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(54) HEAT EXCHANGER

(75) Inventors: **Takashi Yabe**, Oyama-shi (JP); **Hiroyuki Sudoh**, Oyama-shi (JP); **Takashi Hirayama**, Oyama-shi (JP)

Correspondence Address:
OBLON, SPIVAK, MCCLELLAND, MAIER & NEUSTADT, P.C.
1940 DUKE STREET
ALEXANDRIA, VA 22314 (US)

(73) Assignee: **SHOWA DENKO K.K.**, Minato-ku (JP)

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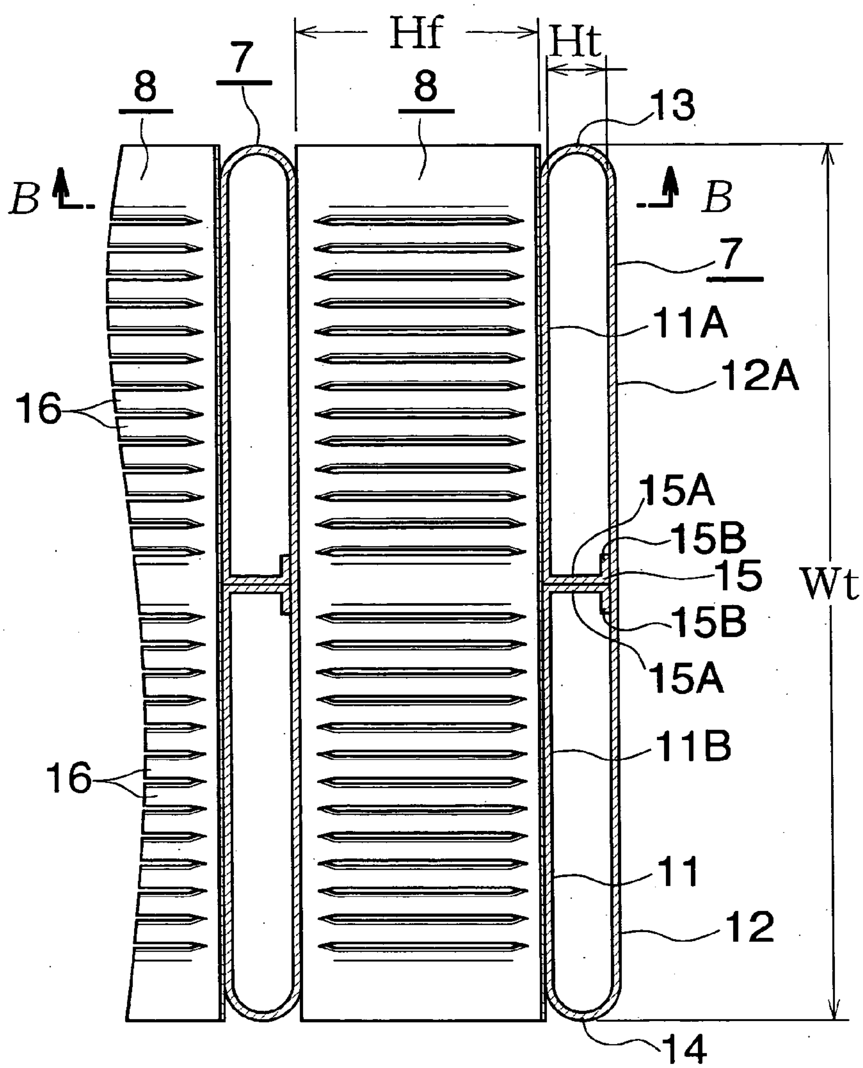
(57) **ABSTRACT**

A heat exchanger to be used as a heater core includes a pair of header tanks spaced apart from each other, a plurality of flat heat exchange tubes which are disposed between the two header tanks at predetermined intervals along a longitudinal direction of the header tanks with their width direction coinciding with an air flow direction and whose opposite end portions are connected to the header tanks, and a plurality of corrugate fins each disposed between the adjacent heat exchange tubes. Each heat exchange tube has an inner height Ht of 1.2 mm to 1.7 mm and a width of 18 mm to 24 mm as measured in the air flow direction. Each corrugate fin has a fin height Hf of 4.0 mm to 7.5 mm. This heat exchanger exhibits excellent heat radiation performance and low resistance to air flow and water flow.



