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(54) **FROST TOLERANT FINS**

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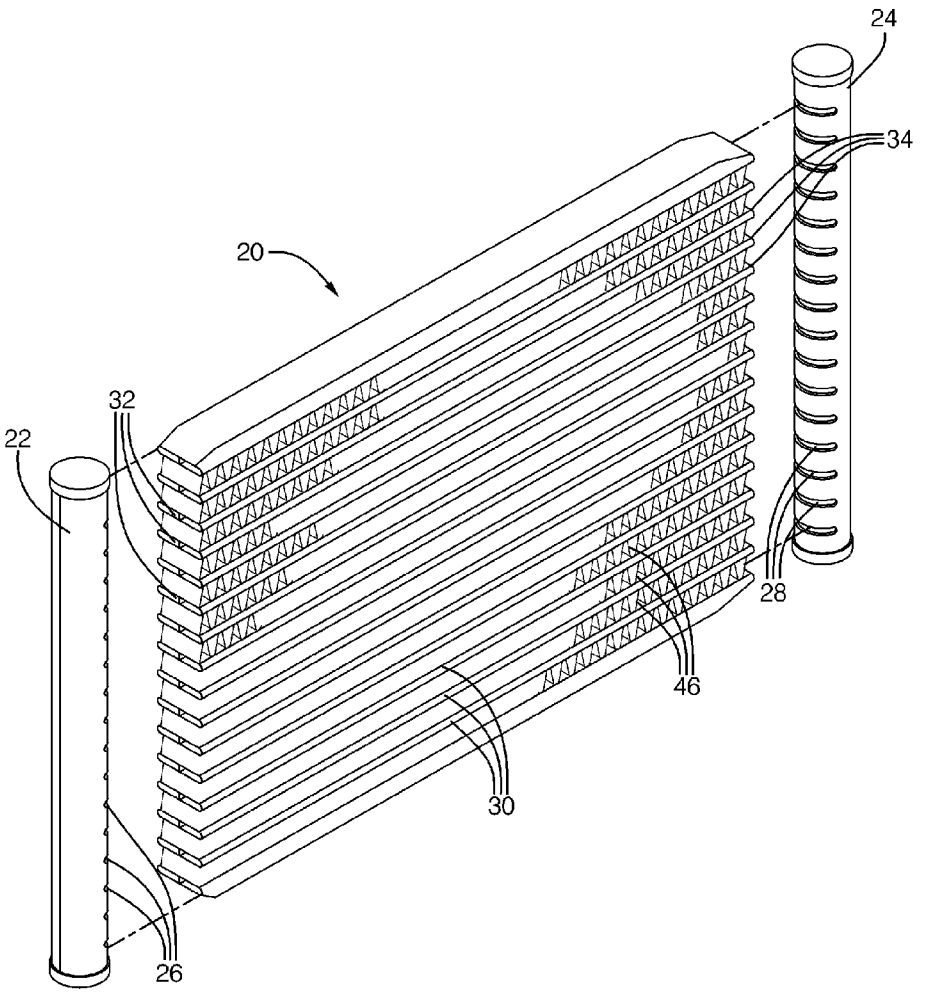
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(57) **ABSTRACT**

A heat exchanger assembly for thermally conditioning a stream of air. The assembly includes a first and second manifolds extending in spaced and parallel relationship. A plurality of tubes extend transversly between the manifolds to establish fluid communication therebetween. A plurality of corrugated air fins is disposed between adjacent tubes with the cross-section of each air fin presenting a plurality of legs extending transversly between the flat sides of adjacent tubes. Each leg defines a plurality of front louvers including a leading half louver disposed adjacent the front edge of the leg and a plurality of leading louvers spaced from each other and from the leading half louver. A plurality of smaller trailing louvers are spaced from the leading louvers. A plurality of rear louvers being spaced from each other is disposed between the trailing louvers and the rear edge of each leg.



