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(54) **VARIABLE CORE HEAT EXCHANGER WITH FLOW CONTROL**

(57) A heat exchanger (10) includes a core (12). The core includes a first layer (22) and a second layer (42). The first layer includes a first plurality of fluid inlets (24). The second layer includes a second plurality of fluid inlets (44). The heat exchanger also includes a fluid header (60) attached to the core adjacent the first plurality of fluid inlets and the second plurality of fluid inlets. The fluid

header (60) includes an inlet (62), an outlet (66), a plenum (64) between the inlet and the outlet, and a flow control mechanism (68) within the plenum (84). The flow control mechanism selectively directs fluid through the first plurality of fluid inlets, through the second plurality of fluid inlets, or through both the first plurality of fluid inlets and the second plurality of fluid inlets.

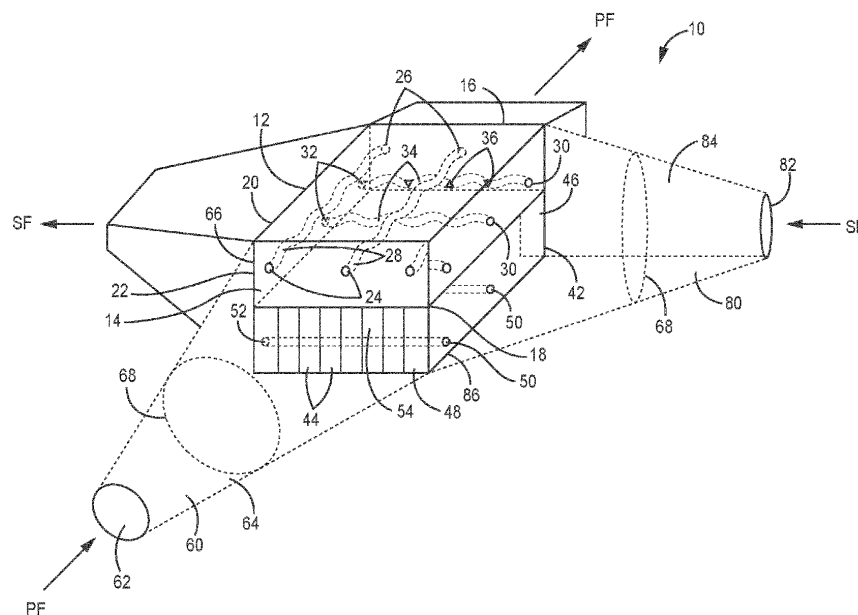


FIG. 1

Description

BACKGROUND

[0001] The present disclosure relates to heat exchangers, and in particular to headers for heat exchangers.

[0002] Heat exchangers are often used to transfer heat between two fluids. For example, on aircraft, heat exchangers are used to transfer heat between a relatively hot air source, e.g., bleed air from a gas turbine engine, and a relatively cool air source, e.g., ram air.

SUMMARY

[0003] In one example, a heat exchanger includes a core. The core includes a first side, a second side opposite the first side, a third side extending from the first side to the second side, a fourth side opposite the third side and extending from the first side to the second side. The core also includes a first layer and a second layer. The first layer includes a first plurality of primary fluid inlets on the first side of the core and a first plurality of primary fluid outlets on the second side of the core. A first plurality of primary fluid passages extends from the first plurality of primary fluid inlets to the first plurality of primary fluid outlets. A first plurality of secondary fluid inlets on the third side of the core and a first plurality of secondary fluid outlets on the fourth side of the core. A first plurality of secondary fluid passages extends from the first plurality of secondary fluid inlets to the first plurality of secondary fluid outlets. The second layer includes a second plurality of primary fluid inlets on the first side of the core and a second plurality of primary fluid outlets on the second side of the core. A second plurality of primary fluid passages extends from the second plurality of primary fluid inlets to the second plurality of primary fluid outlets. The second layer also includes a second plurality of secondary fluid inlets on the third side of the core and a second plurality of secondary fluid outlets on the fourth side of the core. A second plurality of secondary fluid passages extends from the second plurality of secondary fluid inlets to the second plurality of secondary fluid outlets. The heat exchanger also includes a primary fluid header attached to the first side of the core. The primary fluid header includes an inlet, a plenum, and a flow control mechanism within the plenum. The flow control mechanism selectively directs fluid through the first layer, through the second layer, or through both the first layer and the second layer.

[0004] In another example, a heat exchanger includes a core. The core includes a first layer and a second layer. The first layer includes a first plurality of primary fluid inlets, a first plurality of primary fluid outlets, and a first plurality of primary fluid passages extending from the first plurality of primary fluid inlets to the first plurality of primary fluid outlets. The first layer also includes a first plurality of secondary fluid inlets, a first plurality of secondary fluid outlets, and a first plurality of secondary fluid pas-

sages extending from the first plurality of secondary fluid inlets to the first plurality of secondary fluid outlets. The first plurality of secondary fluid passages extends transverse the first plurality of primary fluid passages. The second layer includes a second plurality of primary fluid inlets, a second plurality of primary fluid outlets, and a second plurality of primary fluid passages extending from the second plurality of primary fluid inlets to the second plurality of primary fluid outlets. The second plurality of primary fluid passages extends adjacent the first plurality of primary fluid passages. The second layer also includes a second plurality of secondary fluid inlets, a second plurality of secondary fluid outlets, and a second plurality of secondary fluid passages extending from the second plurality of secondary fluid inlets to the second plurality of secondary fluid outlets. The second plurality of secondary fluid passages extends transverse the second plurality of primary fluid passages. The heat exchanger also includes a primary fluid header attached to the core adjacent the first plurality of primary fluid inlets and the second plurality of primary fluid inlets. The primary fluid header includes an inlet, an outlet, a plenum between the inlet and the outlet, and a flow control mechanism within the plenum. The flow control mechanism selectively directs fluid through the first plurality of primary fluid inlets, through the second plurality of primary fluid inlets, or through both the first plurality of primary fluid inlets and the second plurality of primary fluid inlets.

[0005] Persons of ordinary skill in the art will recognize that other aspects and embodiments of the present invention are possible in view of the entirety of the present disclosure, including the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 is a schematic of a perspective view of a heat exchanger.

FIG. 2A is a schematic diagram of a three-way valve in a first position inside a plenum of a header of the heat exchanger of FIG. 1.

FIG. 2B is a schematic diagram of the three-way valve in a second position inside the plenum of the header of the heat exchanger of FIG. 1.

FIG. 2C is a schematic diagram of the three-way valve in a third position inside the plenum of the header of the heat exchanger in FIG. 1.

FIG. 3A is a schematic diagram of a baffle assembly in a first position inside the plenum of the header of the heat exchanger in FIG. 1.

FIG. 3B is a schematic diagram of the baffle assembly in a second position inside the plenum of the header of the heat exchanger in FIG. 1.

FIG. 3C is a schematic diagram of the baffle assembly in a third position inside the plenum of the header of the heat exchanger in FIG. 1.

FIG. 4A is a schematic diagram of a plate assembly

in a first position inside the plenum of the header of the heat exchanger in FIG. 1.

FIG. 4B is a schematic diagram of the plate assembly in a second position inside the plenum of the header of the heat exchanger in FIG. 1.

FIG. 4C is a schematic diagram of the plate assembly in a third position inside the plenum of the header of the heat exchanger in FIG. 1.

[0007] While the above-identified drawing figures set forth one or more embodiments of the invention, other embodiments are also contemplated. In all cases, this disclosure presents the invention by way of representation and not limitation. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope and spirit of the principles of the invention. The figures may not be drawn to scale, and applications and embodiments of the present invention may include features and components not specifically shown in the drawings. Like reference numerals identify similar structural elements.

DETAILED DESCRIPTION

[0008] This disclosure relates to a heat exchanger with a first layer, a second layer, and a header. The first layer is configured to have a higher heat transfer rate than the second layer. The second layer is configured to have less pressure loss and greater efficiency than the first layer. The header includes a flow control mechanism that directs the fluid within the header to the first layer, the second layer, or both the first and second layer. The flow control mechanism enables the heat exchanger to provide a higher rate of heat exchange by directing the flow through the first layer during modes of operation that require high rates of heat exchange, i.e., during the take-off of an aircraft. The flow control mechanism also enables the heat exchanger to provide a higher efficiency heat exchanger by directing the fluid through the second layer during modes of operation that do not require as much heat exchange, i.e., during cruising speeds of an aircraft. The heat exchanger with the flow control mechanism within the header will be discussed with reference to FIGS. 1-4C below.

