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(54) **Heat exchanger assembly having split mini-louvered fins**

(57) A heat exchanger assembly is provided having at least one header, a plurality of spaced apart fluid tubes in hydraulic communication with the header, and a plurality of corrugated fins disposed between the tubes. The corrugated fins include a planar portion (154) having a louver segment (162) defined between a pair of primary slits (164), in which the louver segment (162) includes an intermediate slit (165) splitting the louver segment (162) into a pair of mini-louvers (176. 178). The mini-louvers (176, 178) are counter-offset such that one of the mini-louvers (176, 178) is on one side of the planar portion (154) and the other one of the mini-louvers (176, 178) is on the other side of the planar portion (154). The mini-louvers (176, 178) may be pivoted about their respective junctures such that each of the mini-louver (176, 178) is oblique relative to the planar portion (154).

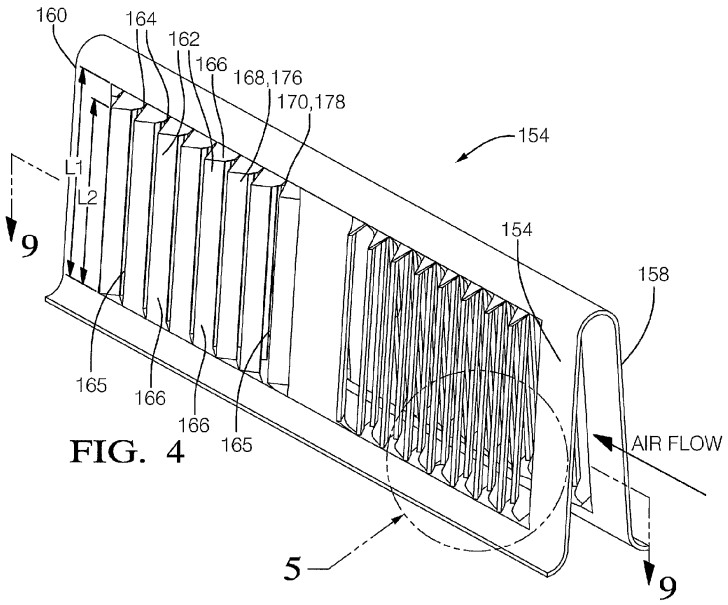


FIG. 4

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Description

TECHNICAL FIELD

[0001] The invention relates to heat exchanger assemblies, particularly to heat exchangers having fins, and more particularly to air cooled heat exchangers having louvered fins.

BACKGROUND OF THE INVENTION

[0002] Air cooled heat exchanger assemblies for automobiles are used for transferring heat from various working fluids, such as an engine coolant, an engine lubricating oil, an air conditioning refrigerant, and a transmission oil. A typical air cooled heat exchanger assembly includes an inlet header, an outlet header spaced from the inlet header, a plurality of fluid tubes hydraulically connecting the inlet and outlet headers, and a plurality of corrugated fins disposed between adjacent fluid tubes. The core of the heat exchanger assembly is defined by the plurality of fluid tubes and the corrugated fins disposed between adjacent tubes. A stream of air is directed through the core of the heat exchanger assembly typically by a cooling fan or motion of the automobile. As the stream of air flows across the fins, heat in a fluid flowing through the fluid tubes is conducted through the walls of the tubes, into the fins, transferred to the stream of air flow.

[0003] Various types of fins and louver designs are known in the art with the object of increasing the heat transfer efficiency of the heat exchanger assembly. Examples of these designs include increasing the numbers of louvers on a planar portion of the fin, forming louvers at a predetermined angle relative to the planar portion of the fin, forming louvers above and below the planar portion of the fin, and disposing louvers at predetermined locations on the planar portion of the fin to alter the air flow pattern through the core to increase the heat transfer coefficient of air encountered by the fluid tubes and fins.

[0004] It is desirable to continuously improve fin and louver designs for a heat exchanger assembly to increase the heat transfer efficiency by maximizing the heat transfer coefficient of air encountered by the fluid tubes and fins while minimizing the pressure drop through the core.

SUMMARY OF THE INVENTION

[0005] In concordance with the instant disclosure, a heat exchanger assembly is provided having at least one header, a plurality of spaced apart fluid tubes in hydraulic communication with the header, and a plurality of corrugated fins disposed between and in thermal contact with the tubes. The corrugated fins include a planar portion having a louver segment defined between a pair of primary slits, in which the louver segment includes an intermediate slit between the pair of primary slits splitting the louver segment into a pair of mini-louvers. The primary slits and the at least one intermediate slit are parallel and each of the primary slit includes a length L1. The at least one intermediate slit includes a length L2, and wherein the length L2 is less than the length L1, thereby defining a primary juncture transitioning the louver segment to the planar portion and defining a secondary juncture transitioning the mini-louvers to the primary juncture. The louver segment includes a primary juncture transitioning the louver segment to the planar portion. The louver segment is pivoted about such primary juncture such that the louver segment is oblique relative to the planar portion. Each of the mini-louvers includes a secondary juncture transitioning the mini-louvers to the primary juncture. The mini-louvers are counter-offset such that one of the mini-louvers is on one side of the planar portion and other one of the mini-louver is on the other side of the planar portion. The mini-louvers may be pivoted about their respective junctures such that each of the mini-louvers is at an angle oblique relative to the planar portion. Each of the mini-louvers includes a front edge and an opposite trailing edge, wherein the mini-louvers partially overlap one another such that the rear edge of one mini-louver extends past the front edge of the other mini-louver. The planar portion includes a leading edge, and the front edges of the mini-louvers are parallel with the leading edge of the planar portion. The intermediate slit defines an air passageway between the mini-louvers on either side of the planar portion.