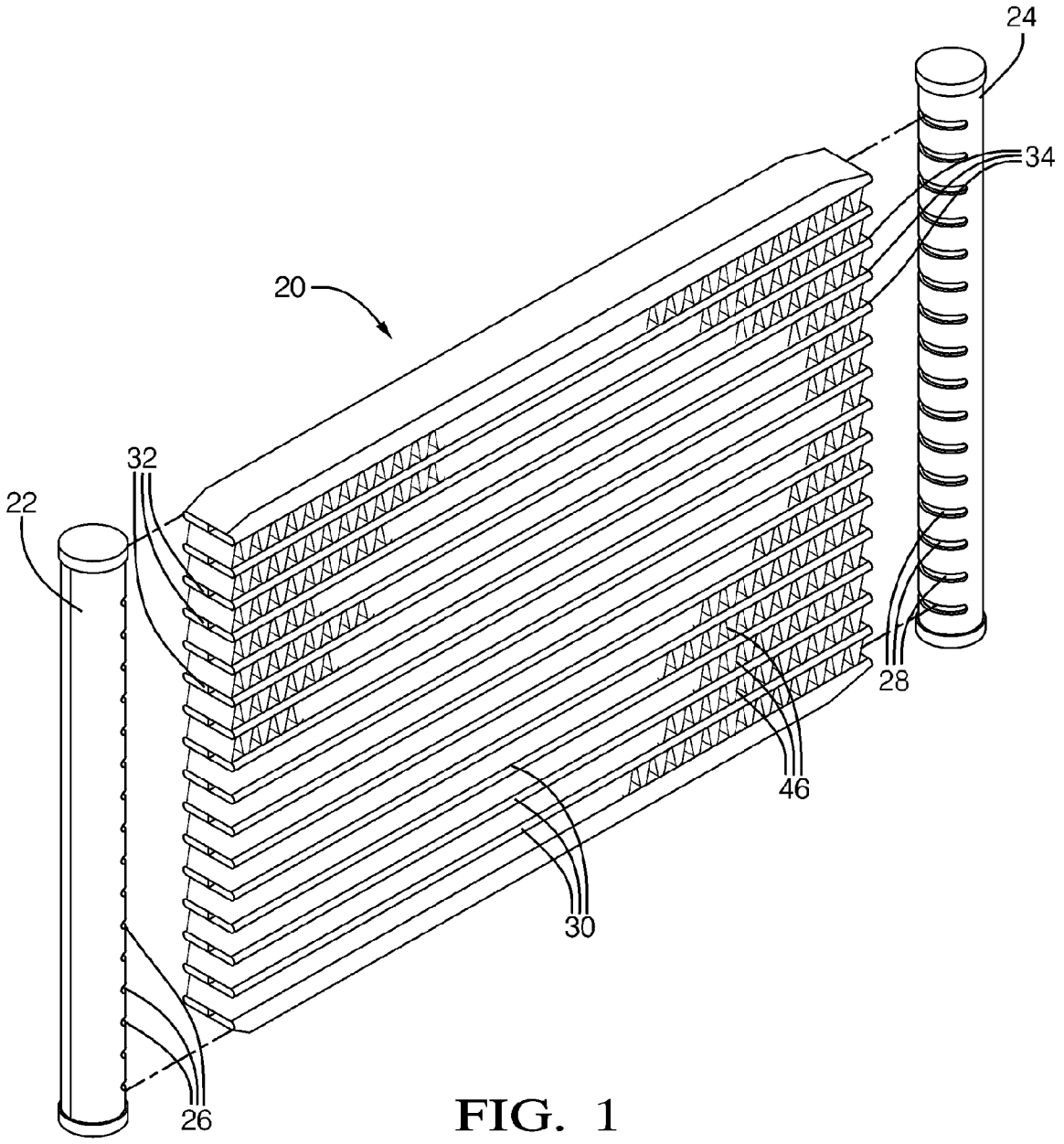


FIG. 1

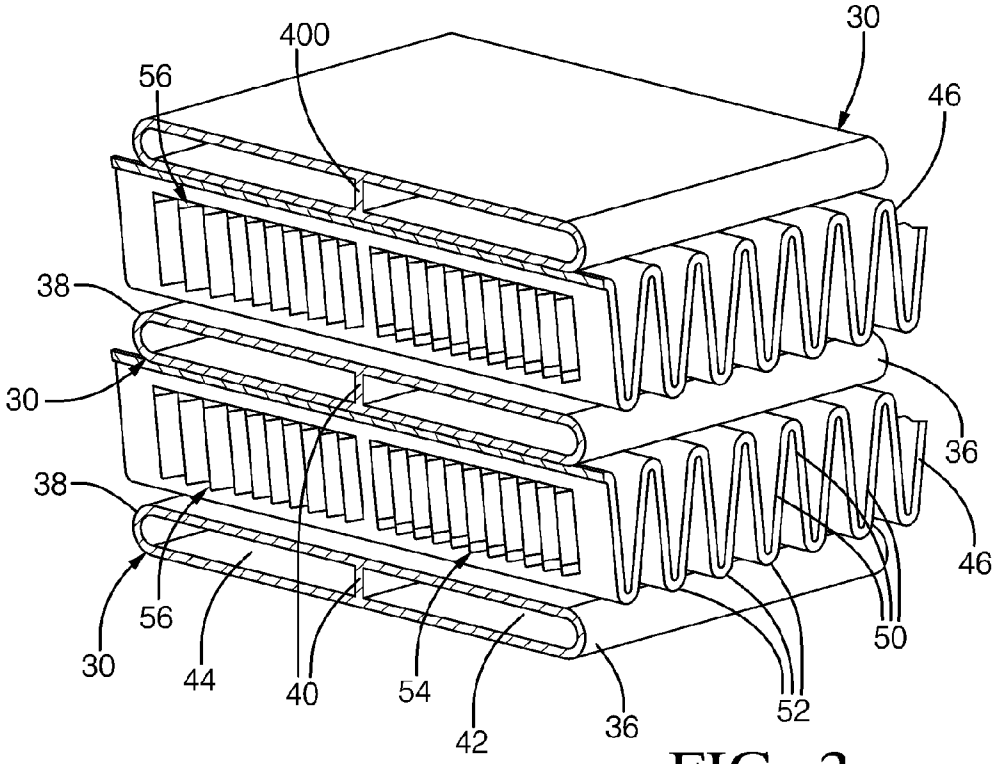

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36
52

FIG. 2