[0009] FIG. 1 is a schematic of a perspective view of heat exchanger 10. Heat exchanger 10 includes core 12, primary fluid header 60 (shown in phantom), and secondary fluid header 80 (shown in phantom). Core 12 includes first side 14, second side 16, third side 18, fourth side 20, first layer 22, and second layer 42. First layer 22 includes first plurality of primary fluid inlets 24 (hereinafter "primary fluid inlets 24"), first plurality of primary fluid outlets 26 (hereinafter "primary fluid outlets 26"), first plurality of primary fluid passages 28 (hereinafter "primary fluid passages 28"), first plurality of secondary fluid inlets 30 (hereinafter "secondary fluid inlets 30"), first plurality of secondary fluid outlets 32 (hereinafter "secondary fluid outlets 32"), and first plurality of secondary fluid passages

34 (hereinafter "secondary fluid passages 34"). Primary fluid passages 28 (shown in phantom) and secondary fluid passages 34 (shown in phantom) can include flow restriction elements 36.

[0010] Second layer 42 includes second plurality of primary fluid inlets 44 (hereinafter "primary fluid inlets 44"), second plurality of primary fluid outlets 46 (hereinafter "primary fluid outlets 46"), second plurality of primary fluid passages 48 (hereinafter "primary fluid passages 48"), second plurality of secondary fluid inlets 50 (hereinafter "secondary fluid inlets 50"), second plurality of secondary fluid outlets 52 (hereinafter "secondary fluid outlets 52"), and second plurality of secondary fluid passages 54 (shown in phantom and hereinafter "secondary fluid passages 54"). Primary fluid header 60 includes inlet 62, plenum 64, outlet 66, and flow control mechanism 68. Secondary fluid header 80 includes inlet 82, plenum 84, outlet 86, and flow control mechanism 68.

[0011] Second side 16 is opposite of first side 14. Third side 18 extends from first side 14 to second side 16. Fourth side 20 is opposite of third side 18 and extends from first side 14 to second side 16. Primary fluid inlets 24 are on first side 14 and primary fluid outlets 26 are on second side 16. Primary fluid passages 28 extend from primary fluid inlets 24 to primary fluid outlets 26. Secondary fluid inlets 30 are on third side 18 and secondary fluid outlets 32 are on fourth side 20. Secondary fluid passages 34 extend from secondary fluid inlets 30 to secondary fluid outlets 32.

[0012] Primary fluid inlets 44 are on first side 14 in second layer 42 and primary fluid outlets 46 are on second side 16 in second layer 42. Primary fluid passages 48 extend from primary fluid inlets 44 to primary fluid outlets 46. Secondary fluid inlets 50 are on third side 18 and secondary fluid outlets 52 are on fourth side 20. Secondary fluid passages 54 extend from secondary fluid inlets 50 to secondary fluid outlets 52.

[0013] First layer 22 has a higher heat transfer rate than second layer 42. As shown in the example in FIG. 1, primary fluid passages 28 of first layer 22 includes a sinusoidal profile as primary fluid passages 28 extend from primary fluid inlets 24 to primary fluid outlets 26. Additionally, secondary fluid passages 34 include a sinusoidal profile as secondary fluid passages 34 extend from secondary fluid inlets 30 to secondary fluid outlets 32. The sinusoidal profiles of primary fluid passages 28 and secondary fluid passages 34 increase the surface area between primary fluid passages 28 and secondary fluid passages 34. The increased surface area between primary fluid passages 28 and secondary fluid passages 34 increases the heat transfer between the fluid within primary fluid passages 28 and the fluid within secondary fluid passages 34.

[0014] As shown in FIG. 1, primary fluid passages 28 and secondary fluid passages 34 of first layer 42 include flow restriction elements 36 which add resistance to flow through primary fluid passages 28 and secondary fluid passages 34 to increase turbulent flow within primary

fluid passages 28 and secondary fluid passages 34. As shown in FIG. 1, flow restriction elements 36 can be protrusions that increase the surface area and increase the restriction to flow through primary fluid passages 28 and secondary fluid passages 34. In another example, flow restriction elements 36 can be fins, airfoils, columns, or any other shape that increases the surface area and restricts flow through primary fluid passages 28 and secondary fluid passages 34, and/or a combination thereof any of the suggested shapes.

[0015] In the example of FIG. 1, primary fluid passages 48 in second layer 42 are rectangular as primary fluid passages 48 extend from primary fluid inlets 44 to primary fluid outlets 46 and secondary fluid passages 54 are tubes that extend from secondary fluid inlets 50 to secondary fluid outlets 52 through primary fluid passages 48. The design of primary fluid passages 48 and secondary fluid passages 54 in second layer 42 minimizes pressure loss within second layer 42 while exchanging heat between the fluid within primary fluid passages 48 and secondary fluid passages 54. Therefore, first layer 22 has a higher heat transfer rate than second layer 42 while second layer 42 has a lower pressure loss than first layer 22.

[0016] Primary fluid header 60 is attached to first side 14 of core 12. Plenum 64 is between inlet 62 and first side 14 of core 12. Plenum 64 includes flow control mechanism 68 to direct primary fluid PF through first layer 22, through second layer 42, or through both first layer 22 and second layer 42. Secondary fluid header 80 is attached to third side 18 of core 12. Plenum 84 is between inlet 82 and third side 18 of core 12. Plenum 84 also includes flow control mechanism 68 to direct secondary fluid SF through first layer 22, second layer 42, and through both first layer 22 and second layer 42. Primary fluid PF enters primary fluid header 60 at a first temperature and secondary fluid SF enters secondary fluid header 80 at a second temperature higher or lower than the first temperature.

[0017] FIGS. 2A-2C will be discussed concurrently. FIGS. 2A-2C show a schematic diagram of primary fluid header 60, plenum 64, flow control mechanism 68, first layer 22, and second layer 42. In the embodiment of FIGS. 2A-2C, flow control mechanism 68 comprises three-way valve 90. FIG. 2A shows three-way valve 90 in a first position. FIG. 2B shows three-way valve 90 in a second position. FIG. 2C shows three-way valve 90 in a third position. Three-way valve 90 includes plate 92, torsional actuator 100, and flow separator 102. Plate 92 includes first side 94, second side 96, and window 98.

[0018] In the example of FIGS. 2A-2C, three-way valve 90 is located within plenum 64 between inlet 62 of primary fluid header 60 and first side 14 of core 12 and controls the flow of primary fluid PF through primary fluid header 60. First side 94 of plate 92 faces inlet 62 of primary fluid header 60 and second side 96 of plate 92 faces first side 14 of core 12. Window 98 extends through first side 94 and through second side 96. In the example of FIGS. 2A-

2C, plate 92 is circular and window 98 is a hole through plate 92 that is non-concentric with plate 92.

[0019] Torsional actuator 100 is attached to second side 96 of plate 92 and is integrated into flow separator 102. Torsional actuator 100 rotates plate 92 of flow control mechanism 68 between the first position, the second position, and the third position. Flow separator 102 extends from second side 96 of plate 92 to first side 14 of core 12 between first layer 22 and second layer 42. Flow separator 102 forms a first channel and a second channel inside primary fluid header 60 downstream from plate 92. The first channel extends from plate 92 to primary fluid inlets 24 of first layer 22. The second channel extends from plate 92 to primary fluid inlets 44 of second layer 42.

[0020] In the first position, as shown in FIG. 2A, window 98 is positioned over the first channel such that plate 92 and window 98 of flow control mechanism 68 fluidically connect inlet 62 of primary fluid header 60 and primary fluid inlets 24 of first layer 22 while closing the second channel and thereby blocking fluidic communication between inlet 62 of primary fluid header 60 and primary fluid inlets 44 of second layer 42. In the second position, as shown in FIG. 2B, window 98 is positioned over the second channel such that plate 92 and window 98 of flow control mechanism 68 fluidically connect inlet 62 of primary fluid header 60 and primary fluid inlets 44 of second layer 42 while blocking fluidic communication between inlet 62 of primary fluid header 60 and primary fluid inlets 24 of first layer 22. In the third position, as shown in FIG. 2C, window 98 is positioned partially over the first channel and partially over the second channel such that plate 92 and window 98 of flow control mechanism 68 fluidically connect inlet 62 of primary fluid header 60 to both primary fluid inlets 24 of first layer 22 and primary fluid inlets 44 of second layer 42.

