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(54) Low pressure drop fin with selective micro surface enhancement

(57) The assembly includes a heat exchanger assembly (20) including a plurality of tubes (32) extending between first and second manifolds. A plurality of fins (42) extend back and forth between and long the tubes (32) in a continuous patch and define a plurality of legs (48) extending between the tubes (32). Each of the legs (48) includes a plurality of front long louvers (52) for conveying a stream of air through the legs. Each of the legs further defines a plurality of main spoilers (56) between the front long louvers (52) and the back edges (44,46) of the legs (48) for inducing turbulence in the stream of air with each of the main spoilers (56) having a spoiler height in the range of 50 to 90 percent of the long louver height and each of the main spoilers (56) having a spoiler length in the range of 10 to 35 percent of the long louver length.

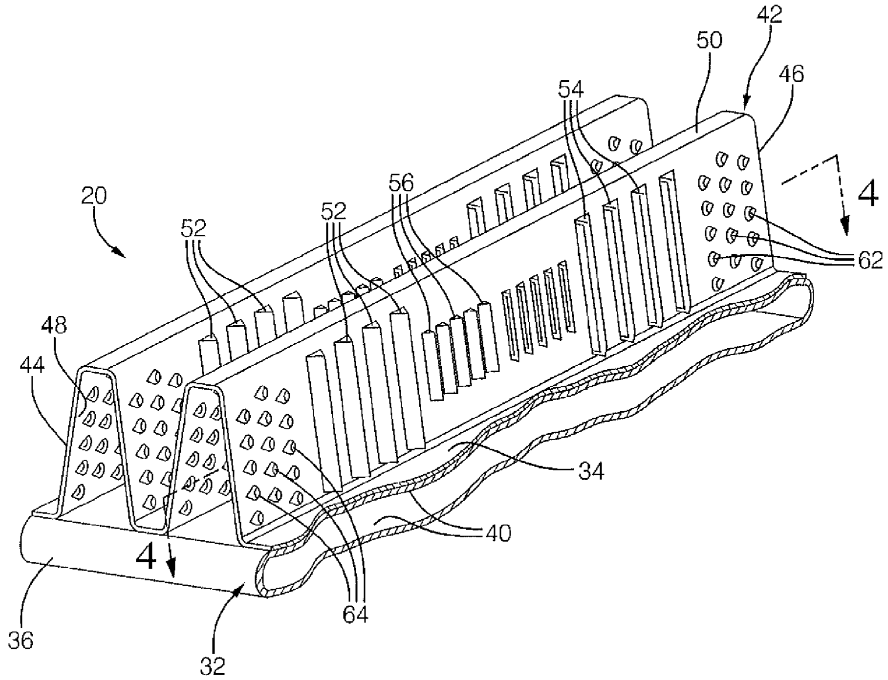

FIG. 2

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Description

TECHNICAL FIELD

[0001] A heat exchanger assembly, and more specifically, a heat exchanger assembly including louvered air fins for transferring heat between a refrigerant and a stream of air.

BACKGROUND OF THE INVENTION

[0002] A vast number of heat transfer applications, e.g. residential HVAC, electronics, etc., operate under very low thermal heat transfer potential. In other words, the temperature difference between the refrigerant and the stream of air entering the heat exchanger is not great. Additionally, the size and power of the fan propelling the stream of air through a heat exchanger is often limited by a number of constraints, e.g. power usage, noise, space, etc. For example, in a laptop computer, the size of the fan must be minimized to fit within the space constraints of the casing, and the power of the fan must be minimized to avoid draining the battery or producing undesirable noise. In these applications, the performance of the air fins in transferring heat between the refrigerant and the stream of air is critical. Air fins generally include louvers to increase heat transfer, but those louvers also create an undesirable pressure drop in the stream of air.

[0003] U.S. Patent Application Publication No. 2008/0121385, to In Chuil Kim (hereinafter referred to as Kim '385) shows a heat exchanger assembly for transferring heat between a refrigerant and a stream of air. Kim'385 includes first and second manifolds spaced from one another. A plurality of tubes extend in spaced relationship with one another between the first and second manifolds for conveying the refrigerant between the first and second manifolds. A plurality of fins are disposed between adjacent tubes for transferring heat between the tubes and the stream of air. Each of the fins has a front edge and a back edge and presents a plurality of legs extending transversely between the adjacent tubes. Each of the legs of the fins defines a plurality of front long louvers disposed between the front and back edges for conveying the stream of air through the legs of the air fins with each of the long louvers having a long louver height and a long louver length.