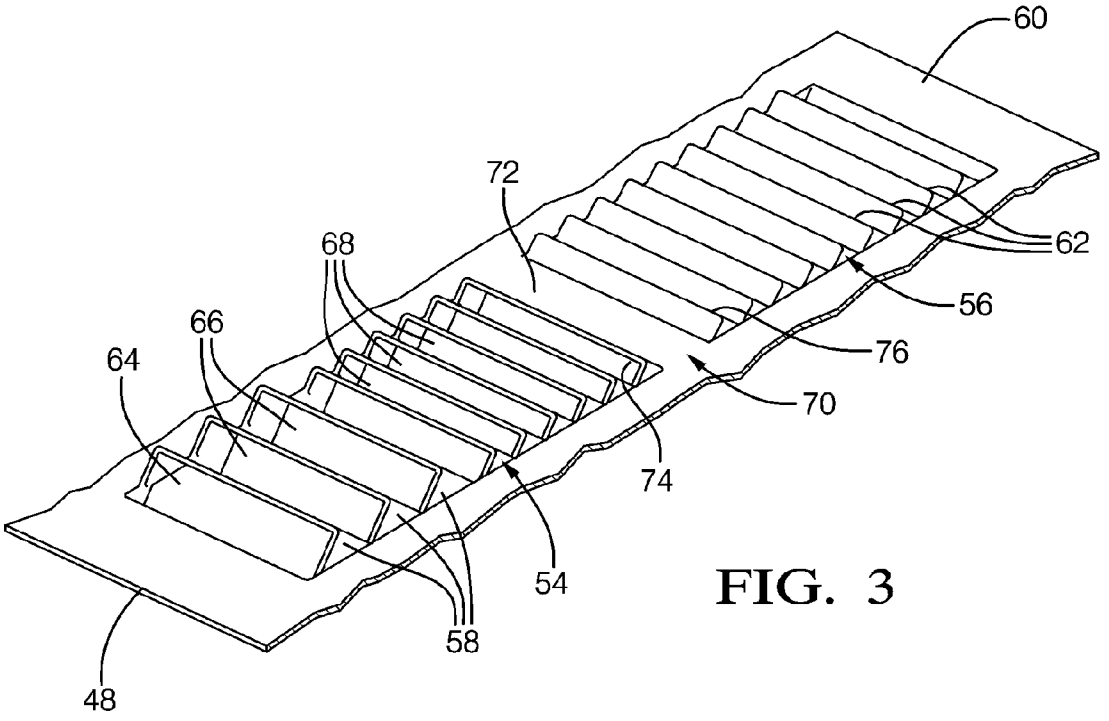

60
72
68
62
56
66
64
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74
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58
48