[0021] Flow control mechanism 68 in secondary fluid header 80 can have a configuration similar to primary fluid header 60. For example, flow control mechanism 68 of secondary fluid header 80 includes three-way valve 90 within plenum 84 between inlet 82 and third side 18 of core 12 to control secondary fluid SF. First side 94 of plate 92 faces inlet 82 of secondary fluid header 80 and second side 96 of plate 92 faces third side 18 of core 12. Window 98 extends through first side 94 and through second side 96. In the example of FIGS. 2A-2C, plate 92 is circular and window 98 is a hole through plate 92 that is non-concentric with plate 92.

[0022] Torsional actuator 100 is attached to second side 96 of plate 92 and is integrated into flow separator 102. Torsional actuator 100 rotates plate 92 of flow control mechanism 68 between the first position, the second position, and the third position. Flow separator 102 extends from second side 96 of plate 92 to third side 18 of core 12 between first layer 22 and second layer 42. Flow separator 102 forms a first channel and a second channel inside secondary fluid header 80 downstream from plate 92. The first channel extends from plate 92 to secondary fluid inlets 30 of first layer 22. The second channel ex-

tends from plate 92 to secondary fluid inlets 50 of second layer 42.

[0023] In the first position, as shown in FIG. 2A, window 98 is positioned over the first channel such that plate 92 and window 98 of three-way valve 90 fluidically connect inlet 82 of secondary fluid header 80 and secondary fluid inlets 30 of first layer 22 while closing the second channel and thereby blocking fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 50 of second layer 42. In the second position, as shown in FIG. 2B, window 98 is positioned over the second channel such that plate 92 and window 98 of three-way valve 90 fluidically connect inlet 82 of secondary fluid header 80 and secondary fluid inlets 50 of second layer 42 while blocking fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 30 of first layer 22. In the third position, as shown in FIG. 2C, window 98 is positioned partially over the first channel and partially over the second channel such that plate 92 and window 98 of three-way valve 90 fluidically connect inlet 82 of secondary fluid header 80 to both secondary fluid inlets 30 of first layer 22 and secondary fluid inlets 50 of second layer 42.

[0024] FIGS. 3A-3C will be discussed concurrently. FIGS. 3A-3C show a schematic diagram of primary fluid header 60, plenum 64, flow control mechanism 68, first layer 22, and second layer 42. In the embodiment of FIGS. 3A-3C, flow control mechanism 68 comprises baffle assembly 110. FIG. 3A shows baffle assembly 110 in a first position. FIG. 3B shows baffle assembly 110 in a second position. FIG. 3C shows baffle assembly 110 in a third position. Baffle assembly 110 includes plate 112, linear actuator 120, and hinge 130. Plate 112 includes base end 114 and distal end 116. Linear actuator 120 includes rod 122 and linkage arm 124.

[0025] In the example of FIGS. 3A-3C, baffle assembly is located within plenum 64 between inlet 62 of primary fluid header 60 and first side 14 of core 12 and controls the flow of primary fluid PF through primary fluid header 60. Plate 112 extends from base end 114 to distal end 116. Base end 114 of plate 112 is connected to first side 14 of core 12 such that plate 112 extends inside plenum 64 from first side 14 of core 12 toward inlet 62 of primary fluid header 60. Base end 114 of plate 112 is attached to first side 14 of core 12 between first layer 22 and second layer 42 by hinge 130. Rod 122 is connected to linear actuator 120 and is driven linearly by linear actuator 120. Linkage arm 124 is attached to rod 122 of linear actuator 120 by a first joint and is attached to distal end 116 of plate 112 by a second joint. As rod 122 of linear actuator 120 extends and retracts within linear actuator 120, linkage arm 124 rotates plate 112 about hinge 130 to position baffle assembly 110 into the first position, the second position, or the third position.

[0026] In the first position, as shown in FIG. 3A, plate 112 is rotated counterclockwise about hinge 130 until distal end 116 of plate 112 contacts the inside wall of primary fluid header 60 to block second layer 42 from

inlet 62 of primary fluid header 60. In this the first position, plate 112 leaves open primary fluid inlets 24 to fluidically connect inlet 62 of primary fluid header 60 and primary fluid inlets 24 of first layer 22 while plate 112 blocks fluidic communication between inlet 62 of primary fluid header 60 and primary fluid inlets 44 of second layer 42. In the second position, as shown in FIG. 3B, plate 112 is rotated clockwise about hinge 130 until distal end 116 of plate 112 contacts the inside wall of primary fluid header 60 to block first layer 22 from inlet 62 of primary fluid header. In the second position, plate 112 leaves open primary fluid inlets 44 to fluidically connect inlet 62 of primary fluid header 60 and primary fluid inlets 44 of second layer 42 while plate 112 blocks fluidic communication between inlet 62 of primary fluid header 60 and primary fluid inlets 24 of first layer 22. In the third position, as shown in FIG. 3C, plate 112 is rotated normal to first side 14 of core 12 to fluidically connect inlet 62 of primary fluid header 60 to primary fluid inlets 24 of first layer 22 and primary fluid inlets 44 of second layer 42.

[0027] Flow control mechanism 68 in secondary fluid header 80 can have a configuration similar to the example of primary fluid header 60 in FIGS. 3A-3C. For example, flow control mechanism 68 of secondary fluid header 80 includes baffle assembly 110 within plenum 84 between inlet 82 and third side 18 of core 12 to control secondary fluid SF. Baffle assembly 110 includes plate 112, linear actuator 120, and hinge 130. Plate 112 includes base end 114 and distal end 116. Linear actuator 120 includes rod 122 and linkage arm 124. Plate 112 extends from base end 114 to distal end 116. Base end 114 of plate 112 is connected to third side 18 of core 12 such that plate 112 extends inside plenum 84 from third side 18 of core 12 toward inlet 82 of secondary fluid header 80. Base end 114 of plate 112 is attached to third side 18 of core 12 between first layer 22 and second layer 42 by hinge 130. Rod 122 is connected to linear actuator 120 and is driven linearly by linear actuator 120. Linkage arm 124 is attached to rod 122 of linear actuator 120 by a first joint and is attached to distal end 116 of plate 112 by a second joint. As rod 122 of linear actuator 120 extends and retracts within linear actuator 120, linkage arm 124 rotates plate 112 about hinge 130 to position baffle assembly 110 into the first position, the second position, or the third position.

[0028] In the first position, as shown in FIG. 3A, plate 112 is rotated counterclockwise about hinge 130 until distal end 116 of plate 112 contacts the inside wall of secondary fluid header 80 to block second layer 42 from inlet 82 of secondary fluid header 80. In this the first position, plate 112 leaves open secondary fluid inlets 30 to fluidically connect inlet 82 of secondary fluid header 80 and secondary fluid inlets 30 of first layer 22 while plate 112 blocks fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 50 of second layer 42. In the second position, as shown in FIG. 3B, plate 112 is rotated clockwise about hinge 130 until distal end 116 of plate 112 contacts the inside wall of

secondary fluid header 80 to block first layer 22 from inlet 82 of secondary fluid header 80. In the second position, plate 112 leaves open secondary fluid inlets 50 to fluidically connect inlet 82 of secondary fluid header 80 and secondary fluid inlets 50 of second layer 42 while plate 112 blocks fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 30 of first layer 22. In the third position, as shown in FIG. 3C, plate 112 is rotated normal to third side 18 of core 12 to fluidically connect inlet 82 of secondary fluid header 80 to secondary fluid inlets 30 of first layer 22 and secondary fluid inlets 50 of second layer 42.