[0006] A split mini-louver for a heat exchanger assembly comprises a planar portion having a louver segment defined between a pair of primary slits. The louver segment includes at least one intermediate slit between the pair of primary slits, thereby splitting the louver segment into at least two mini-louvers. The mini-louvers are counter-offset such that one of the mini-louvers is on one side of the planar portion and the other one of the mini-louvers is on the other side of said planar portion. The intermediate slit defines an air passageway between the mini-louvers. Each of the mini-louvers includes a front edge and an opposite trailing edge. The mini-louvers partially overlap one another such that the rear edge of one mini-louver extends past the front edge of the other mini-louver. Each of the mini-louvers transitions into a secondary juncture. Each of the secondary juncture transitions into primary juncture which transitions into the planar portion.

[0007] The counter off-setting of the mini-louvers onto both sides of the planar portion allows the mini-louvers to extend a greater distance from the planar portion into the air-flow channel than what a single larger louver would allow. The greater louver penetration into the air flow channels increases the distance that the air flow has to travel and increases the number of boundary layer interruptions that the air flow has to encounter, thereby increasing heat transfer efficiency. The intermediate slit separating the first from the second mini-louver in each pair of mini-louvers defines an air flow passageway, which allows greater air flow efficiency and less air pres-

sure drop for air flow through the core of the heat exchanger assembly.

[0008] Further features and advantages of the invention will appear more clearly on a reading of the following detailed description of an embodiment of the invention, which is given by way of non-limiting example only and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] This invention will be further described with reference to the accompanying drawings in which:

Fig. 1 shows a perspective front view of an exemplary embodiment of a heat exchanger assembly having corrugated fins with louvers.
Fig. 2 shows a perspective view of single louvered fins known in the art.
Fig. 3 is a detailed perspective view of the prior art single louvered fins of Fig. 2.
Fig. 4 shows a perspective view of an exemplary embodiment of split mini-louvered fins of the current invention.
Fig. 5 is a detailed perspective view of the split mini-louvered fins of Fig. 4.
Fig. 6 is a schematic cross-sectional view of single louvered fins of Fig. 3 along line 6-6.
Fig. 7 is a schematic cross-sectional view of the split mini-louvered fins of Fig. 5 along line 7-7.
Fig. 8 is a schematic cross-sectional view of an alternative embodiment of the split mini-louvered fins.
Fig. 9 is a schematic cross-sectional view of an alternative embodiment of the split mini-louvered fins of Fig. 5 along line 9-9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0010] The following detailed description and appended drawings describe and illustrate various embodiments of the invention. The description and drawings serve to enable one skilled in the art to make and use the inventions, and are not intended to limit the scope of the invention in any manner.

[0011] Referring to Figures 1, 4, 5, and 7-9 wherein like numerals indicate corresponding parts throughout the several views, is an exemplary embodiment of a heat exchanger assembly 20 having split mini-louvered fins 150 of the current invention. The split mini-louvered fins 150 enable greater heat transfer efficiency by allowing greater louver penetration into the air flow channels 36 to increase the distance that the air flow has to travel through the heat exchanger core 34 and to increase the number of boundary layer interruptions that the air flow has to encounter, while minimizing the pressure drop.

[0012] Shown in Fig. 1 is a perspective front view of an exemplary embodiment of the heat exchanger assembly 20 of the present invention, which includes a first manifold 22 extending along a manifold A-axis and a second manifold 24 extending in a spaced and substantially parallel relationship with the first manifold 22. The first and second manifolds 22, 24 present a plurality of corresponding tube slots 26 axially spaced along the respective manifolds 22, 24. A plurality of fluid tubes 28 is inserted into the corresponding tube slots 26 of the manifolds 22 in a spaced and parallel arrangement for hydraulic fluid communication between the manifolds 22, 24. A plurality of corrugated fins 32 is disposed between and in thermal contact with adjacent fluid tubes 28 for increased heat transfer efficiency between the fluid in the tubes 28 and ambient air. The plurality of tubes 28 and corrugated fins 32 between adjacent tubes 28 define the heat exchanger core 34. The spaces between the corrugated fins 32 and the plurality of tubes 28 define a plurality of airflow channels 36 through the core 34.

[0013] In a normal operating state, a stream of ambient air is directed through the core 34 of the heat exchanger assembly 20 to transfer heat from a fluid flowing through the fluid tubes 28 to the ambient air. Heat is conducted through the walls of the tubes 28, into the fins, and transferred to the stream of air flow. It should be appreciated that heat may be transferred to the fluid flowing through the tubes 28 if the temperature of the stream of air is higher than the temperature of the fluid flowing through the tubes 28.