FIG. 3

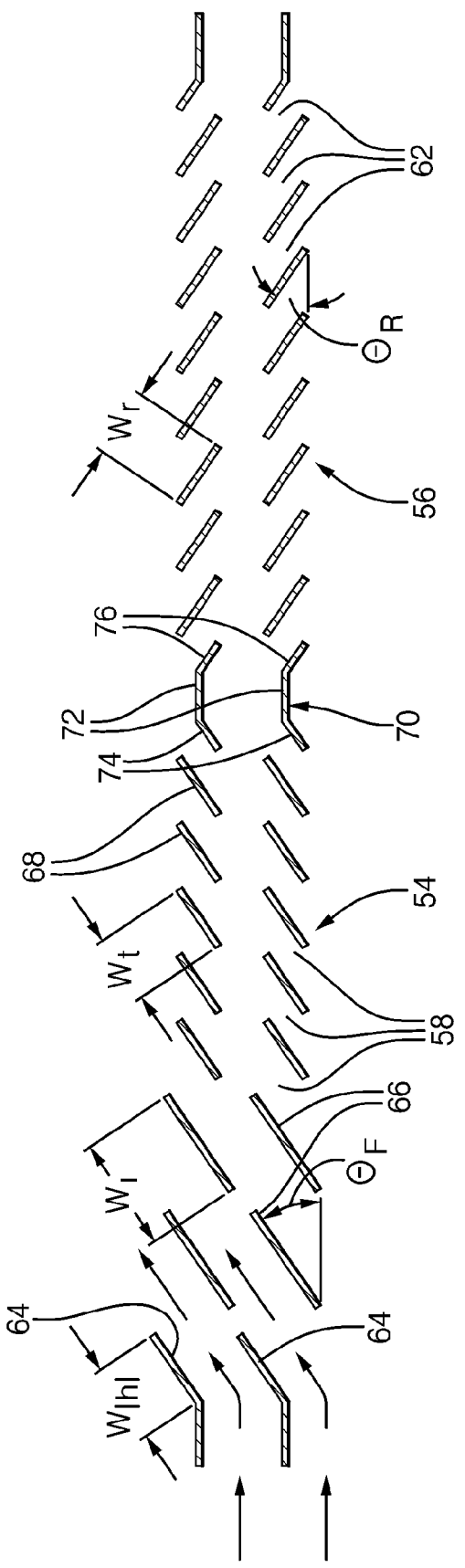

64
W_{lhl}
W_l
W_t
W_r
Θ_F
Θ_R
66
68
72
74
76
70
54
56
58
62

FIG. 4

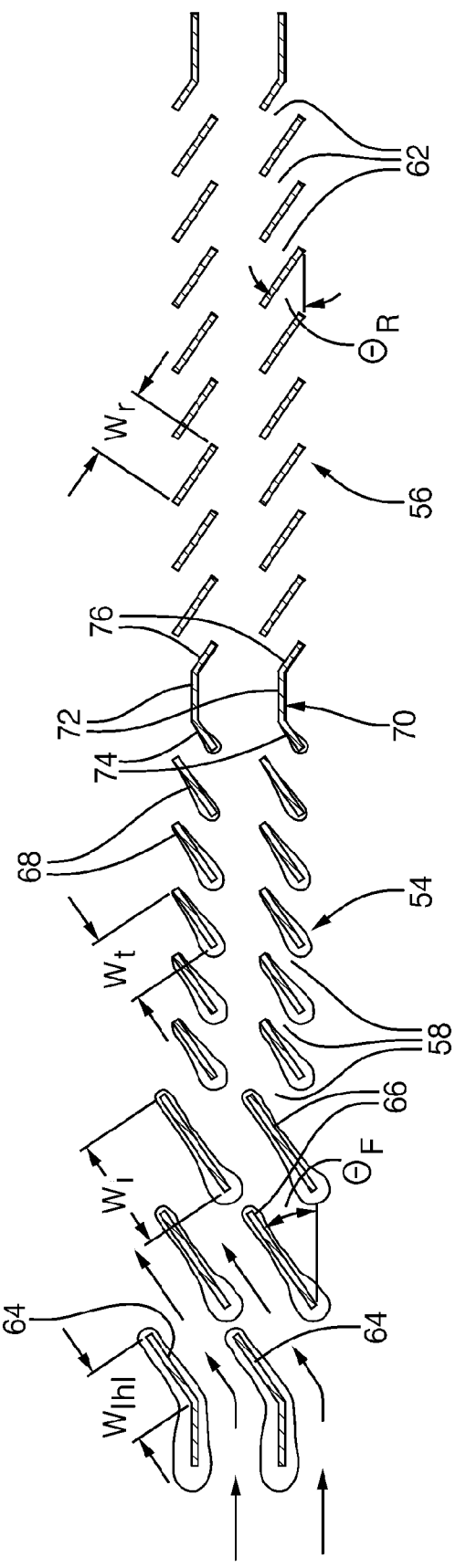

64
W_{lhl}
W_l
W_t
W_r
Θ_F
Θ_R
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72
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FIG. 5

FROST TOLERANT FINS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates to heat exchangers and more particularly, to heat exchanger fins.

[0003] 2. Description of the Prior Art

[0004] U.S. Patent Application No. 2007/0051502 to Shinobu Yamauchi and published on Mar. 8, 2007 (hereinafter referred to as Yamauchi '502) discloses a heat exchanger including a plurality of tubes extending in parallel and spaced relationship with each other and having a plurality of air fins each presenting a plurality of legs extending transversely between the adjacent tubes to define a plurality of air channels for the flow of air between adjacent legs. Each leg has a front edge and defines a plurality of front louvers being spaced from each other and adjacent the front edge to define a plurality of front air gaps. The front louvers present a plurality of leading louvers having a predetermined leading louver width and a plurality of trailing louvers being spaced from the leading louvers. The leading width ranges from 0.8 to 1.3 mm.

[0005] Often heat exchangers, are used as outdoor evaporators in heat pumps operating in cold weather. In order to absorb heat from the outside air in such conditions, the coolant in the heat exchanger must operate at extremely low temperatures, often below the freezing temperatures of water. The cold and wet air causes moisture to condense on the leading edge of the fins. The condensed moisture then may freeze and accumulate on the leading edge of the fins as frost. This frost obstructs the flow of air from passing through the air channels and between adjacent louvers, which dramatically decreases the heat exchanger's performance. Since the frost accumulation is concentrated at the leading edges of the fins, the air channels can become blocked with a relatively small amount of frost. The heat exchanger must then be stopped and defrosted before it can resume operation.