SUMMARY OF THE INVENTION

[0004] The invention is about a heat exchanger assembly for transferring heat between a refrigerant and a stream of air, comprising a first manifold, a second manifold spaced from said first manifold, a plurality of tubes extending in spaced relationship with one another between said first and second manifolds for conveying the refrigerant between said first and second manifolds, a plurality of fins disposed between adjacent ones of said tubes for transferring heat between the refrigerant in said tubes and the stream of air, each of said fins having a front edge and a back edge and including a plurality of legs extending transversely between said adjacent tubes, each of said legs of said fins defining a plurality of front long louvers disposed between said front and back edges for conveying the stream of air through said legs of said air fins with each of said long louvers having a long louver height and a long louver length; and each of said legs of said fins defining a plurality of main spoilers disposed between said front long louvers and said back edges for inducing turbulence in the stream of air with each of said main spoilers having a spoiler height in the range of 50 to 90 percent of said long louver height and each of said main spoilers having a spoiler length in the range of 10 to 35 percent of said long louver length.The main spoilers are micro-louvers.The legs of said air fins presents a plurality of front spoilers disposed between said front edge and said front long louvers for inducing turbulence in the stream of air. Each of said front spoilers extends outwardly from said legs and has a triangular shape and, each of said legs of said air fins defines a plurality of back spoilers disposed adjacent to said back edge and a plurality of back long louvers disposed between said micro-louvers and said back spoilers. Also, each of said legs of said fins has a fin height and said long louver height is in the range of 50 to 90 percent of said fin height.The long louver length is in the range of 0.7 to 1.5 mm.The spoiler length is in the range of 0.15 to 0.4 mm. Each of said front long louvers extends diagonally outwardly from said legs of said fins. The first and second manifolds extend in spaced and parallel relationship with one another.The first manifold defines a plurality of first tube slots spaced from one another and said second manifold defines a plurality of second tube slots spaced from one another and aligned with said first tube slots. Each of said tubes has a cross-section presenting flat sides interconnected by a round front and a round back. The tubes extend in spaced and parallel relationship with one another between said aligned first and second tube slots of said first and second manifolds. Each of said tubes defines a fluid passage for conveying the refrigerant between said manifolds. The main spoilers are disposed in a staggered arrangement. The main spoilers are semi-cylindrical bumps or triangular notches.The invention provides for such a heat exchanger assembly and wherein each of the legs of the fins defines a plurality of main spoilers disposed between the front long louvers and the back edges for inducing turbulence in the stream of air with each of the main spoilers having a spoiler height in the range of 50 to 90 percent of the long louver height and each of the main spoilers having a spoiler length in the range of 10 to 35 percent of the long louver length.

[0005] The potential for heat transfer between the refrigerant and the stream of air decreases as the air flows downstream through the heat exchanger because the temperature difference between the refrigerant and the stream of air is reduced. The long louvers have more potential for heat transfer than the main spoilers because the long louvers turn and induce turbulence to the stream of air, whereas the main spoilers function mainly to induce turbulence in the air. Therefore, the long louvers are disposed upstream, where the temperature difference between the stream of air and the refrigerant is greatest, of the main spoilers. The upstream long louvers perform the majority of the heat transfer between the stream of air and the refrigerant. Although long louvers are very effective at transferring heat between the stream of air and the refrigerant, they come at a cost. Namely, long louvers create a large pressure drop in the stream of air flowing through the heat exchanger. Therefore, it is undesirable to have long louvers extend the entire length of the air fin. The smaller main spoilers are disposed downstream of the long louvers to induce turbulence in the stream of air to increase the air's heat transfer potential without compromising the overall pressure drop of the heat exchanger. This allows for a greater quantity of air to flow through the upstream long louvers of the fins and improves the overall efficiency of the heat exchanger assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0007] Figure 1 is a perspective view of a heat exchanger assembly;

[0008] Figure 2 is a perspective view, partially cut away a first embodiment of a fin with louvers and one tube of a heat exchanger assembly;

[0009] Figure 3 is a front view, partially cut away of a first embodiment of a fin;

[0010] Figures 4 a through f are cross-sectional views of the first through sixth embodiments of the louvers and spoilers of the fins;

[0011] Figure 5 is a cross-sectional view showing the flow of air over the louvers and spoilers according to one of the embodiment of Figure 4a; and

[0012] Figure 6 is a front view, partially cut away for an alternate embodiment of a fin having micro-louvers disposed in a staggered arrangement.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, a heat exchanger assembly 20 for transferring heat between a refrigerant and a stream of air 22 is generally shown in Figure 1.

[0014] Referring to Figure 1, the heat exchanger assembly 20 includes a first manifold 24 and a second manifold 26 extending in spaced and parallel relationship with one another. The first manifold 24 defines a plurality of first tube slots 28 being spaced from one another. The second manifold 26 defines a plurality of second tube slots 30 being spaced from each other and aligned with the first tube slots 28. A plurality of tubes 32 extend in spaced and parallel relationship to one another between the aligned first and second tube slots 28, 30. Each of the tubes 32 has a cross-section defining flat sides 34 interconnected by a round front 36 and a round back 38. Each of the tubes 32 defines a fluid passage 40 for conveying refrigerant between the manifolds 24, 26.

[0015] A plurality of fins 42, generally indicated, are disposed between adjacent ones of the tubes 32 for transferring heat between the refrigerant in the fluid passages 40 of the tubes 32 and the stream of air 22. The fins 42 have a fin height HF. The fins 42 extend continuously between a front edge 44 adjacent to the round front 36 of the tubes 32 and back edge 46 adjacent to the round back 38 of the tubes 32. In other words, the front edge 44 of the fins 42 is upstream of the back edge 46 of the fins 42. Each of the fins 42 includes a plurality of legs 48 extending transversely between the adjacent tubes 32. The fins 42 also include a plurality of end portions 50 engaging the flat sides 34 of the adjacent tubes 32. Together, the legs 48 and end portions 50 of the fins 42 present a serpentine path extending between the first and second manifolds 24, 26. In other words, adjacent legs 48 of the fins 42 are connected by end portions 50 engaging opposite ones of the flat sides 34 of the adjacent tubes 32.