[0014] Shown in Fig. 2 is a view of a prior art corrugated louvered fin 50 having single louvers 52 along a planar portion 54 of the fin 50. The corrugated louvered fin 50 is formed from a thin strip of heat conductive material into corner portions 56 and planar portions 54 that are alternately continuously arranged to define a corrugation. Each of the planar portions 54 includes a leading edge 58 oriented into the oncoming air flow, an opposite trailing edge 60 spaced from the leading edge 58, and a plurality of louvers 52 therebetween. Each louver 52 is defined by a louver segment 62 of the planar portion 54 between a pair of slits 64. Best shown in Figs. 2 and 6, on opposite ends of the louver segment 62 is a juncture 66 that transitions the louver segment 62 to the planar portion 54. The single louvers 52 are formed by pivoting the louver segments 62 about the junctures 66 such that the louver segments 62 are oblique to the planar portion 54. Best shown in Fig. 3, the pivoting of the louver segment 62 about the juncture 66 defines a twisted transition that connects the single louver 52 to the planar portion 54. The louver 52 includes a front edge 59 oriented toward the direction of air flow and an opposite rear edge 60. The front edges 59 of the louvers 52 are substantially parallel with each other and may be parallel with the leading edge 58 of the planar portion 54.

[0015] Shown in Figs. 4, 5, and 7 are views of an embodiment of a corrugated split mini-louvered fin 150 of the current invention. Best shown in Fig. 7, each pair of split mini-louvers 152 is defined by pivoting a louver segment 162 about a primary juncture 166 to a predetermined first angle relative to the planar portion 154, splitting the louver segment 162 into a first mini-louver 176

and a second mini-louver 178, counter off-setting the mini-louvers 176, 178 onto both sides of the planar portion 154, and pivoting the mini-louvers 176,178 about their respective secondary junctures 172 to a predetermine second angle with respect to the planar portion 154. Show in Figs. 8 and 9, the mini-louvers 176, 178 may also be off-set in the axial direction with respect to the direction of airflow such that a portion of one mini-louver overlaps with a portion of the other mini-louver.

[0016] Shown in Figs. 4 and 7, the split mini-louvered fin 150 includes a planar portion 154 having a leading edge 158 and an opposite trailing edge 160. The planar portion 154 includes a louver segment 162 defined between a pair of primary slits 164 having a first length L1. On opposite ends of the louver segment 162 is a primary juncture 166 that transitions the louver segment 162 to the planar portion 154. The louver segment 162 is split into a first segment 168 and a second segment 170 by an intermediate slit 165 having a length L2 between the pair of primary slits 164. The length L2 of the intermediate slit is shorter than the length of the primary slit L1, thereby defining a secondary juncture 172 on opposite sides of each of the first and second segments 168, 170. The secondary junctures 172 transition the respective segments 168, 170 into the primary juncture 166, which then transitions into the planar portion 154. The pair of primary slits 164 and intermediate slit 165 may be parallel with each other and as well as with the leading edge 158 of the planar portion 154.

[0017] Shown in Fig. 7 is a cross-sectional view of the split mini-louvered fins 150 of Fig. 5 along line 7-7. The louver segment 162 is pivoted in a first direction about the primary juncture 166 to a first angle that is oblique to the planar portion 154. A first mini-louver 176 and a second mini-louver 178 are then defined by counter-offsetting the first and second segments 168, 170 onto opposite sides of the planar portion 154. While only two mini-louvers 176, 178 are shown per louver segment 162, it should be appreciated that additional mini-louvers 176 may be formed on the same louver segment 162 by providing additional intermediate splits 165 between the pair of primary slits 164.

[0018] The counter-offsetting of the first and second segments 168, 170 to define the first and second mini-louvers 176, 178 may be accomplished by mechanically displacing the material defining the secondary junctures 172 such that one of the first and second mini-louvers 176, 178 is on one side of the planar portion 154 and the other of the first and second mini-louvers 176, 178 is on the other side of the planar portion 154. Once off-set, the first and second mini-louvers 176, 178 may be individually pivoted about their respective secondary junctures 172 to a predetermined angle with respect to the planar portion 154. The predetermined degree of angle for the first and second mini-louvers 176, 178 may be the same or offset from each other.

[0019] As an alternative to mechanically displacing the material defining the secondary junctures 172 such that one of the first and second mini-louvers 176, 178 are on opposite side of the planar portion 154, the counter-offsetting of the first and second segments 168, 170 to define the first and second mini-louvers 176, 178 may be accomplished by pivoting the first and second segments 168, 170 in a second direction opposite that of the first pivot direction of the louver segment 162 such that one of the first and second mini-louvers 176, 178 is on one side of the planar portion 154 and the other of the first and second mini-louvers 176, 178 is on the other side of the planar portion 154. The pivoting of the first and second segments 168, 170 in a second direction opposite that of the first pivot direction may be varied according to the desired angle of the mini-louvers 176, 178 with respect to the planar portion 154.

[0020] Fig. 8 shows a cross-sectional view of an alternative embodiment of the split mini-louvered fins 150 of Fig. 5 along line 7-7. The first mini-louver 176 includes a front edge 159a oriented in the direction of air flow and a downstream rear edge 161a. Similarly, the associated second mini-louver 178 includes a front edge 159b oriented in the direction of air flow and a downstream trailing edge 161b. The offset first and second mini-louvers 176, 178 are displaced axially relative to the direction of air flow from the leading edge 158 to the trailing edge 160 such that a portion of the first and second mini-louvers 176, 178 overlaps each other in way that the rear edge 161a of the first mini-louver 176 extends rearward pass the front edge 159b of the second mini-louver 178.