SUMMARY OF THE INVENTION

[0006] The invention provides for such a heat exchanger assembly wherein the leading louver width ranges from 1.5 to 2.0 mm.

[0007] The larger leading louvers of the invention provide for increased space for the air to flow between adjacent louvers. The trailing louvers then have a smaller trailing louver width than the leading louver width because they are not as susceptible to the frost accumulation of the leading louvers. The use of smaller trailing louvers minimizes the impact of the reduction in heat transfer performance associated with the large leading louvers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] 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:

[0009] FIG. **1** is a perspective and exploded view of the heat exchanger according to the present invention;

[0010] FIG. **2** is a perspective and fragmentary view of the tubes, fins and louvers according to the present invention;

[0011] FIG. **3** is a fragmentary view of one of the legs of the air fins and showing the louvers;

[0012] FIG. **4** is a schematic view showing a cross-section of the louvers; and

[0013] FIG. **5** is a schematic view showing a cross-section of the louvers in an operating condition with frost accumulation.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENT

[0014] Referring to the Figures wherein like numerals indicate corresponding parts throughout the several views, the invention includes a heat exchanger assembly **20** for thermally conditioning a stream of air. The heat exchanger assembly **20** is generally shown in FIG. **1** and includes and first manifold **22** and a second manifold **24** being spaced and extending in parallel relationship with each other.

[0015] The first manifold **22** defines a plurality of first tube slots **26** spaced from each other, and the second manifold **24** defines a plurality of second tube slots **28** being spaced to correspond with the first tube slots **26** of the first manifold **22**.