[0029] FIGS. 4A-4C will be discussed concurrently. FIGS. 4A-4C show a schematic diagram of primary fluid header 60, plenum 64, flow control mechanism 68, first layer 22, and second layer 42. In the embodiment of FIGS. 4A-4C, flow control mechanism 68 comprises plate assembly 140. FIG. 4A shows plate assembly 140 in a first position. FIG. 4B shows plate assembly 140 in a second position. FIG. 4C shows plate assembly 140 in a third position. Plate assembly 140 includes plate 142 and linear actuator 144. Linear actuator 144 includes rod 146.

[0030] In the example of FIGS. 4A-4C, plate assembly 140 is located within plenum 64 between inlet 62 of primary fluid header 60 and first side 14 of core 12 and controls the flow of primary fluid PF through primary fluid header 60. Plate 142 extends perpendicular first side 14 of core 12. Linear actuator 144 extends and retracts rod 146. Rod 146 is attached to plate 142 and connects plate 142 to linear actuator 144 to move plate 142 and put plate assembly 140 in the first position, the second position, or the third position.

[0031] In the first position, as shown in FIG. 4A, linear actuator 144 retracts rod 146 to position plate 142 in front of primary fluid inlets 44 of second layer 42 and block fluidic communication between inlet 62 of primary fluid header 60 and primary fluid inlets 44 while allowing fluidic communication between inlet 62 of primary fluid header 60 and primary fluid inlets 24 of first layer 22. In second position, as shown in FIG. 4B, linear actuator 144 extends rod 146 to position plate 142 in front of primary fluid inlets 24 of first layer 22 and block fluidic communication between inlet 62 of primary fluid header 60 and primary fluid inlets 44 of second layer 42. In third position, as shown in FIG. 4C, linear actuator 144 moves rod 146 to position plate 142 between first layer 22 and second layer 42. With plate 142 positioned between first layer 22 and second layer 42, inlet 62 of primary fluid header 60 can fluidically communicate with both primary fluid inlets 24 of first layer 22 and primary fluid inlets 44 of second layer 42.

[0032] Flow control mechanism 68 in secondary fluid header 80 can have a configuration similar to primary fluid header 60. For example, flow control mechanism 68 of secondary fluid header 80 includes plate assembly 140 located within plenum 84 between inlet 82 and third

side 18 of core 12 to control secondary fluid SF. Plate assembly 140 includes plate 142 and linear actuator 144. Linear actuator 144 includes rod 146. Plate 142 extends perpendicular third side 18 of core 12.

[0033] In the first position, as shown in FIG. 4A, linear actuator 144 retracts rod 146 to position plate 142 in front of secondary fluid inlets 50 of second layer 42 to block fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 50 of second layer 42 while allowing fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 30 of first layer 22. In second position, as shown in FIG. 4B, linear actuator 144 extends rod 146 to position plate 142 in front of secondary fluid inlets 30 of first layer 22 and block fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 30 of first layer 22 while allowing fluidic communication between inlet 82 of secondary fluid header 80 and secondary fluid inlets 50 of second layer 42. In third position, as shown in FIG. 4C, linear actuator 144 moves rod 146 to position plate 142 between first layer 22 and second layer 42. With plate 142 positioned between first layer 22 and second layer 42, inlet 82 of secondary fluid header 80 can fluidically communicate with both secondary fluid inlets 30 of first layer 22 and secondary fluid inlets 50 of second layer 42.

[0034] In another example, flow control mechanism 68 within primary fluid header 60 can be three-way valve 90 and flow control mechanism 68 within secondary fluid header 80 can be baffle assembly 110 or plate assembly 140. Similarly, flow control mechanism 68 within primary fluid header 60 and flow control mechanism 68 within secondary fluid header 80 can be any combination of three-way valve 90, baffle assembly 110, and/or plate assembly 140. In yet another example, heat exchanger 10 can include flow control mechanism 68 within only within primary fluid header 60. In contrast, heat exchanger 10 can include flow control mechanism 68 within only secondary fluid header 80.

Discussion of Possible Embodiments

[0035] The following are non-exclusive descriptions of possible embodiments of the present invention.

[0036] A heat exchanger includes a core. The core includes a first side, a second side opposite the first side, a third side extending from the first side to the second side, a fourth side opposite the third side and extending from the first side to the second side. The core also includes a first layer and a second layer. The first layer includes a first plurality of primary fluid inlets on the first side of the core and a first plurality of primary fluid outlets on the second side of the core. A first plurality of primary fluid passages extends from the first plurality of primary fluid inlets to the first plurality of primary fluid outlets. A first plurality of secondary fluid inlets on the third side of the core and a first plurality of secondary fluid outlets on the fourth side of the core. A first plurality of secondary

fluid passages extends from the first plurality of secondary fluid inlets to the first plurality of secondary fluid outlets. The second layer includes a second plurality of primary fluid inlets on the first side of the core and a second plurality of primary fluid outlets on the second side of the core. A second plurality of primary fluid passages extends from the second plurality of primary fluid inlets to the second plurality of primary fluid outlets. The second layer also includes a second plurality of secondary fluid inlets on the third side of the core and a second plurality of secondary fluid outlets on the fourth side of the core. A second plurality of secondary fluid passages extends from the second plurality of secondary fluid inlets to the second plurality of secondary fluid outlets. The heat exchanger also includes a primary fluid header attached to the first side of the core. The primary fluid header includes an inlet, a plenum, and a flow control mechanism within the plenum. The flow control mechanism selectively directs fluid through the first layer, through the second layer, or through both the first layer and the second layer.

[0037] The heat exchanger of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

the first layer has a higher heat transfer rate than the second layer;

the flow control mechanism is a three-way valve operating between a first position, a second position, and a third position;

the three-way valve in the first position fluidically connects the inlet of the primary fluid header to the first plurality of primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the second plurality of primary fluid inlets, the three-way valve in the second position fluidically connects the inlet of the primary fluid header to the second plurality of primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets, and the three-way valve in the third position fluidically connects the inlet of the primary fluid header to the first plurality of primary fluid inlets of the first layer and the second plurality of primary fluid inlets;

the three-way valve further comprises: a plate, wherein the plate comprises: a first side facing the inlet of the primary fluid header; a second side facing the outlet of the primary fluid header; and a window, wherein the window extends through the first side and the second side of the plate; and a torsional actuator mechanically coupled to the second side of the plate, wherein the torsional actuator rotates the plate to place the three-way valve in the first position, the second position, and the third position, and wherein the window enables fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets and/or the second

plurality of primary fluid inlets;

a flow separator within the plenum of the primary fluid header extending between the second side of the flow control mechanism and the core, wherein the flow separator forms a first channel and a second channel inside the primary fluid header downstream from the plate, wherein the first channel extends from the plate to the first plurality of primary fluid inlets, and wherein the second channel extends from the plate to the second plurality of primary fluid inlets; the flow control mechanism is a baffle assembly, and wherein the baffle assembly comprises: a baffle extending from the first side of the core between the first layer and the second layer toward the inlet of the primary fluid header; and an actuator mechanically attached to the baffle to operate the baffle between a first position, a second position, and a third position;

the baffle comprises: a base end; and a distal end opposite the base end, wherein a hinge attaches the base end of the baffle to the first side of the core; the actuator comprises: a rod; at least one linkage arm attached to the rod by a first joint and attached to the distal end of the baffle by a second joint;

the baffle in the first position fluidically connects the inlet of the primary fluid header to the first plurality of primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the second plurality of primary fluid inlets, the baffle in the second position fluidically connects the inlet of the primary fluid header to the second plurality of primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets, and the baffle in the third position fluidically connects the inlet of the primary fluid header to the first plurality of primary fluid inlets of the first layer and the second plurality of primary fluid inlets;

the flow control mechanism is a plate assembly, and wherein the plate assembly comprises: a plate located between the inlet of the primary fluid header and the first side of the core and extending perpendicular the first plurality of primary fluid inlets and the second plurality of primary fluid inlets; and a linear actuator that moves the plate between a first position, a second position, and a third position;

the plate in the first position blocks fluidic communication between the inlet of the primary fluid header and the second plurality of primary fluid inlets while allowing fluid communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets, the plate in the second position blocks fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets while allowing fluid communication between the inlet of the primary fluid header and the second plurality of primary fluid inlets, and the plate in the third position allows the first plurality of primary

fluid inlets and the second plurality of primary fluid inlets to fluidically communicate with the inlet of the primary fluid header;