[0016] In all of the embodiments of the subject invention, shown in Figures 4 a-f, each of the legs 48 of the fins 42 presents a plurality of front long louvers 52 disposed between the front and back edges 44, 46. In addition to inducing turbulence in the stream of air 22, the front long louvers 52 function to turn the stream of air 22. In other words, the front long louvers 52 convey the stream of air 22 through the legs 48 of the air fins 42. This keeps the stream of air 22 in the heat exchanger longer and gives the stream of air 22 more time to receive heat from or dispense heat to the refrigerant in the tubes 32, depending on the application of the heat exchanger assembly 20. The long louvers 52, 54 have a long louver height HL, which is preferably in the range of 60 to 90 percent of the fin height HF, and the long louvers 52, 54 have a long louver length LL, which is preferably in the range of 0.7 to 1.5 mm.

[0017] In all of the embodiments of the subject invention, shown in Figures 4a-f, each of the legs 48 of the fins 42 presents a plurality of main spoilers 56, 58, 60 disposed between the front long louvers 52 and the back edge 46, i.e. downstream of the front long louvers 52. The main spoilers 56, 58, 60 serve to interrupt the airflow and induce turbulence in the stream of air 22, but do not substantially turn the air as the front long louvers 52 do. In other words, although some air might be conveyed cross-stream between the legs 48 of the fins 42 through the main spoilers 56, 58, 60, the majority of the air is flows straight through the heat exchanger assembly 20.

Each of the main spoilers 56, 58, 60 has a spoiler height HS preferably in the range of 50 to 90 percent of the long louver height HL, and each of the main spoilers 56, 58, 60 has a spoiler length LS preferably in the range of 10 to 35 percent of the long louver length LL. A small spoiler length LS compared to the long louver length LL keeps the airflow blockage due to the main spoilers 56, 58, 60 small, thereby achieving good heat transfer with a low pressure drop penalty.

[0018] As shown in Figures 4 a-f, each of the legs 48 of the fins 42 is symmetrical. In other words, all of the embodiments include back long louvers 54 disposed between the main spoilers 56, 58, 60 and the back edge 46 of the air fin 42. Additionally, some of the embodiments include back spoilers 62 disposed between the back long louvers 54 and the back edge 46 of the air fin 42. The symmetry of the fins 42 is primarily for manufacturing purposes because symmetrical fins 42 can be made less expensively than non-symmetrical fins 42. It should be appreciated that the main spoilers 56, 58, 60 could extend from the front long louvers 52 to the back edge 46, or the air fin 42 could be flat between the main spoilers 56, 58, 60 and the back edge 46.

[0019] In the first embodiment, shown in Figure 4a, each of the legs 48 of the fins 42 presents a plurality of front spoilers 64 adjacent to the front edge 44 for interrupting the flow and inducing turbulence in the stream of air 22. The delta-wing, or triangular, shaped front spoilers 64 are best shown in Figures 2 and 3. The delta wings are disposed over the entire fin height HF. The width and height of the delta-wings is comparable to the spoiler length LS. The front spoilers 64 are most useful when used in a cold environment. In cold environments, frost has a tendency of building up on the front edge 44 of the fins 42 when there is large heat transfer rate between the air and the refrigerant at that front edge 44. The frost can block the stream of air 22 from flowing through the heat exchanger, which drastically reduces the efficiency of the heat exchanger. The front spoilers 64 disposed upstream of the front long louvers 52 ensure that the maximum rate of heat transfer takes place slightly downstream of the front edge 44 of the fins 42 to prevent the frost from building up on the front edge 44 of the fins 42. Although the efficiency of the heat exchanger assembly 20 might be reduced in some operating conditions, i.e. in warm environments, heat exchanger assemblies 20 having front spoilers 64 can be used in a wider variety of operating conditions. The main spoilers 56, 58, 60 of the first embodiment are micro-louvers 56.

[0020] The second embodiment, shown in Figure 4b, is similar to the first embodiment, but the delta-wing shaped front spoilers 64 of the first embodiment are replaced with front micro-louvers 64, shaped similarly to the main spoilers 56, 58, 60. The front micro-louvers 64 function similar to the delta-wing shaped front spoilers 64 of the first embodiment in that they interrupt the airflow and induce turbulence in the air, but leave the majority of the heat transfer to the long louvers 52, 54 disposed between the micro-louvers 64 and the main spoilers 56, 58, 60, which are also shown as micro-louvers 56.

[0021] The third embodiment, shown in Figure 4c, has front long louvers 52 disposed upstream of the main spoilers 56, 58, 60, shown as micro-louvers 56. Because the third embodiment does not have front spoilers 64, airflow is steered in the cross stream direction by the front and back long louvers 52, 54. Airflow is mostly straight in the mid section.

[0022] Like the third embodiment, the fourth embodiment, shown in Figure 4d, shows the main spoilers 56, 58, 60 as being micro-louvers 56. The micro-louvers 56 of the fourth embodiment extend outwardly on both sides of the legs 48 of the fins 42.