[0016] The heat exchanger assembly **20** further includes a plurality of tubes **30** extending in parallel and spaced relationship with each other between first and second tube ends **32**, **34**. Each of the tubes **30** has a cross-section presenting flat sides interconnecting a round front **36** and a round back **38**. In one embodiment, each tube **30** (generally indicated in FIG. **3**) includes a tube divider **40** extending between the first and second tube ends **32**, **34** to divide each tube **30** into first and second passages **42**, **44**. However, the tubes **30** may have any shape or features to transmit a fluid. For example, the tubes **30** could be hollow, they could include a plurality of webs extending transversely between the flat sides of the tubes **30** to define a plurality of passages, or they could define a plurality of microchannels extending between the first and second tube ends **32**, **34**.

[0017] The first tube end **32** of each tube **30** extends into one of the first tube slots **26** of said first manifold **22** to establish fluid communication between the first manifold **22** and the tubes **30**, and the second tube end **34** of each tube **30** extends into the corresponding second tube slot **28** of the second manifold **24** to establish fluid communication between the second manifold **24** and the tubes **30**.

[0018] The assembly **20** further includes a plurality of air fins **46** disposed between and engaging the flat sides of adjacent tubes **30**. Each of the fins **46** (generally indicated in FIG. **2** and generally shown in FIG. **3**) includes a front edge **48** adjacent the round front **36** of the tubes **30** and a back edge adjacent the round back **38** of the tubes **30**. Referring to FIG. **1**, the cross-section of each of the air fins **46** presents a plurality of legs **50** extending transversely between the adjacent flat sides of the tubes **30**. The legs **50** of the air fins **46** are interconnected by bases **52** engaging the flat sides of alternating tubes **30** to present a serpentine pattern extending between the first and second manifolds **22**, **24**. The serpentine pattern of the air fins **46** presents a plurality of air channels for the flow of air between adjacent legs **50** of said air fins **46**. While the air fins **46** of the exemplary embodiment have a serpentine pattern, the invention is meant to include any pattern for transferring heat between the tubes **30** and the passing air.

[0019] Referring to FIG. **3**, each of the legs **50** of the air fins **46** defines a plurality of front louvers **54** (generally indicated) and a plurality of rear louvers **56** (generally indicated). The front louvers **54** are disposed adjacent the front edge **48** of each fin **46** and are spaced apart from each other. The louvers

54, **56**, **64**, **66**, **68** may be formed by any means including but not limited to bending, cutting, soldering, welding, adhesion, etc.

[0020] Each of the front louvers **54** is disposed at a predetermined front louver angle Θ_F to define a plurality of front air gaps **58** in each of the legs **50** of the air fins **46** for conveying air from a first air channel on one side of the leg **50** to a second air channel on the other side of the leg **50**. The rear louvers **56** are disposed adjacent the rear edge **60** of each fin **46** and are spaced apart from each other. Each of the rear louvers **56** is disposed at a predetermined rear louver angle Θ_R to define a plurality of rear air gaps **62** in each of the legs **50** of the air fins **46** for conveying air from the second air channel to the first air channel. The front and rear louver angles Θ_F, Θ_R are preferably in the range of 20 to 50 degrees and most preferably in the range of 35 to 45 degrees. In the exemplary embodiment, the louver angle is depicted as constant, but it is also possible to vary the louver angle to enhance the effect achieved with variable louver width.

[0021] In the exemplary embodiment, a center rib **70** is disposed between the front and rear louvers **54**, **56** for turning the air flow and directing it to the rear louvers **56**. Each center rib **70** has a center portion **72** extending parallel to the leg **50** of the air fin **46** and includes a front side **74** and a rear side **76** opposite from the front side **74**. The front side **74** extends transversely from the center portion **72** toward the front louvers **54** to define one of the front air gaps **58**, and the rear side **76** extends transversely from the center portion **72** toward the rear louvers **56** to define one of the rear air gaps **62**.

[0022] Referring to FIG. **4**, the front louvers **54** include a leading half louver **64** disposed adjacent the front edge **48** and a plurality of leading louvers **66** spaced from the leading half louver **64**. Each of the leading louvers **66** has a predetermined leading louver width W_l. The front louvers **54** also include a plurality of trailing louvers **68** disposed between the leading louvers **66** and the center rib **70**, and each of the trailing louvers **68** has a predetermined trailing louver width W_t.