a secondary fluid header attached to the third side of the core, wherein the secondary fluid header comprises: an inlet; a plenum; and a flow control mechanism within the plenum, wherein the flow control mechanism of the secondary fluid header selectively directs fluid through the first layer, through the second layer, or through both the first layer and second layer;

the flow control mechanism of the secondary fluid header comprises one of: a three-way valve comprising: a plate, wherein the plate comprises: a first side facing the inlet of the secondary fluid header; a second side facing the third side of the core; and a window extending through the first side and the second side of the plate; and a torsional actuator mechanically coupled to the second side of the plate, wherein the torsional actuator rotates the plate to change the orientation of the window, and wherein the window enables fluidic communication between the inlet of the secondary fluid header and the first plurality of secondary fluid inlets and/or the second plurality of secondary fluid inlets; a baffle assembly comprising: a baffle extending from the third side of the core between the first layer and the second layer toward the inlet of the secondary fluid header and an actuator mechanically attached to the baffle to actuate the baffle, wherein baffle comprises a base end opposite a distal end, wherein a hinge attaches the base end of the baffle to the first side of the core, and wherein the actuator comprises at least one linkage arm attached to the distal end of the baffle; and a plate assembly comprising: a plate located between the inlet of the secondary fluid header and the third side of the core extending perpendicular third side of the core and an actuator that moves the plate, wherein the flow control mechanism of the secondary fluid header operates between a first position, a second position, and a third position; and/or the flow control mechanism of the secondary fluid header in the first position fluidically connects the inlet of the secondary fluid header to the first plurality of secondary fluid inlets while blocking fluidic communication between the inlet of the secondary fluid header and the second plurality of secondary fluid inlets, the flow control mechanism in the second position fluidically connects the inlet of the secondary fluid header to the second plurality of secondary fluid inlets and blocks fluidic communication between the inlet of the secondary fluid header and the first plurality of secondary fluid inlets, and second control mechanism in the third position fluidically connects the inlet of the primary fluid header to the first plurality of secondary fluid inlets and the second plurality of secondary fluid inlets.

[0038] A heat exchanger includes a core. The core includes a first layer and a second layer. The first layer includes a first plurality of primary fluid inlets, a first plurality of primary fluid outlets, and a first plurality of primary fluid passages extending from the first plurality of primary fluid inlets to the first plurality of primary fluid outlets. The first layer also includes a first plurality of secondary fluid inlets, a first plurality of secondary fluid outlets, and a first plurality of secondary fluid passages extending from the first plurality of secondary fluid inlets to the first plurality of secondary fluid outlets. The first plurality of secondary fluid passages extends transverse the first plurality of primary fluid passages. The second layer includes a second plurality of primary fluid inlets, a second plurality of primary fluid outlets, and a second plurality of primary fluid passages extending from the second plurality of primary fluid inlets to the second plurality of primary fluid outlets. The second plurality of primary fluid passages extends adjacent the first plurality of primary fluid passages. The second layer also includes a second plurality of secondary fluid inlets, a second plurality of secondary fluid outlets, and a second plurality of secondary fluid passages extending from the second plurality of secondary fluid inlets to the second plurality of secondary fluid outlets. The second plurality of secondary fluid passages extends transverse the second plurality of primary fluid passages. The heat exchanger also includes a primary fluid header attached to the core adjacent the first plurality of primary fluid inlets and the second plurality of primary fluid inlets. The primary fluid header includes an inlet, an outlet, a plenum between the inlet and the outlet, and a flow control mechanism within the plenum. The flow control mechanism selectively directs fluid through the first plurality of primary fluid inlets, through the second plurality of primary fluid inlets, or through both the first plurality of primary fluid inlets and the second plurality of primary fluid inlets.

[0039] The heat exchanger of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

the first layer has a greater heat transfer rate than the second layer;

the first primary fluid passages and the first secondary fluid passages are sinusoidal, and wherein the first primary fluid passages and the first secondary fluid passages comprise flow restriction elements that increase the heat transfer rate between the first primary fluid passages and the first secondary fluid passages;

the flow control mechanism of the primary fluid header comprises one of the following: a three-way valve comprising: a plate, wherein the plate comprises: a first side facing the inlet of the primary fluid header; a second side facing the outlet of the primary fluid header; and a window, wherein the window extends through the first side and the second side of the plate;

and a torsional actuator mechanically coupled to the plate, wherein the torsional actuator rotates the plate to change the orientation of the window, and wherein the window enables fluidic communication between the inlet of the primary fluid header and the first primary fluid inlets and/or the second primary fluid inlets; a baffle assembly comprising: a baffle extending from the core between the first layer and the second layer toward the inlet of the primary fluid header and an actuator mechanically attached to the baffle to actuate the baffle, wherein the baffle comprises a base end opposite a distal end, wherein a hinge attaches the base end of the baffle to the core, and wherein the actuator comprises at least one linkage arm attached to the distal end of the baffle; and a plate assembly comprising: a plate located between the inlet of the primary header and the core extending perpendicular the first plurality of primary fluid inlets and the second plurality of primary fluid inlets; and an actuator that moves the plate, wherein the flow control mechanism of the primary fluid header operates between a first position, a second position, and a third position; and/or the flow control mechanism in the first position fluidically connects the inlet of the primary fluid header to the first primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the second primary fluid inlets, the flow control mechanism in the second position fluidically connects the inlet of the primary fluid header to the second primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the first primary fluid inlets, and flow control mechanism in the third position fluidically connects the inlet of the primary fluid header to the first primary fluid inlets and the second primary fluid inlets.

[0040] While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

Claims

1. A heat exchanger (10) comprising:

a core (12), wherein the core comprises:

a first side (14);
a second side (16) opposite the first side;
a third side (18) extending from the first side to the second side;
a fourth side (20) opposite the third side and extending from the first side to the second side;
a first layer (22) comprising:

a first plurality of primary fluid inlets (24) on the first side of the core; and
a first plurality of primary fluid outlets (26) on the second side of the core;
a first plurality of primary fluid passages (28) extending from the first plurality of primary fluid inlets to the first plurality of primary fluid outlets;
a first plurality of secondary fluid inlets (30) on the third side of the core;
a first plurality of secondary fluid outlets (32) on the fourth side of the core; and
a first plurality of secondary fluid passages (34) extending from the first plurality of secondary fluid inlets to the first plurality of secondary fluid outlets; and

a second layer (42) comprising:

a second plurality of primary fluid inlets (44) on the first side of the core;
a second plurality of primary fluid outlets (46) on the second side of the core;
a second plurality of primary fluid passages (48) extending from the second plurality of primary fluid inlets to the second plurality of primary fluid outlets;
a second plurality of secondary fluid inlets (50) on the third side of the core; and
a second plurality of secondary fluid outlets (52) on the fourth side of the core;
a second plurality of secondary fluid passages (54) extending from the second plurality of secondary fluid inlets to the second plurality of secondary fluid outlets; and

a primary fluid header (60) attached to the first side of the core, wherein the primary fluid header comprises:

an inlet (62);
a plenum (64);
an outlet (66); and
a flow control mechanism (68) within the plenum, wherein the flow control mechanism selectively directs fluid through the first