[0021] Fig. 9 shows a cross-sectional view of the alternative embodiment of the split mini-louvered fins 150 of Fig. 5 along line 9-9. The counter off-setting of the first and second mini-louvers 176, 178 onto both sides of the planar portion 154 allows the mini-louvers 176, 178 to extend at a greater distance from the planar portion 154 into the flow channel 36 than what a single larger louver 52 would allow. The greater louver penetration into the air flow channels 36 increases the distance that the air flow has to travel and increases the number of boundary layer interruptions that the air flow has to encounter, thereby increasing heat transfer efficiency. Furthermore, the intermediate slit 165 separating the first from the second mini-louver 176, 178 in each pair of mini-louvers 176, 178 defines an air flow passageway 190 thereby allowing greater air flow efficiency, resulting in less air pressure drop associated with the change in airflow direction caused by the fins and louvers.

Claims

1. A split mini-louver (150) for a heat exchanger assembly (20), comprising:

   a planar portion (154) having a louver segment (162) defined between a pair of primary slits (164),
   wherein said louver segment (162) includes at

least one intermediate slit (165) between said pair of primary slits (164), thereby splitting said louver segment (162) into at least two mini-louvers (176, 178).

2. Split mini-louver (150) for a heat exchanger assembly (20) of claim 1 wherein said mini-louvers (176, 178) are counter-offset such that one of said mini-louvers (176, 178) is on one side of said planar portion (154) and other one of said mini-louvers (176, 178) is on the other side of said planar portion (154).

3. Split mini-louver (150) for a heat exchanger assembly (20) according to any one of the preceding claims wherein said intermediate slit (165) defines an air passageway between said mini-louvers (176).

4. Split mini-louver (150) for a heat exchanger assembly (20) according to any one of the preceding claims wherein each of said mini-louvers (176, 178) includes a front edge (159) and an opposite trailing edge (161), wherein said mini-louvers (176, 178) partially overlap one another such that the rear edge (161) of one mini-louver (52) extends past the front edge (159) of the other said mini-louver (176, 178).

5. Split mini-louver (150) for a heat exchanger assembly (20) according to any one of the preceding claims wherein each of said mini-louvers (176, 178) transitions into a secondary juncture (172).

6. Split mini-louver (150) for a heat exchanger assembly (20) of claim 5 wherein each of said secondary juncture (172) transitions into primary juncture (166) which transitions into said planar portion (154).

7. A heat exchanger assembly (20) comprising:

at least one header (22);
a plurality of fluid tubes (28) in hydraulic communication with said header (22), wherein said tubes (28) are spaced apart; and
a plurality of corrugated fins (32) disposed between and in thermal contact with said tubes (28), at least one of said corrugated fins (32) comprises a split mini louver (150) according to any one of the preceding claims.

8. Heat exchanger assembly (20) of claim 7, wherein:

said primary slits (164) and said at least one intermediate slit (165) are parallel,
each of said primary slit includes a length L1,
said at least one intermediate slit (165) includes a length L2, and
wherein said length L2 is less than said length L1, thereby defining a primary juncture (166) transitioning said louver segment (162) to said planar portion (154) and defining a secondary juncture (172) transitioning said mini-louvers (176, 178) to said primary juncture (166).

