** form a header manifold adapted for accepting fluid flow and at the distal outlet port end section **54** define an outlet header manifold adapted for discharging fluid flow with an interconnecting manifold intermediate spacer disc washers **60** therebetween. At least one base plate subassembly, when placed in a base position in the vertical tubular panel subassembly **20** tubular panel stack, provides the structural support base for the series of elongated tubular panel subassemblies **20** forming the intank oil cooler assembly **10**.

[0052] Prior to tubular panel subassembly **20** fabrication, each single plate element is fabricated with embossments to produce a structural surface dimpled condition having on one side a exterior convex projection **42** and on the opposing interior side an axially complimentary dimpled interior concave depression surface **44**. The exterior convex projections **42** are embossed dimples **40** of equidistant vertical height, and are positionally located between opposing outer sidewall surfaces **24** of each tubular panel subassembly **20**, and are flattened on the dimpled projection top surface for interconnection brazing. Each tubular panel subassembly **20** dimpled projection top surface that is joined and sealed together to positionally fix and space each said tubular panel subassembly **20** equidistant from an opposing tubular panel subassembly **20** surface.

[0053] The intank oil cooler assembly **10** dimple projection top surfaces, when joined together in a common horizontal plane **48**, are uniformly staggered to define a desired, configures external passageway regions between adjacent tubular panel subassemblies **20** and in a design configuration that maximizes the cooling heat transfer effect.

[0054] After embossing the dimple projection embossments in each plate element member **30** in an alternating transverse singular and end paired set, plate element members **22** to thus define the external fluid flow circulation passageway regions **29** between each of the tubular panel subassembly **20**, the internal turbulizer subassembly **90** is fabricated for installation in the internal channel region/longitudinal flow **28**. The internal turbulizer subassembly **90** may be constructed of various materials to produce a turbulizer corrugated triangular cross-sectional area **92**; a turbulizer of corrugated rounded, semi-circular cross-sectional area **94**; or a hybrid composition corrugated cross-section. The tubular panel subassembly **20** turbulizer subassembly may be constructed of a metallic wire mesh or solid wall composition having various cross-sectional area geometric configurations. Accordingly, in other embodiments, the intank oil cooler assembly **10** may be constructed with various internal turbulizer subassemblies **90** constructed of various composite material compositions.

[0055] The function of the internal turbulizer subassembly **90** is to provide for the internal intermixing of fluid flow for promoting fluid temperature distribution in the fluid flow channel of the tubular panel subassembly **20**, which in turn, produces enhanced uniform heat transfer in the interior of the tubular panel subassembly **20** for the intank oil cooler assembly **10**

[0056] The header manifold intermediate spacer disc washer **60**, the bottom structural base support plate subassembly **80**, and the external circular wide flange top connector end is designed to provide, in combination with the vertical stack of tubular panel subassemblies **20**, the substantially ideal structural composite strength for the thin-walled tubular panel, intank oil cooler **10**.

[0057] The design variables that influence the construction structural configuration of a intank oil cooler **10** are the plate element thin-wall minimal thickness, the structural strength of the tubular panel subassembly **20**, the design of the external circular wide flanges of the top connector mounting posts of the header manifold, the header manifold intermediate spacer disc washers **60**, the structural reinforcing support plate, all contributing design factors calculated to produce a minimal weight and size, distortion resistant, efficient intank oil cooler **10** that maximizes heat transfer.

[0058] While we have shown and described particular embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention in its broader aspects; and it is our intention herein to cover all such changes and modifications that fall within the spirit and scope of this invention.

We claim:

1. An intank oil cooler assembly comprising:

a. a thin-walled, paired set of single plate elements, each embossed on one sidewall surface with dimpled convex projections and embossed on the reverse sidewall surface with axially corresponding complimentary concave dimpled depressions, and then being laminated peripherally together to form an elongate, tubular panel subassembly having a header manifold, one at the proximal end and one at the distal end, and therewithin at least one longitudinal internal flow channel region;

b. at least two said elongate, tubular panel subassemblies being vertically stacked in parallel series, and each said tubular panel assembly being end joined together with an adjacent tubular panel subassembly at the proximal ends to define an inlet header manifold section being adapted for accepting fluid flow and at the distal ends to define an outlet header manifold section being adapted for discharging fluid flow, and said each manifold section being axially joined together with manifold intermediate-spacer disc washers, said manifold sections having external circular wide retention flanges;

c. each of said dimpled convex projections being of equal vertical height, top flattened, and joined together for positionally fixing and spacing each said tubular panel subassembly equidistant from and in parallel relationship with respect to an adjacent tubular panel subassembly; and

d. at least one structural support plate subassembly being constructed with a pre-determined thickness for being fastened to at least one said tubular panel subassembly member in said vertical stack to structurally reinforce said intank oil cooler assembly.