- layer, through the second layer, or through both the first layer and the second layer.
2. The heat exchanger (10) of claim 1, wherein the first layer (22) has a higher heat transfer rate than the second layer (42) .
 3. The heat exchanger (10) of claim 1 and 2, wherein the flow control mechanism (68) is a three-way valve (90) operating between a first position, a second position, and a third position.
 4. The heat exchanger of claim 3, wherein the three-way valve in the first position fluidically connects the inlet of the primary fluid header (60) to the first plurality of primary fluid inlets (24) while blocking fluidic communication between the inlet of the primary fluid header and the second plurality of primary fluid inlets (26), the three-way valve in the second position fluidically connects the inlet of the primary fluid header to the second plurality of primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets, and the three-way valve in the third position fluidically connects the inlet of the primary fluid header to the first plurality of primary fluid inlets of the first layer and the second plurality of primary fluid inlets.
 5. The heat exchanger of claim 3 or 4, wherein the three-way valve (90) further comprises:
 - a plate (92), wherein the plate comprises:
 - a first side (94) facing the inlet of the primary fluid header (60);
 - a second side (96) facing the outlet of the primary fluid header; and
 - a window (98), wherein the window extends through the first side and the second side of the plate; and
 - a torsional actuator (100) mechanically coupled to the second side of the plate, wherein the torsional actuator rotates the plate to place the three-way valve in the first position, the second position, and the third position, and wherein the window enables fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets and/or the second plurality of primary fluid inlets.
 6. The heat exchanger of claim 5, further comprising: a flow separator (102) within the plenum of the primary fluid header (60) extending between the second side of the flow control mechanism (68) and the core (12), wherein the flow separator forms a first channel and a second channel inside the primary fluid header downstream from the plate (92), wherein the first channel extends from the plate to the first plurality of primary fluid inlets (24), and wherein the second channel extends from the plate to the second plurality of primary fluid inlets (26).
 7. The heat exchanger of claim 1 or 2, wherein the flow control mechanism (68) is a baffle assembly (110), and wherein the baffle assembly comprises:
 - a baffle extending from the first side (14) of the core (12) between the first layer (22) and the second layer (42) toward the inlet (62) of the primary fluid header; and
 - an actuator (120) mechanically attached to the baffle to operate the baffle between a first position, a second position, and a third position.
 8. The heat exchanger of claim 7, wherein the baffle comprises:
 - a base end (114); and
 - a distal end (116) opposite the base end, wherein a hinge (130) attaches the base end of the baffle to the first side (14) of the core (12).
 9. The heat exchanger of claim 8, wherein the actuator comprises:
 - a rod (122);
 - at least one linkage arm (124) attached to the rod (122) by a first joint and attached to the distal end (116) of the baffle by a second joint.
 10. The heat exchanger of claim 9, wherein the baffle in the first position fluidically connects the inlet (62) of the primary fluid header (60) to the first plurality of primary fluid inlets (24) while blocking fluidic communication between the inlet of the primary fluid header and the second plurality of primary fluid inlets (26), the baffle in the second position fluidically connects the inlet of the primary fluid header to the second plurality of primary fluid inlets while blocking fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets, and the baffle in the third position fluidically connects the inlet of the primary fluid header to the first plurality of primary fluid inlets of the first layer and the second plurality of primary fluid inlets.
 11. The heat exchanger of claim 1 or 2, wherein the flow control mechanism is a plate assembly (140), and wherein the plate assembly comprises:
 - a plate (142) located between the inlet of the primary fluid header and the first side of the core and extending perpendicular the first plurality of primary fluid inlets and the second plurality of

primary fluid inlets; and
a linear actuator (144) that moves the plate between a first position, a second position, and a third position.

12. The heat exchanger of claim 11, wherein the plate (142) in the first position blocks fluidic communication between the inlet of the primary fluid header (60) and the second plurality of primary fluid inlets (50) while allowing fluid communication between the inlet (62) of the primary fluid header (60) and the first plurality of primary fluid inlets (24), the plate in the second position blocks fluidic communication between the inlet of the primary fluid header and the first plurality of primary fluid inlets while allowing fluid communication between the inlet of the primary fluid header and the second plurality of primary fluid inlets, and the plate in the third position allows the first plurality of primary fluid inlets and the second plurality of primary fluid inlets to fluidically communicate with the inlet of the primary fluid header.

13. The heat exchanger of claim 1 or 2, further comprising:
a secondary fluid header (80) attached to the third side (18) of the core, wherein the secondary fluid header comprises:

an inlet (82);
a plenum (84); and
a flow control mechanism (68) within the plenum, wherein the flow control mechanism of the secondary fluid header selectively directs fluid through the first layer, through the second layer, or through both the first layer and second layer.

14. The heat exchanger of claim 13, wherein the flow control mechanism (68) of the secondary fluid header comprises one of:

a three-way valve (90) comprising:

a plate (92), wherein the plate comprises:

a first side (94) facing the inlet (62) of the secondary fluid header (60);
a second side (96) facing the third side of the core; and
a window (98) extending through the first side and the second side of the plate; and

a torsional actuator (100) mechanically coupled to the second side of the plate, wherein the torsional actuator rotates the plate to change the orientation of the window, and wherein the window enables fluidic communication between the inlet of the secondary

fluid header and the first plurality of secondary fluid inlets and/or the second plurality of secondary fluid inlets;

a baffle assembly comprising:

a baffle extending from the third side of the core between the first layer and the second layer toward the inlet of the secondary fluid header and an actuator mechanically attached to the baffle to actuate the baffle, wherein baffle comprises a base end opposite a distal end, wherein a hinge attaches the base end of the baffle to the first side of the core, and wherein the actuator comprises at least one linkage arm attached to the distal end of the baffle; and

a plate assembly comprising:

a plate located between the inlet of the secondary fluid header and the third side of the core extending perpendicular third side of the core and an actuator that moves the plate,

wherein the flow control mechanism of the secondary fluid header operates between a first position, a second position, and a third position.

15. The heat exchanger of claim 14, wherein the flow control mechanism (68) of the secondary fluid header in the first position fluidically connects the inlet of the secondary fluid header to the first plurality of secondary fluid inlets while blocking fluidic communication between the inlet of the secondary fluid header and the second plurality of secondary fluid inlets, the flow control mechanism in the second position fluidically connects the inlet of the secondary fluid header to the second plurality of secondary fluid inlets and blocks fluidic communication between the inlet of the secondary fluid header and the first plurality of secondary fluid inlets, and second control mechanism in the third position fluidically connects the inlet of the primary fluid header to the first plurality of secondary fluid inlets and the second plurality of secondary fluid inlets.