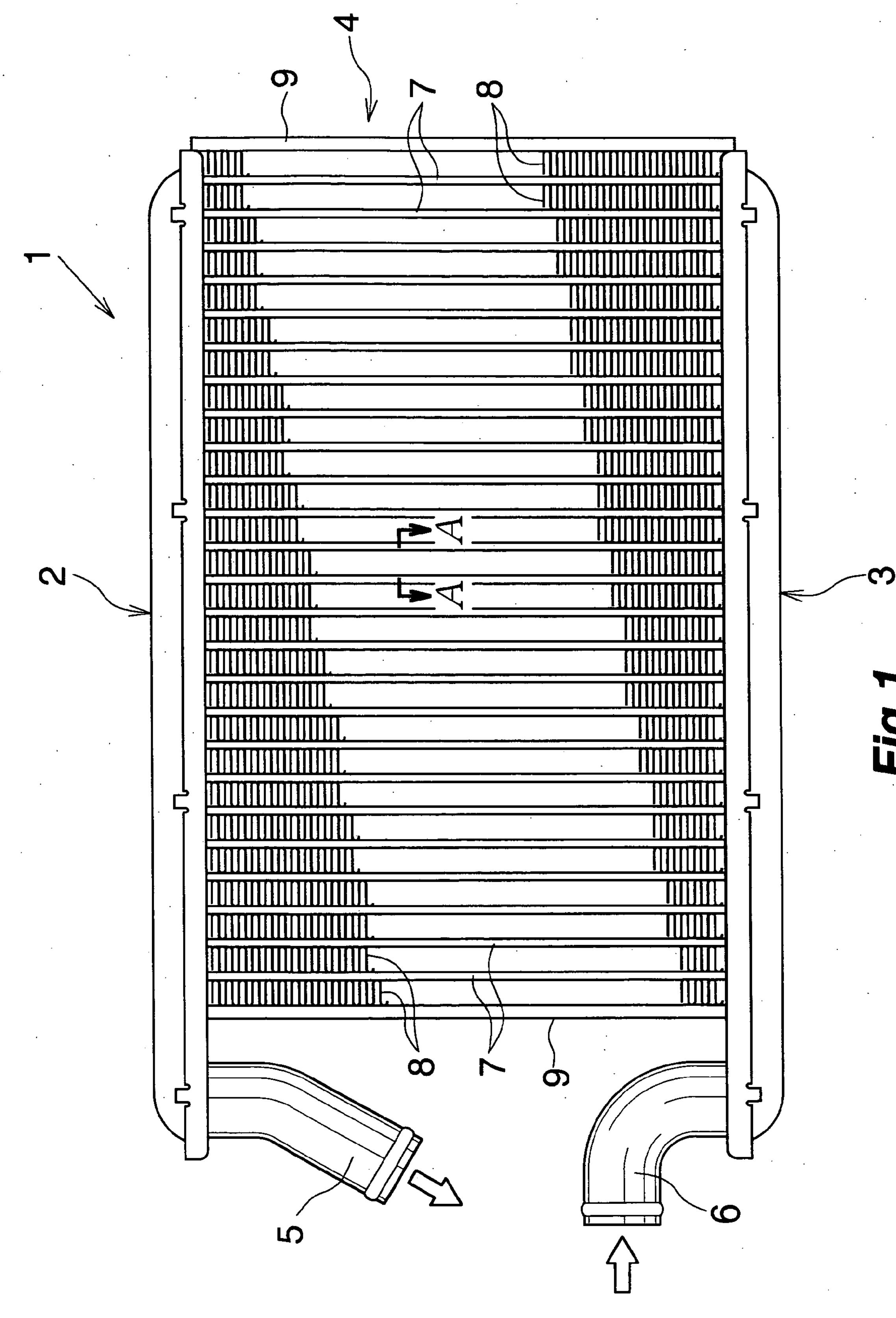


Fig.1

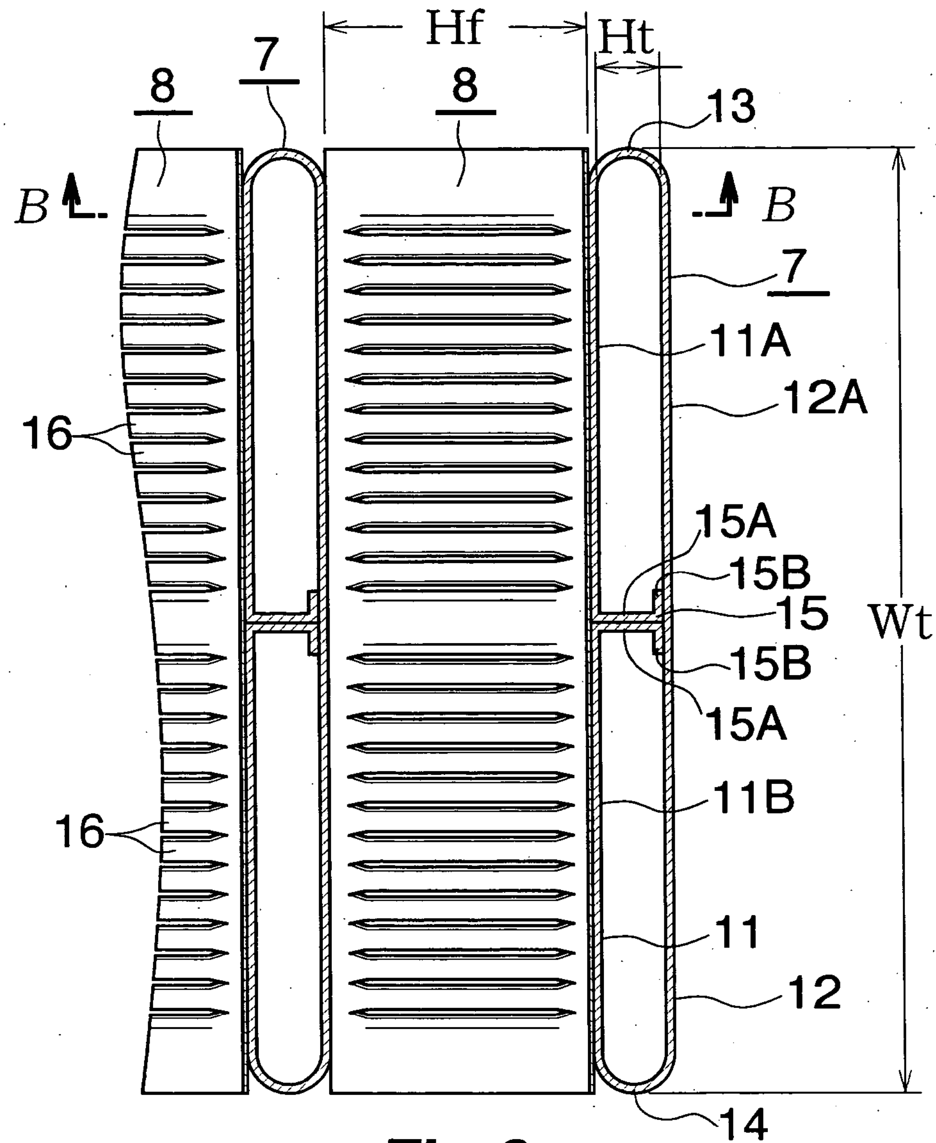

Hf
Ht
7
8
8
13
B
B
7
11A
12A