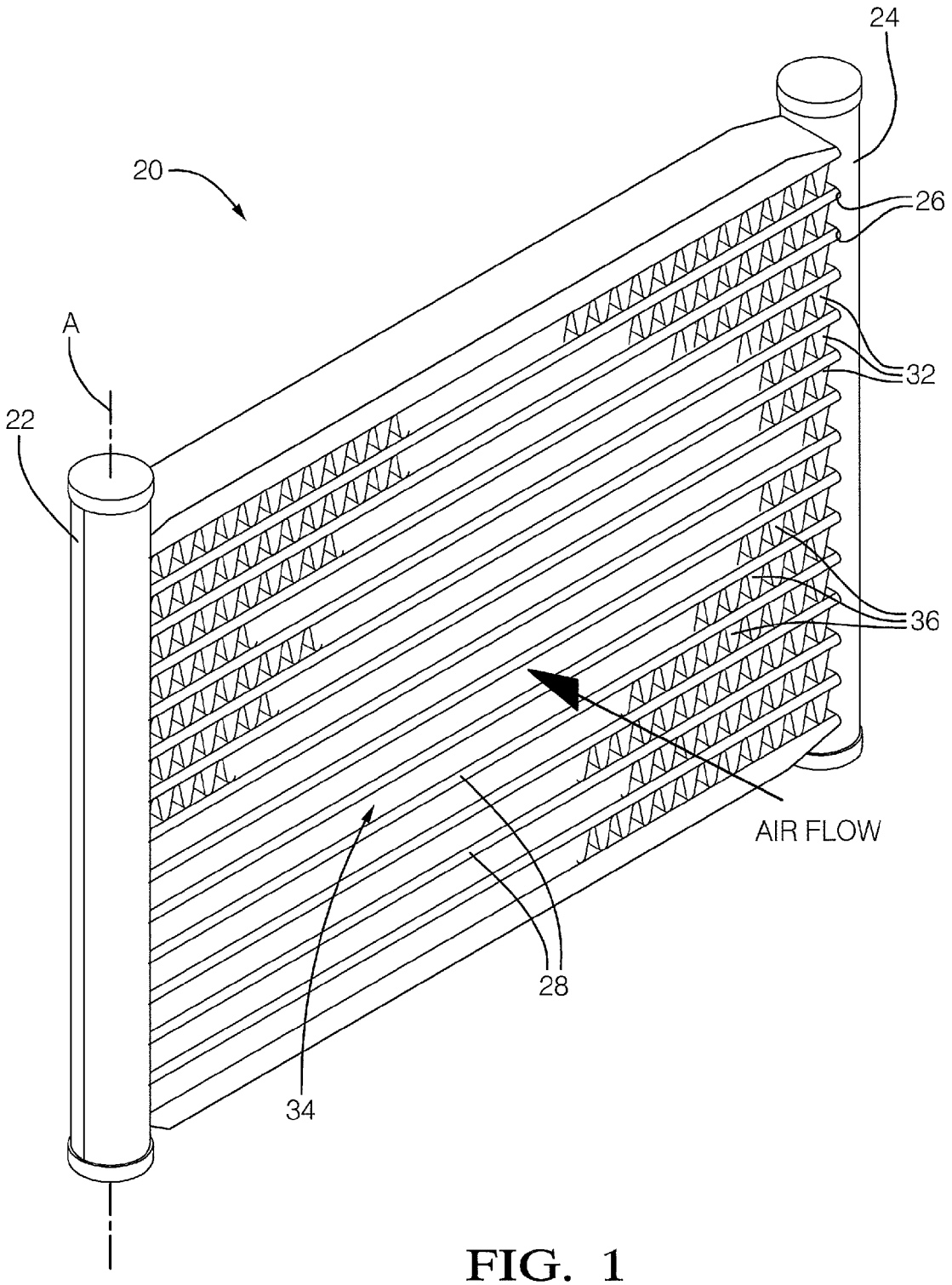
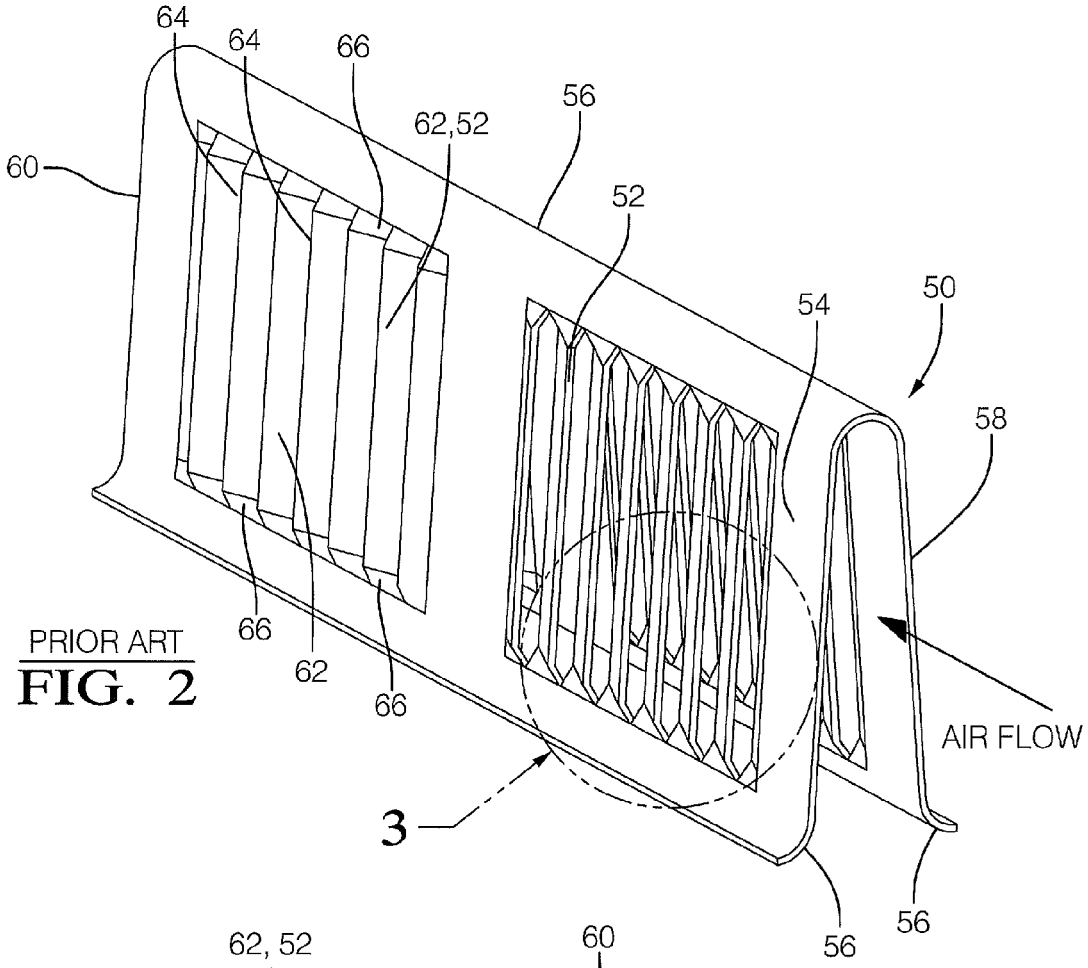