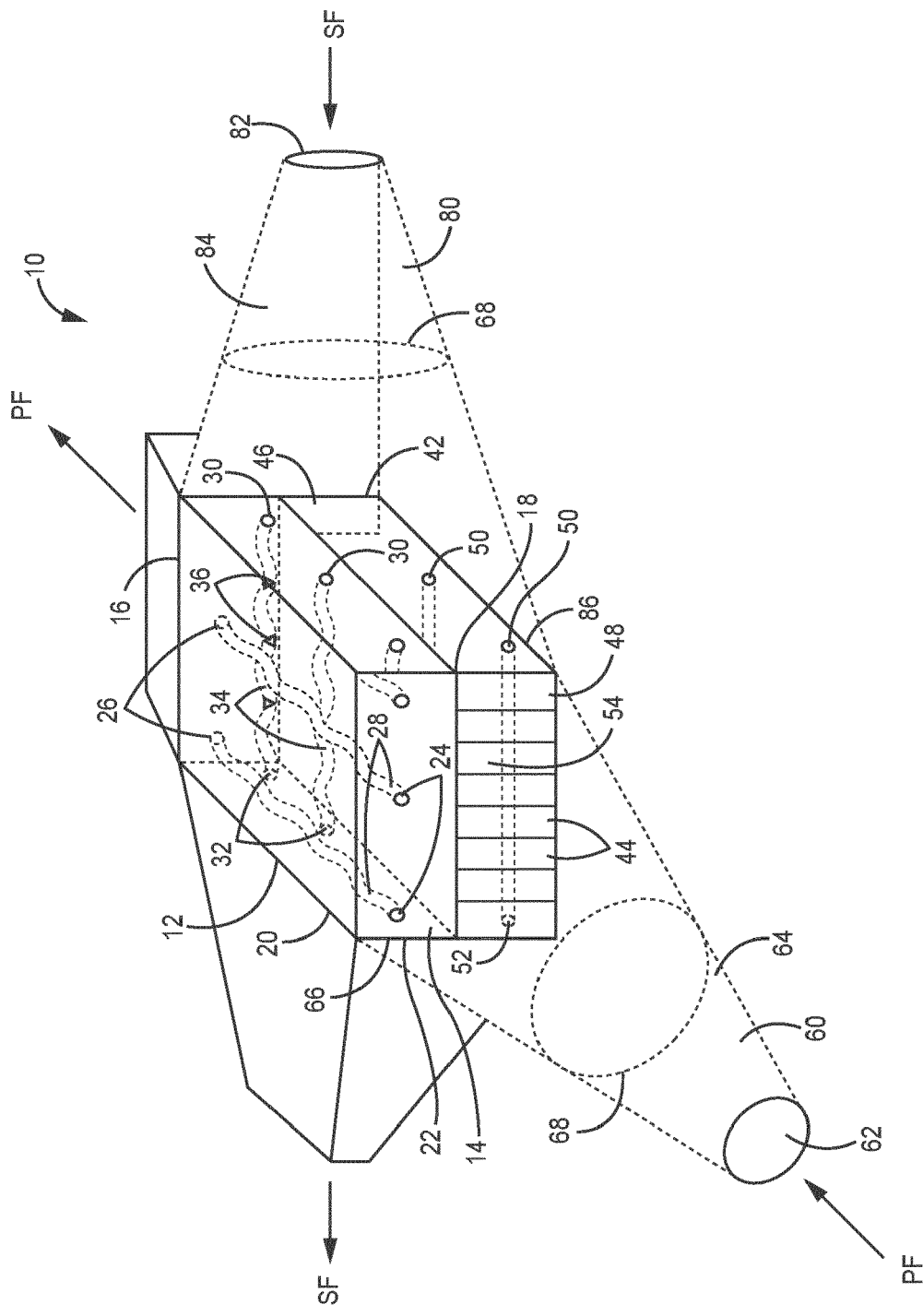


FIG. 1

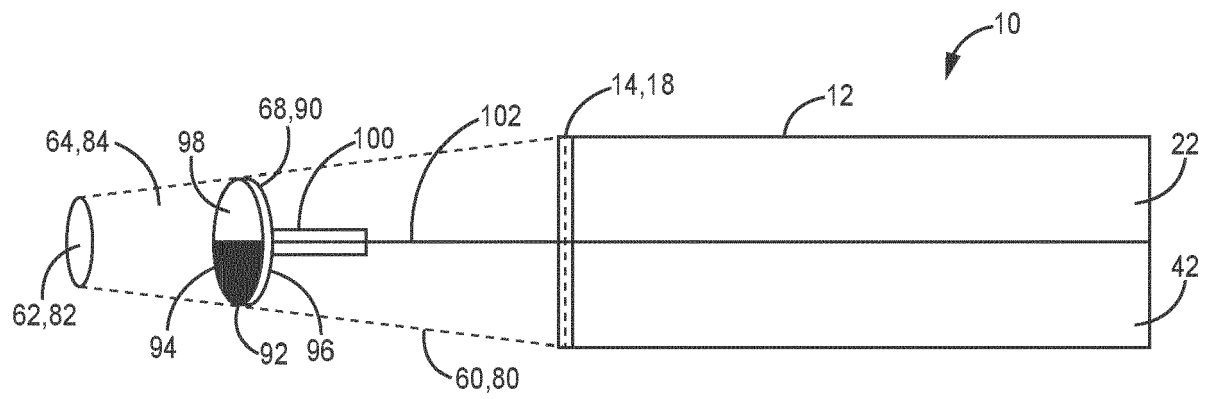


FIG. 2A

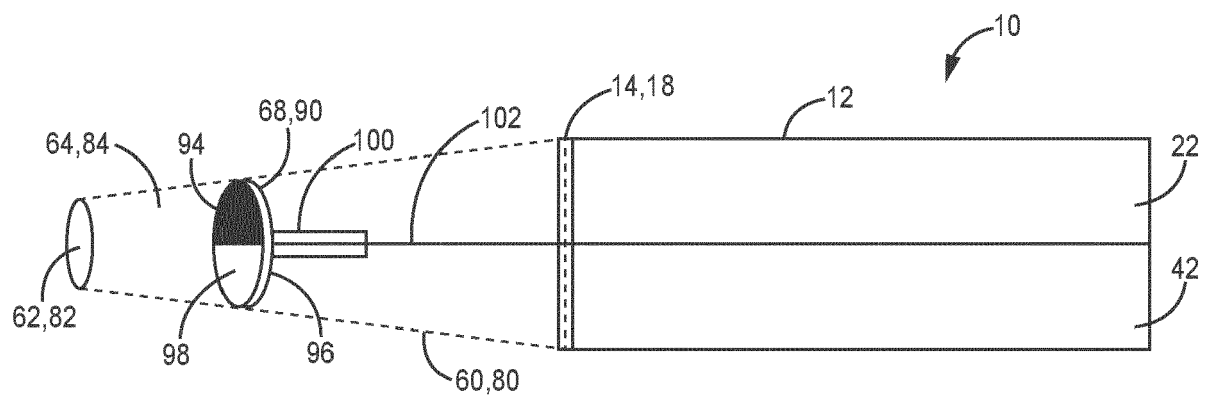


FIG. 2B

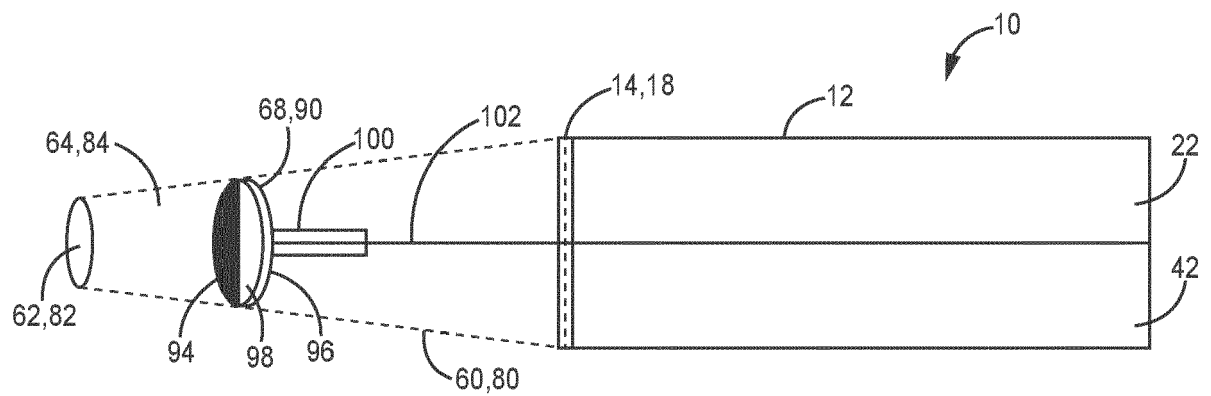


FIG. 2C

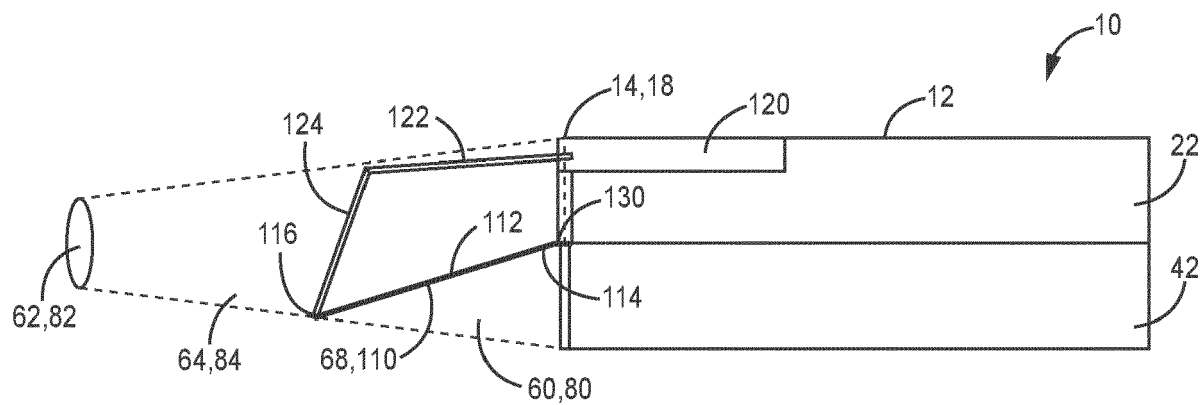


FIG. 3A

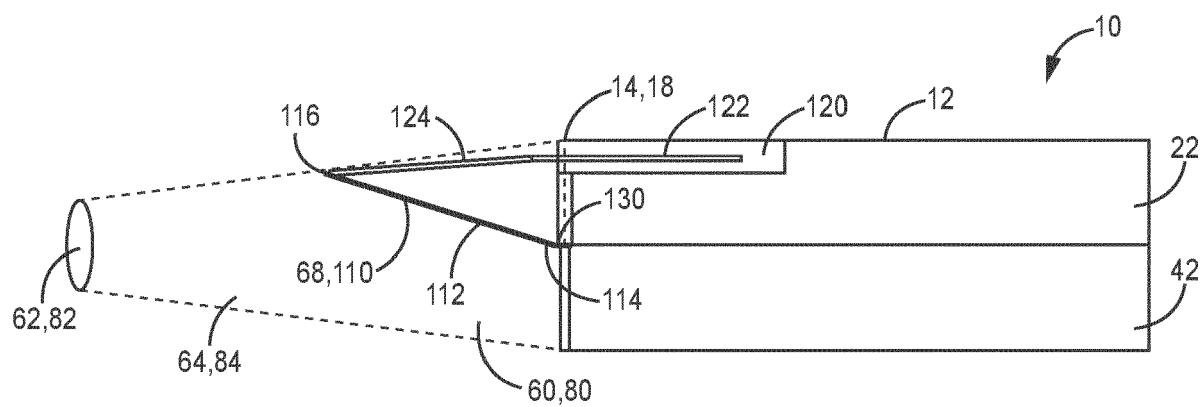