[0023] The rear louvers **56** define a trailing half louver disposed adjacent the rear edge **60** of each fin **46**. Each of the rear louvers **56** has a predetermined rear louver width W_r.

[0024] The leading half louver width W_{lhl} is in the range of 0.75 to 1.50 mm and the leading louver width W_l is in the range of 1.5 to 2.0 mm. The trailing louver width W_t is less than the leading louver width W_l and is in the range of 0.9 to 1.5 mm, and consequently, each of the front air gaps **58** is larger than each of the rear air gaps **62**. In one embodiment, the rear louver width W_r is less than the trailing louver width W_t of the front louvers **54**. However, the rear louvers **56** may also be made to be a mirror image of the front louvers **54**. Although it is not as efficient to have larger rear louvers **56** as having smaller rear louvers **56**, it may decrease manufacturing costs to build an air fin **46** that is symmetrical about its center rib **70** and is meant to be included in the scope of the invention.

[0025] While the invention has been described with reference to an exemplary embodiment, 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 disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A heat exchanger assembly for heating and/or cooling a stream of air comprising:
- a plurality of tubes extending in parallel and spaced relationship with each other;
- a plurality of air fins disposed between and engaging adjacent tubes and having a front edge and a back edge;
- said air fins defining a plurality of front louvers being spaced from each other and adjacent said front edge to define a plurality of front air gaps;
- said front louvers including at least one leading louver having a predetermined leading louver width and at least one trailing louver having a trailing louver width;
- said leading louver width being greater than said trailing louver width; and
- said leading louver width ranging from 1.3 to 2.5 mm.

2. The assembly as set forth in claim **1** wherein said leading louver width is further defined as ranging from 1.5 to 2.0 mm.

3. The assembly as set forth in claim **1** wherein said leading louver width is further defined as ranging from 1.9 to 2.0 mm.

4. The assembly as set forth in claim **1** wherein said trailing louvers have a predetermined trailing louver width ranging from 0.9 to 1.5 mm.

5. The assembly as set forth in claim **1** wherein said trailing louvers have a predetermined trailing louver width ranging from 1.00 to 1.25 mm.

6. The assembly as set forth in claim **5** wherein said trailing louver width is further defined as 1.14 mm.

7. The assembly as set forth in claim **1** wherein the cross-section of each of said air fins presents a plurality of legs extending transversly between said adjacent tubes and defining a plurality of air channels for the flow of air between adjacent legs of said air fins.

8. The assembly as set forth in claim **7** wherein each of said legs of said air fins includes a plurality of rear louvers being spaced from each other and adjacent said rear edge to define a plurality of rear air gaps in each of said legs of said air fin for conveying air from said second air channel to said first air channel.

9. The assembly as set forth in claim **8** wherein each of said legs of said air fins includes a center rib disposed between said front louvers and said rear louvers for directing airflow delivered from said first air channel to said second air channel by said front louvers back to said first air channel.

10. The assembly as set forth in claim **9** wherein said center rib has a center portion extending parallel to said legs of said fins and has a front side extending transversely from said center portion toward said front louvers to define one of said front air gaps adjacent to said front side and has a rear side opposite of said front side and extending transversely from said center portion toward said rear louvers to define one of said rear air gaps adjacent to said rear side.

11. The assembly as set forth in claim **8** wherein said rear louvers have a rear louver width ranging from 0.8 to 1.5 mm.

12. The assembly as set forth in claim **8** wherein said rear louvers are disposed at a predetermined rear louver angle ranging from 20 to 50 degrees.

13. The assembly as set forth in claim **8** wherein said rear louvers are disposed at a rear louver angle ranging from 35 to 45 degrees.

14. The assembly as set forth in claim **1** wherein said front louvers are disposed at a front louver angle ranging from 20 to 50 degrees.

15. The assembly as set forth in claim **1** wherein said front louvers are disposed at a front louver angle ranging from 35 to 45 degrees.

16. The assembly as set forth in claim **1** further including a first manifold and a second manifold extending in spaced and parallel relationship with said first manifold; and

each of said tubes extending between a first tube end engaging said first manifold and a second tube end engaging said second manifold.

17. The assembly as set forth in claim **16** wherein said first manifold defines a plurality of first tube slots spaced from each other and engaging said tubes.