[0023] The fifth embodiment, shown in Figure 4e, shows the main spoilers 56, 58, 60 as being semi-cylindrical bumps 58. The semi-cylindrical bumps 58 extend outwardly on both sides of the legs 48 of the fins 42.

[0024] The sixth embodiment, shown in Figure 4f, shows the main spoilers 56, 58, 60 as being triangular notches 60. The triangular notches 60 extend outwardly from the leg 48 on opposite sides of the leg 48.

[0025] It should be appreciated that the main spoilers 56, 58, 60 may take any number of shapes, not just those shown in Figures 4 a-f. The main spoilers 56, 58, 60 can be disposed both upstream or downstream of at least one front long louver 52. Additionally, each of the main spoilers 56, 58, 60 must have a spoiler height HS in the range of 50 to 90 percent of the long louver height HL, and each of the main spoilers 56, 58, 60 must have a spoiler length LS in the range of 10 to 35 percent of the long louver length LL.

[0026] In applications where the maximum thermal potential for total heat dissipation is small, it is paramount that total airflow through the heat exchanger assembly 20 be high. With fan power and noise constraints, airflow can be high only when the overall pressure drop of the heat exchanger is kept to a minimum. Having front spoilers 64, as shown in Figures 4 a-c, allows the flow a better entrance condition into the core of the heat exchanger with a low pressure drop but with some heat transfer enhancement as compared to an un-louvered surface. In this fashion high pressure drop is expended locally only where heat transfer potential is maximum without compromising the tendency of frost to build up on the front edges 44 of the fins 42. The bulk of the heat transfer between the refrigerant and the stream of air 22 occurs at the front long louvers 52. The rest of the fin 42 is utilized for pressure drop management with some heat transfer augmentation through the main spoilers 56, 58, 60 downstream of the front long louvers 52.

[0027] Figure 5 shows the stream of air 22 flowing through the heat exchanger assembly 20 of the first embodiment. As shown, the air flows straight between the legs 48 of the fins 42 past the micro-louvers or the delta-wing shaped front spoilers 64. As the stream of air 22 flows downstream between the legs 42, most of the air is turned by the front long louvers 52 between the legs

42. The stream of air 22 then straightens out as it passes the main spoilers 56, 58, 60. The back long louvers 54, which are optional as explained above, turn the stream of air 22 again between the legs 42. The stream of air 22 once again straightens out when it passes the delta-wing shaped back spoilers 62. Although not shown in Figure 5, it should be appreciated that each of the front spoilers 64, front long louvers 52, main spoilers 56, 58, 60, back long louvers 54, and back spoilers 62 induces turbulence into the stream of air 22. The micro-louver segment can be disposed anywhere symmetrically or asymmetrically within the fins 42.

[0028] As shown in Figure 6, the micro-louvers 56 can alternately be disposed in a staggered arrangement. The staggered arrangement can be easily manufactured and provide for a large number of micro-louvers 56 with a smaller pressure drop penalty. Additionally, the staggered micro-louvers 56 are disposed close to the end portions 50 of the fins 42, which have the a higher heat transfer potential than the middle of the fins 42.

Claims

1. A heat exchanger assembly (20) for transferring heat between a refrigerant and a stream of air, comprising:

a first manifold (24);
a second manifold (26) spaced from said first manifold (24);
a plurality of tubes (32) extending in spaced relationship with one another between said first and second manifolds (24, 26) for conveying the refrigerant between said first and second manifolds (24, 26);
a plurality of fins (42) disposed between adjacent ones of said tubes (32) for transferring heat between the refrigerant in said tubes (32) and the stream of air;
each of said fins (42) having a front edge (44) and a back edge (46) and including a plurality of legs (48) extending transversely between said adjacent tubes (32);
characterized in that each of said legs (48) of said fins (42) defining a plurality of front long louvers (52) disposed between said front and back edges (44, 46) for conveying the stream of air through said legs (48) of said air fins (42) with each of said long louvers (52) having a long louver height (H_L) and a long louver length (L_L); and each of said legs (48) of said fins (42) defining a plurality of main spoilers (56) disposed between said front long louvers (52) and said back edges (44, 46) for inducing turbulence in the stream of air with each of said main spoilers (56) having a spoiler height (H_s) in the range of 50 to 90 percent of said long louver height (H_L) and each of said main spoilers (56) having a spoiler length (L_s) in the range of 10 to 35 percent of said long louver length (L_L).

2. The assembly (20) as set forth in claim 1 wherein said main spoilers (56) are micro-louvers.

3. The assembly (20) as set forth in any of the preceding claims wherein each of said legs (48) of said air fins (42) presents a plurality of front spoilers (64) disposed between said front edge (44) and said front long louvers (52) for inducing turbulence in the stream of air.

4. The assembly (20) as set forth in claim 3 wherein each of said front spoilers (64) extends outwardly from said legs (48) and has a triangular shape.

5. The assembly (20) as set forth in any of the claim 3 or 4 wherein each of said legs (48) of said air fins (42) defines a plurality of back spoilers (62) disposed adjacent to said back edge (46) and a plurality of back long louvers (54) disposed between said micro-louvers and said back spoilers (62).