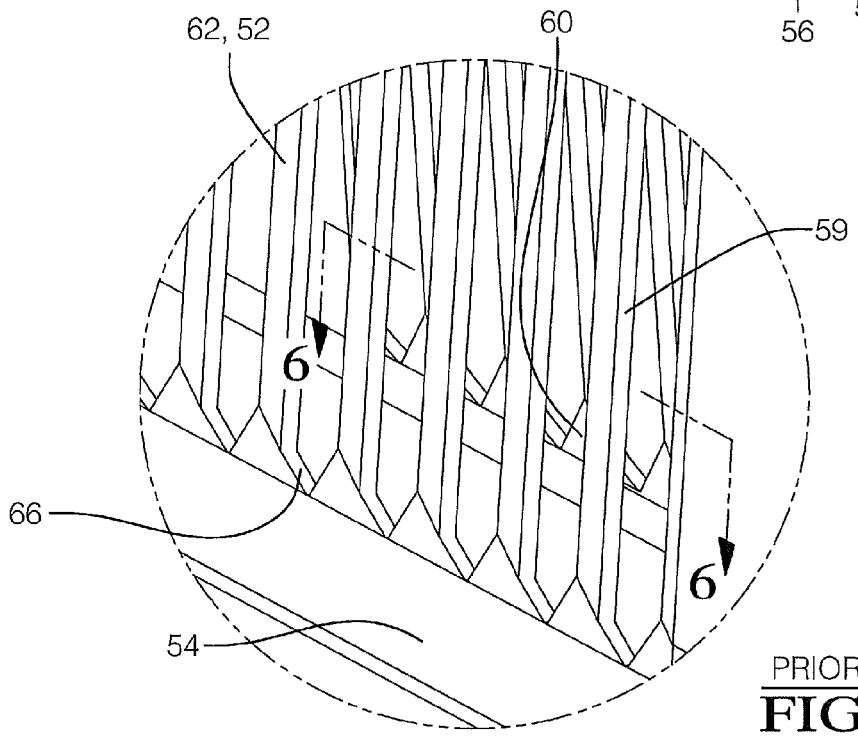