2. The intank oil cooler, as claimed in claim 1 wherein the predetermined dimensions of said external circular wide retention flanges, said manifold intermediate spacer washers, and said support plate subassembly are determined by the structural distortion stabilization required by said vertical stacked, tubular panel subassembly.

3. The intank oil cooler, as claimed in claim 2, wherein said structural support plate is secured to the lower surface of the most bottom positioned tubular panel subassembly.

4. The intank oil cooler, as claimed in claim 3, wherein all of said dimple projection top surfaces are individually sealed together along a common horizontal plane.

5. The intank oil cooler, as claimed in claim 4, wherein said dimple embossed projections are staggered uniformly to define parallel passageway regions between adjacent tubular panel subassemblies.

6. The intank oil cooler, as claimed in claim 5, wherein said dimple projections are embossed in said plate element member, alternating in a pattern of single and paired sets to define each said fluid flow passageway region between adjacent said tubular panel subassemblies.

7. The intank oil cooler, as claimed in claim 6, wherein said turbulizer subassembly is constructed with corrugations, each having a triangular cross-sectional area.

8. The intank oil cooler, as claimed in claim 6, wherein said turbulizer subassembly is constructed with corrugations, each having a rounded semi-circular, cross-sectional area.

9. The intank oil cooler, as claimed in claim 6, wherein each said turbulizer subassembly is constructed of a wire mesh composite material.

10. The intank oil cooler, as claimed in claim 6, wherein each said turbulizer subassembly is corrugated to form a triangular cross-section and is constructed from wire mesh.

11. A method for constructing an intank oil cooler assembly comprising the steps of:

a. first fabricating and then laminating peripherally together a thin-walled, paired set of single plate elements each embossed on one sidewall surface area with dimpled convex projections and on the reverse sidewall surface area with axially corresponding, complimentary concave dimpled depressions to form a thin-walled, elongate tubular panel subassembly having between the proximal and distal ends therewithin at least one longitudinal internal flow channel region;

b. vertically stacking in series, and then end joining together in a header manifold, each said thin-walled elongate, tubular panel subassembly with an adjacent said tubular panel subassembly along their respective perimeters to define a header manifold inlet section at the proximal end adapted for accepting inlet fluid flow and at the distal end to define a header manifold outlet section adapted for discharging fluid flow, and each said manifold section having external circular wide retention flanges being axially connected together by manifold intermediate spacer disc washers;

c. each said dimpled convex projection top surfaces being of equal vertical height and adapted for positioning said tubular panels in said vertical stack equidistant from and parallel with an adjacent tubular panel subassembly; and

d. fastening at least one support plate subassembly in a structural position in said vertical stack to provide structural reinforcement to the intank oil cooler assembly.

12. The intank oil cooler, as claimed in claim 11, wherein said structural support plate is fastened to the lower surface of the most bottom positioned tubular panel subassembly.

13. The intank oil cooler, as claimed in claim 12, wherein all of said dimple projection top surfaces are individually sealed together along a common horizontal plane.

14. The intank oil cooler, as claimed in claim 13, wherein said dimple embossed projections are staggered uniformly to define fluid passageway regions between each adjacent tubular panel subassemblies.

15. The intank oil cooler, as claimed in claim 14, wherein said dimple embossed projections are embossed in said plate element member in alternating singular and paired sets to define fluid flow parallel passageway regions between adjacent said tubular panel subassemblies.

16. The intank oil cooler, as claimed in claim 15, wherein said dimple embossed projections are embossed with flattened, round-edged top surfaces in said plate element member in a pattern of alternating single and paired sets within said fluid flow passageway regions positioned between adjacent said tubular panel subassemblies.

17. The intank oil cooler, as claimed in claim 16, wherein said turbulizer subassembly is constructed with triangular cross-sectional corrugations.

18. The intank oil cooler, as claimed in claim 16, wherein said turbulizer subassembly is constructed with corrugations having a rounded, semi-circular cross-sectional area.

19. The intank oil cooler, as claimed in claim 16, wherein said turbulizer subassembly is constructed of a wire mesh composite material.

20. The intank oil cooler, as claimed in claim 16, wherein said turbulizer subassembly is corrugated and constructed from a wire mesh material.

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