FIG. 3B

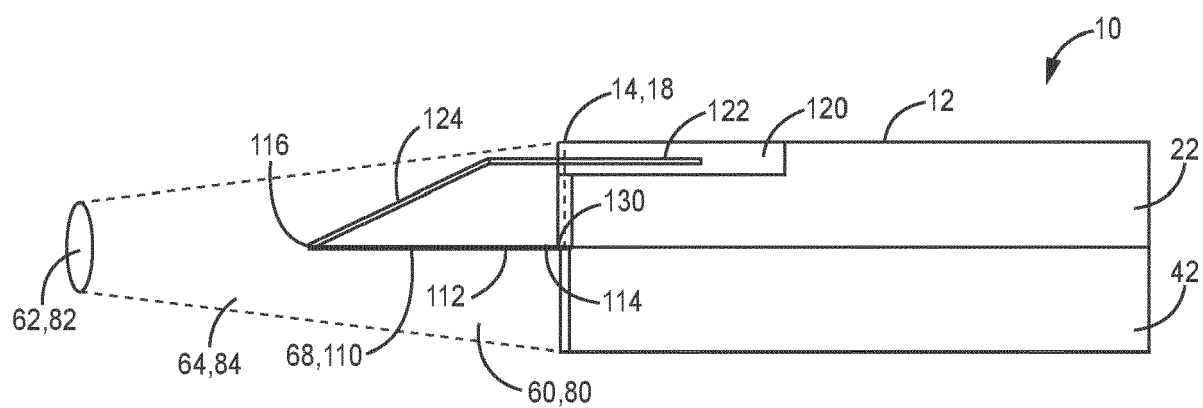


FIG. 3C

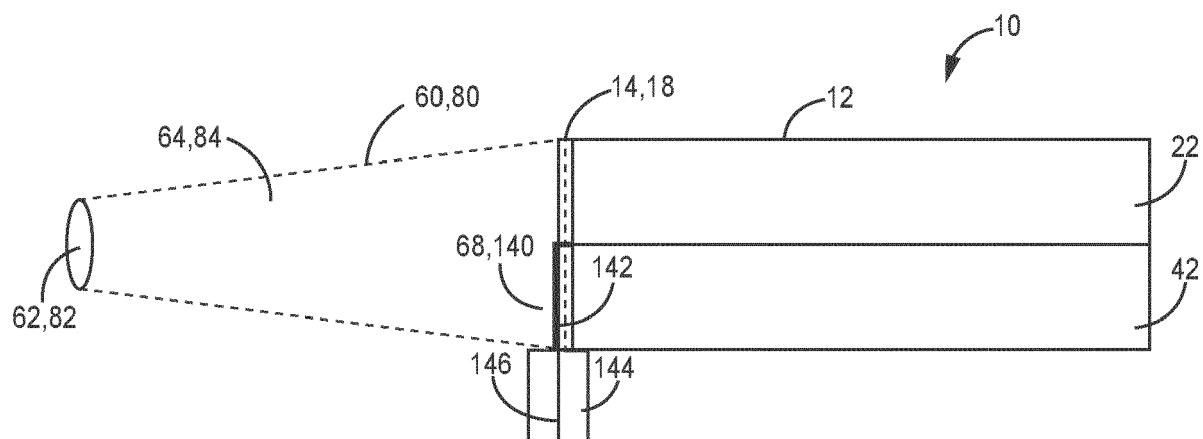


FIG. 4A

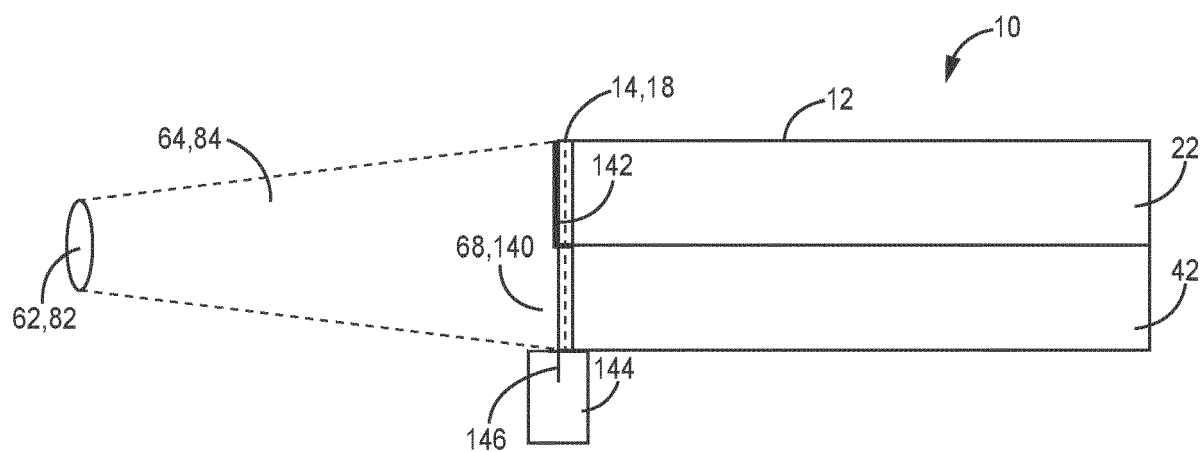


FIG. 4B

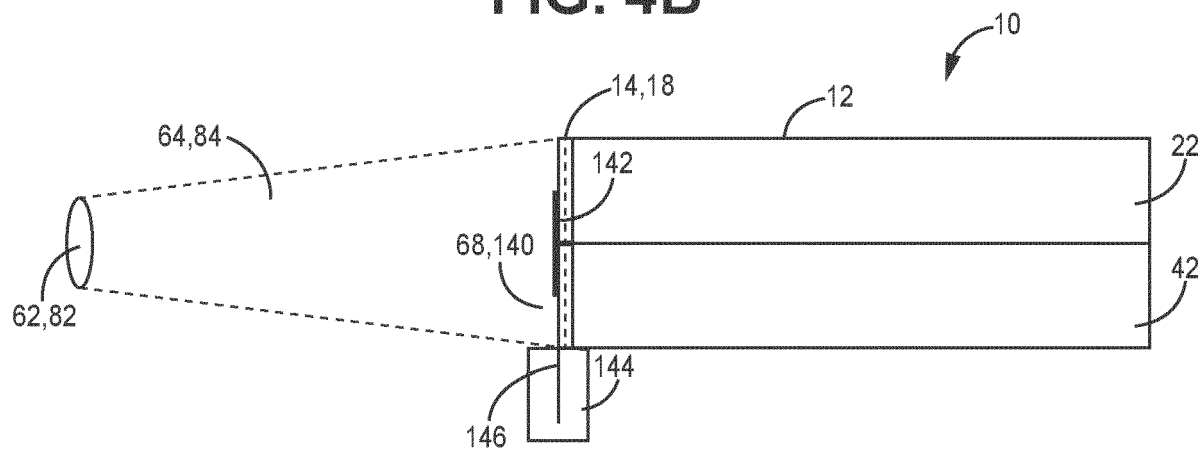


FIG. 4C



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