FIG. 1



PRIOR ART
FIG. 2



PRIOR ART
FIG. 3

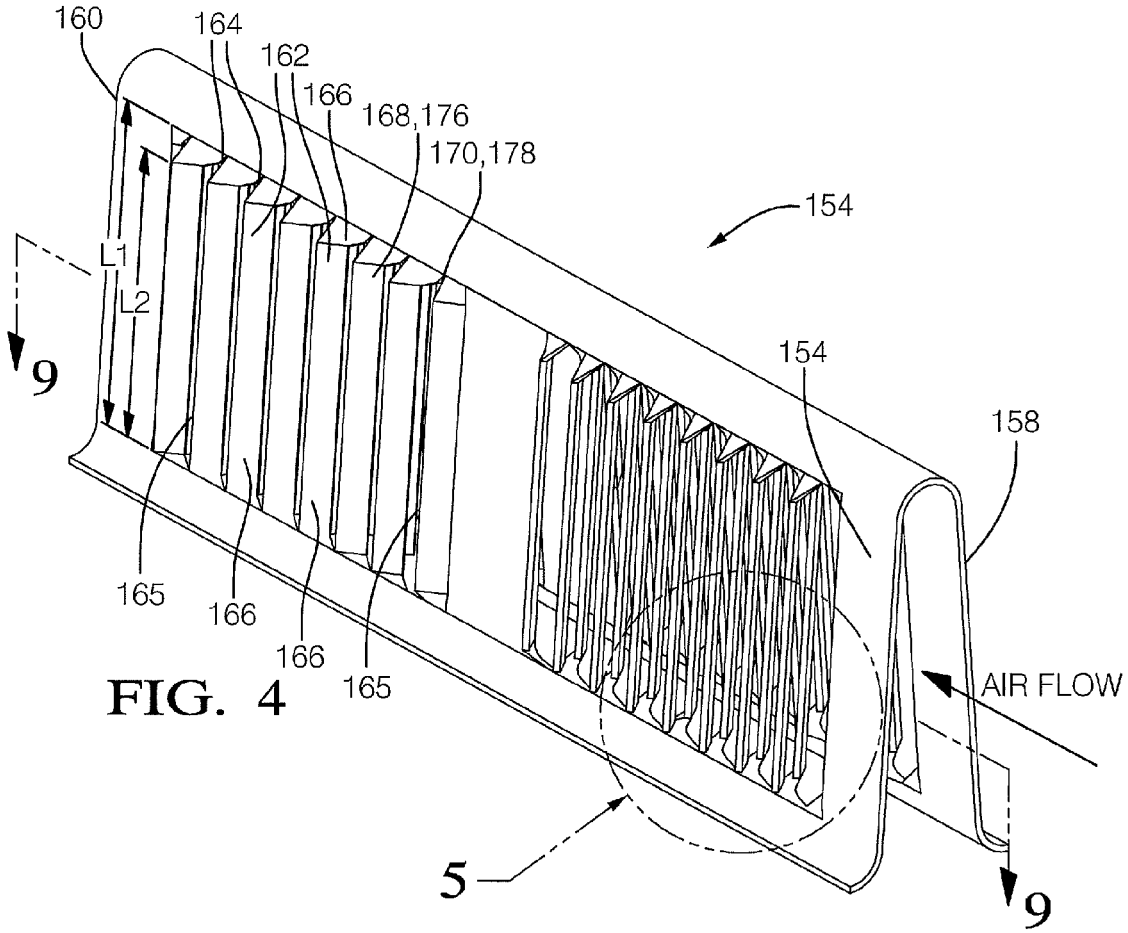

160
164
162
166
168,176
170,178
154
L1
L2
9
154
158
165
166
166
165
AIR FLOW
5
9

FIG. 4

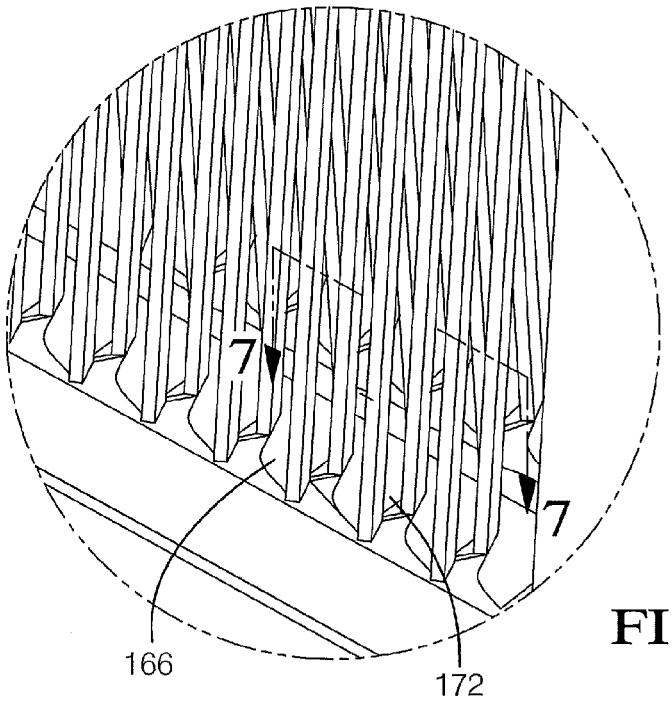
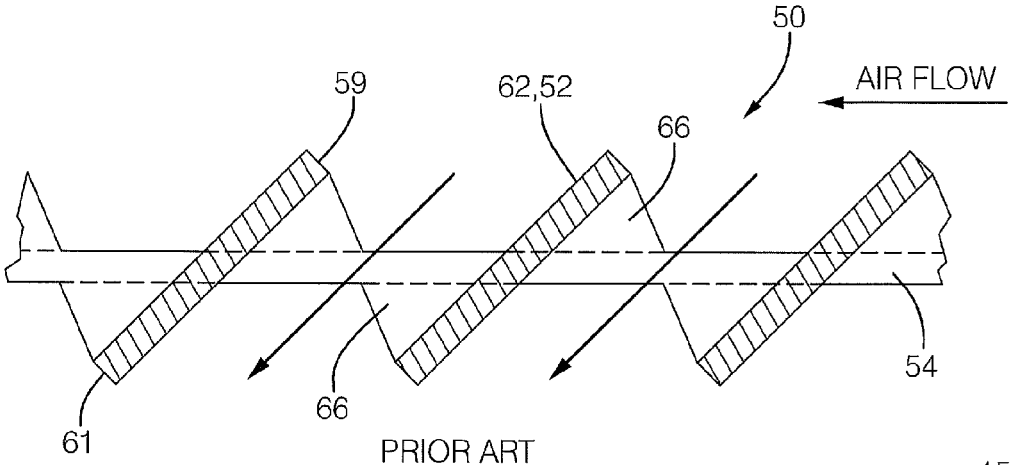