6. The assembly (20) as set forth in any of the preceding claims wherein each of said legs (48) of said fins (42) has a fin height (H_F) and said long louver height (H_L) is in the range of 50 to 90 percent of said fin height (H_F).

7. The assembly (20) as set forth in any of the preceding claims wherein said long louver length (L_L) is in the range of 0.7 to 1.5 mm.

8. The assembly (20) as set forth in any of the preceding claims wherein said spoiler length (L_s) is in the range of 0.15 to 0.4 mm.

9. The assembly (20) as set forth in any of the preceding claims wherein each of said front long louvers (52) extends diagonally outwardly from said legs (48) of said fins (42).

10. The assembly (20) as set forth in any of the preceding claims where said main spoilers (56) are disposed in a staggered arrangement.

11. The assembly (20) as set forth in any of the preceding claims wherein said main spoilers (56) are semi-cylindrical bumps.

12. The assembly (20) as set forth in any of claims 1 to 10 wherein said main spoilers (56) are triangular notches.

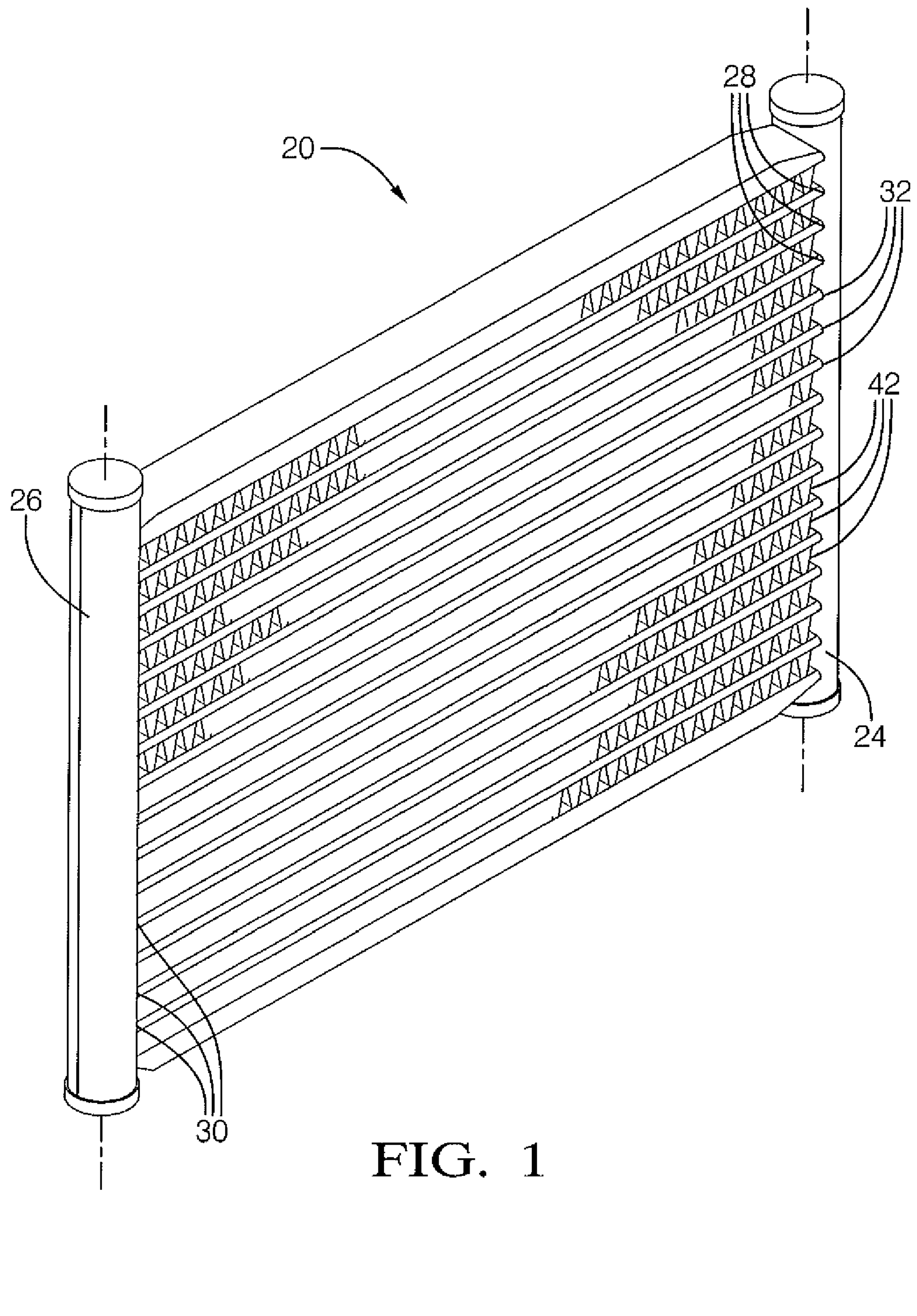
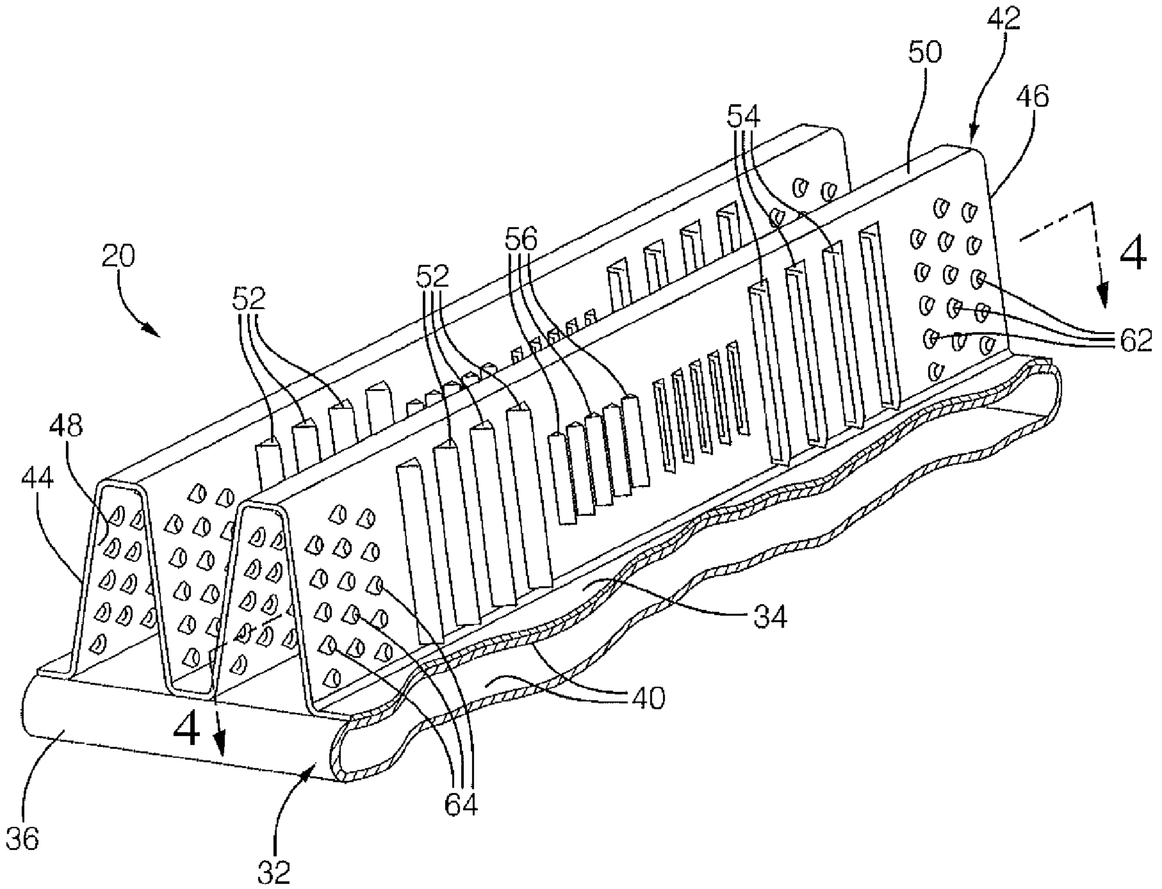