18. The assembly as set forth in claim **17** wherein said second manifold defines a plurality of second tube slots being spaced to correspond with said first tube slots of said first manifold.

19. The assembly as set forth in claim **18** wherein said first tube end of each of said tubes extends into one of said first tube slots of said first manifold to establish fluid communication between said first manifold and said tubes.

20. The assembly as set forth in claim **19** wherein said second tube end of each of said tubes extends into said corresponding second tube slot of said second manifold to establish fluid communication between said second manifold and said tubes.

21. The assembly as set forth in claim **1** wherein each of said tubes has a cross-section presenting flat sides interconnecting a round front and a round back.

22. The assembly as set forth in claim **21** wherein each of said tubes includes at least one tube divider dividing each tube into first and second passages and extending between said first and second tube slots.

23. The assembly as set forth in claim **21** wherein said legs of each of said fins are interconnected by bases engaging said flat sides of alternating tubes to present a serpentine pattern extending between said first and second manifolds.

24. The assembly as set forth in claim **1** further including a leading half louver disposed adjacent said front edge of each of said air fins.

25. The assembly as set forth in claim **24** wherein said leading half louver has a leading half louver width ranging from 0.75 to 1.50 mm.

26. A heat exchanger assembly for heating and/or cooling a stream of air comprising:

a first manifold presenting a plurality of first tube slots spaced from each other;

a second manifold extending in spaced an parallel relationship with said first manifold and defining a plurality of second tube slots being spaced to correspond with said first tube slots of said first manifold;

a plurality of tubes extending in parallel and spaced relationship with each other between first and second tube ends;

said first tube end of each tube extending into one of said first tube slots of said first manifold to establish fluid communication between said first manifold and said tubes;

said second tube end of each tube extending into said corresponding second tube slot of said second manifold to establish fluid communication between said second manifold and said tubes;

each of said tubes having a cross-section presenting flat sides interconnecting a round front and a round back;

each of said tubes including at least one tube divider dividing each tube into first and second passages and extending between said first and second tube slots;

a plurality of air fins disposed between and engaging said flat sides of adjacent tubes and having a front edge adjacent said round front of said tubes and a back edge adjacent said round back of said tubes;

the cross-section of each of said air fins presenting a plurality of legs extending transversely between said adjacent flat sides of said tubes and interconnected by bases engaging said flat sides of alternating tubes to present a serpentine pattern extending between said first and second manifolds and defining a plurality of air channels for the flow of air between adjacent legs of said air fins;

each of said legs of said air fins defining a plurality of front louvers including a leading half louver and a plurality of rear louvers including a trailing half louver and a center rib disposed between said front and rear louvers;

said plurality of front louvers spaced from each other and disposed at a predetermined front louver angle to define a plurality of front air gaps in each of said legs of said air fins for conveying air from a first air channel on one side of said leg to a second air channel on the other side of said leg;

said plurality of rear louvers being spaced from each other and disposed adjacent said rear edge of said air fin at a predetermined rear louver angle to define a plurality of rear air gaps in each of said legs of said air fin for conveying air from said second air channel to said first air channel;

said center rib being disposed between said front and rear louvers for directing airflow delivered from said first air channel to said second air channel by said front louvers back to said first air channel;

said center rib having a center portion extending parallel to said legs of said fins and having front side extending transversely from said center portion toward said front louvers to define one of said front air gaps adjacent to said front side and having a rear side opposite from said front side and extending transversely from said center portion toward said rear louvers to define one of said rear air gaps adjacent to said rear side;

said leading half louver being disposed adjacent said front edge of each leg of said air fin and said trailing half louver being disposed adjacent said rear edge of each leg of said air fin;

said front louvers including a plurality of leading louvers spaced from said leading half louver and having a predetermined leading louver width;

said front louvers including a plurality of trailing louvers disposed between said leading louvers and said center rib and having a predetermined trailing louver width;

said rear louvers having a rear louver width;

said leading louver width of said leading louvers being wider than said trailing louver width of said trailing louvers; and

said leading half louver width ranging from 0.75 to 1.50 mm;

said leading louver width ranging from 1.3 to 2.5 mm;

said trailing louver width ranging from 1.00 to 1.25 mm;

said rear louver width ranging from 0.8 to 1.5 mm; and

said front and rear louver angles ranging from 35 to 45 degrees.

* * * * *