7
7
166
172

FIG. 5



PRIOR ART

FIG. 6

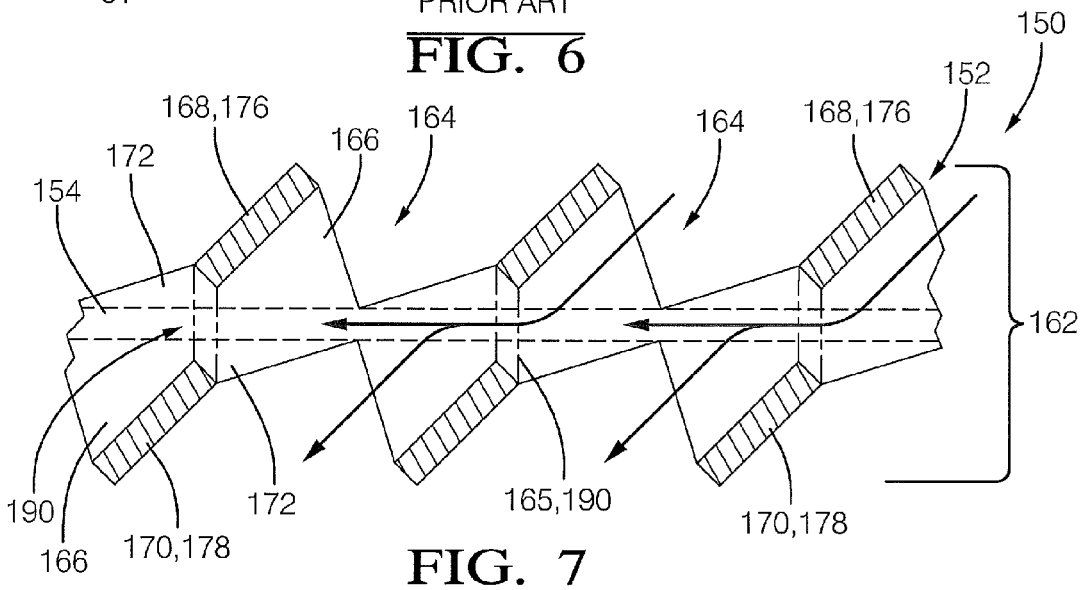


FIG. 7

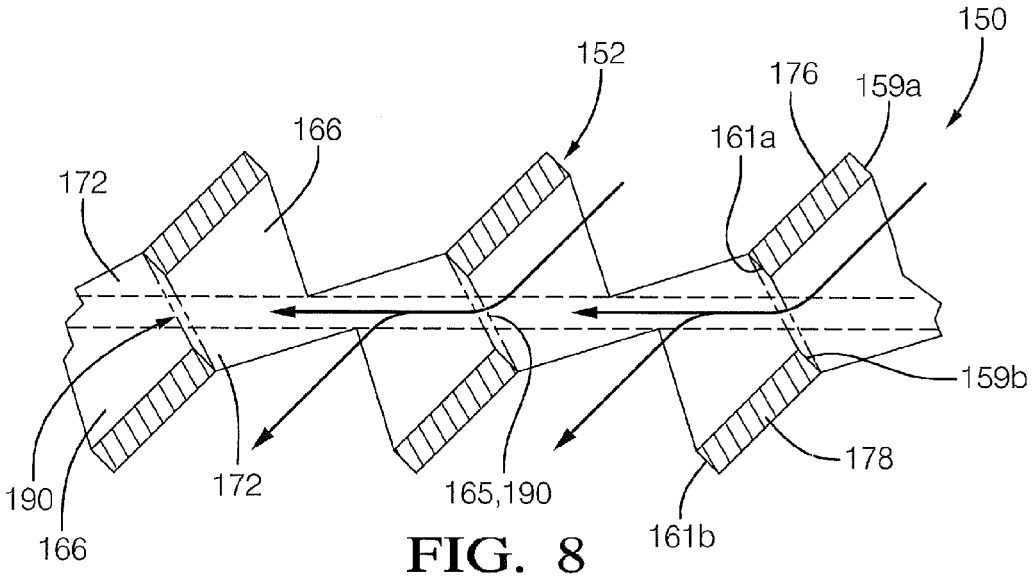


FIG. 8

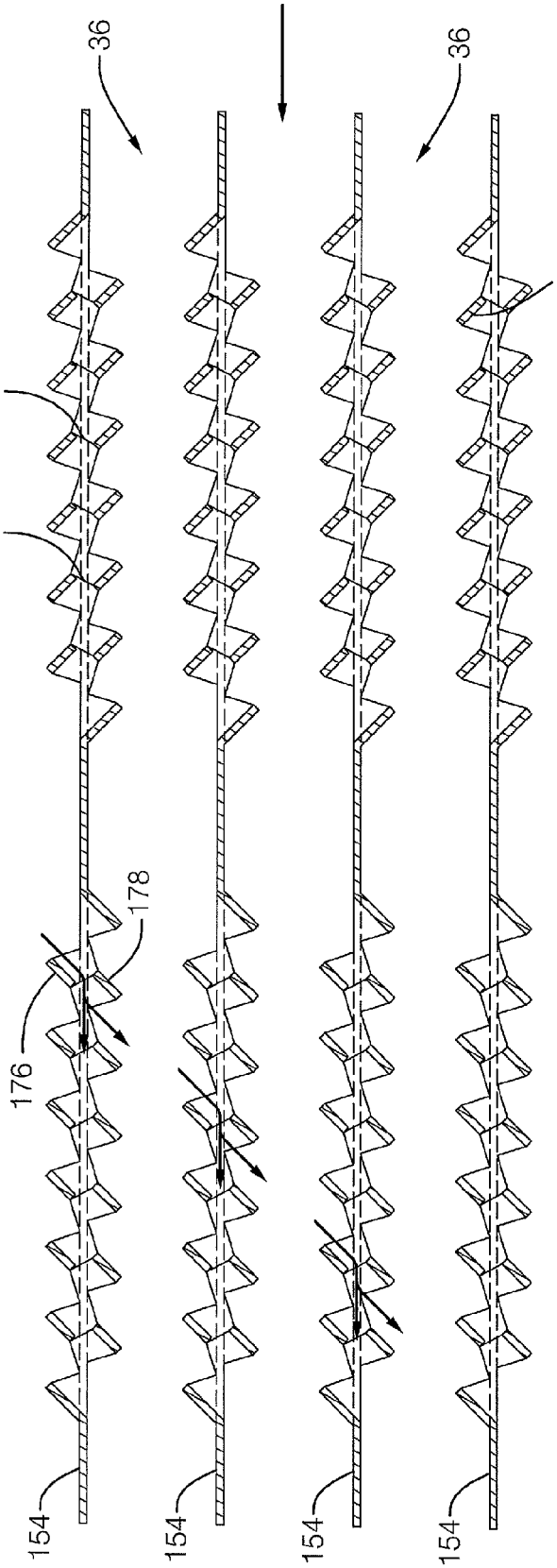


FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 9252

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2009/173479 A1 (HUANG LIN-JIE [US]) 9 July 2009 (2009-07-09) * figures 3,3a *	1-8	INV. F28F1/00 F28F1/12 F28D1/053
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TECHNICAL FIELDS SEARCHED (IPC)
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 June 2014	Bain, David

CATEGORY OF CITED DOCUMENTS

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