FIG. 1


20
52
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50
42
46
4
62
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44
34
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4
64
36
32

FIG. 2

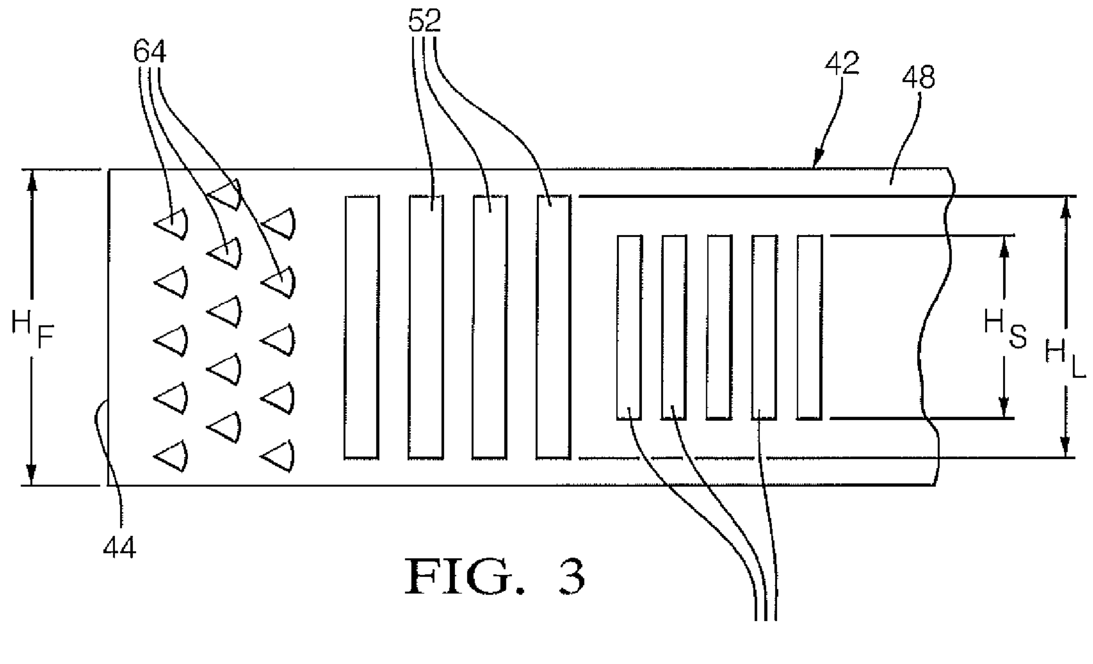
64
52
42
48
H
F
H
S
H
L
44

FIG. 3

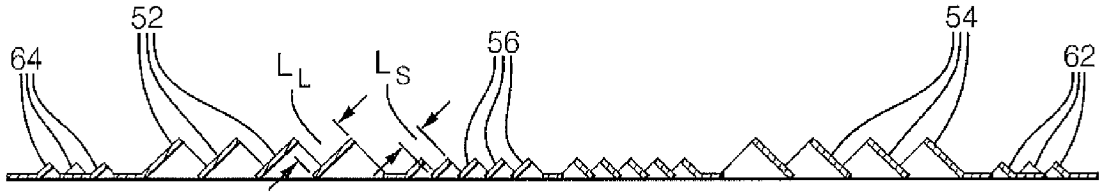

FIG. 4 A

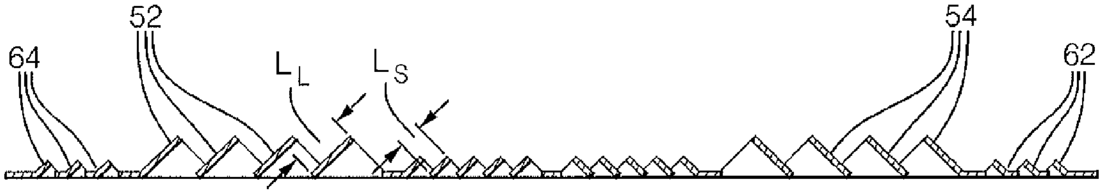

FIG. 4 B

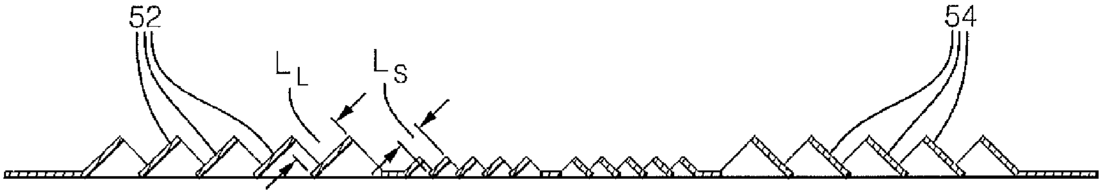

FIG. 4 C

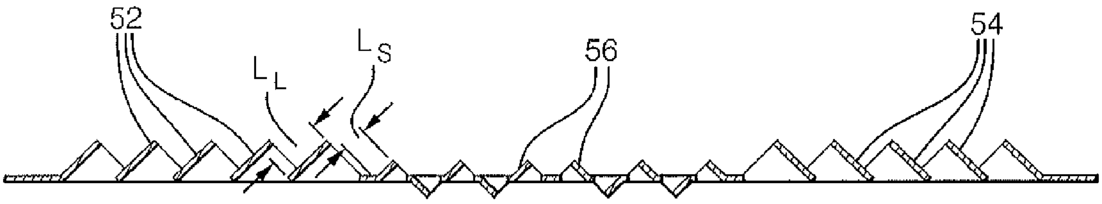

FIG. 4 D

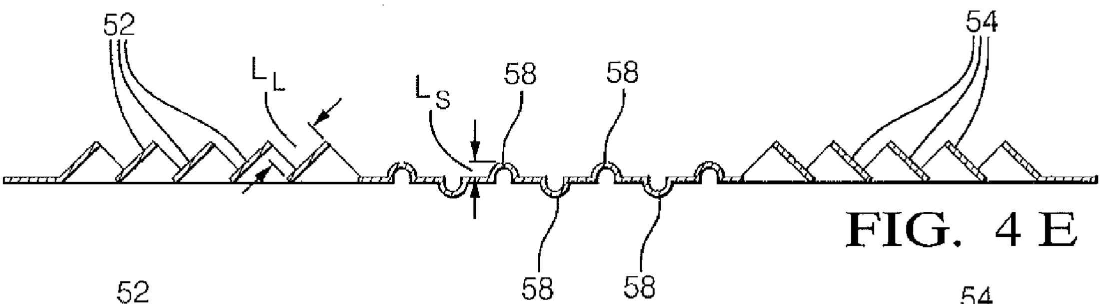

FIG. 4 E

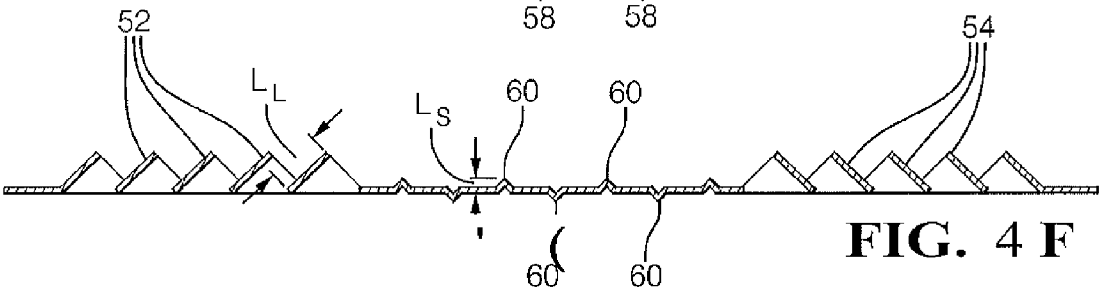

FIG. 4 F

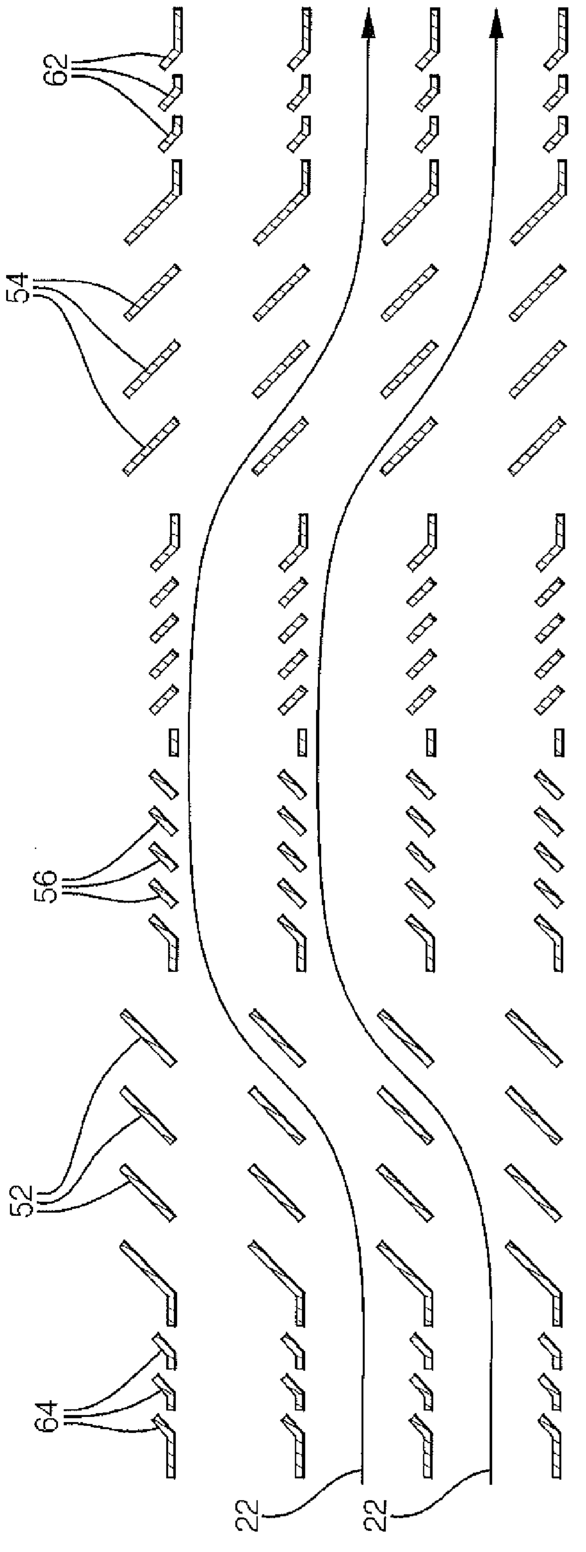

FIG. 5

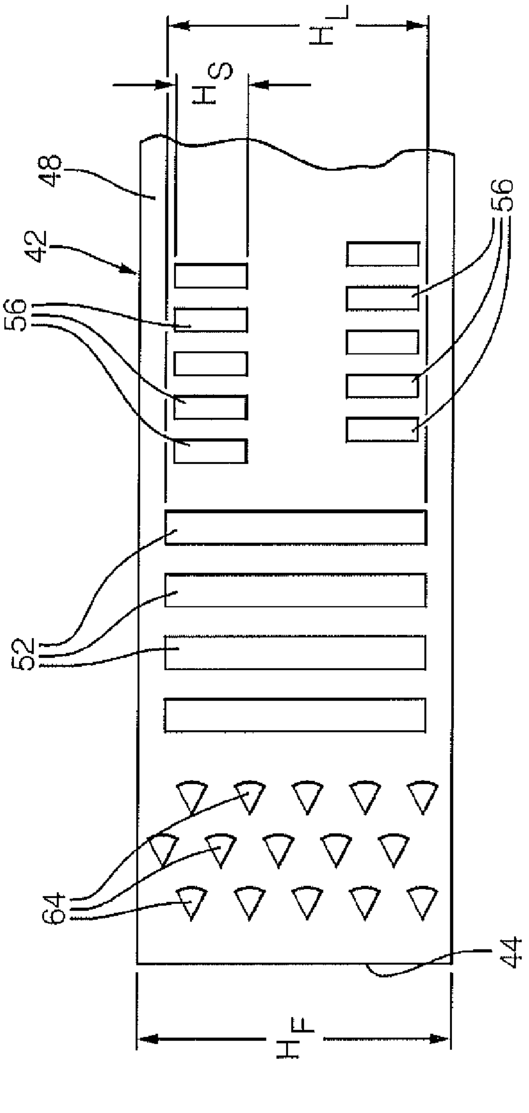

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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