16
15A
15B
15
Wt
15B
15A
11B
16
11
12
14

Fig.2

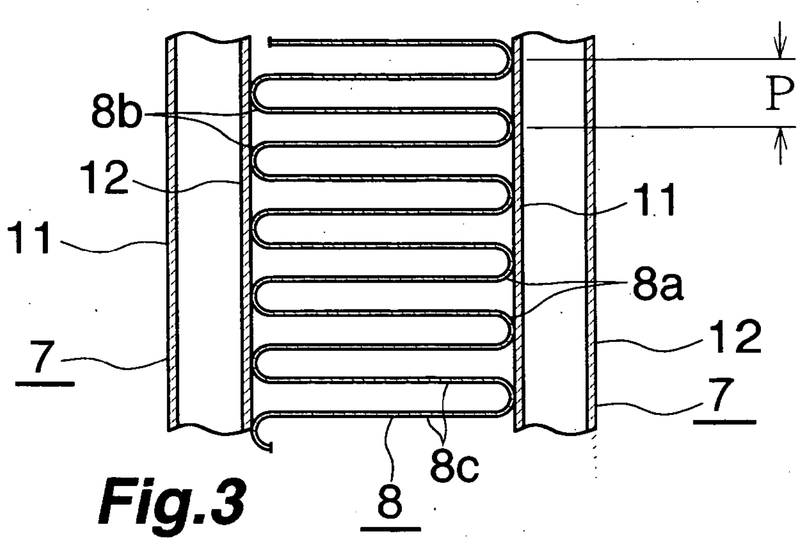

P
8b
12
11
11
8a
12
7
7
8c
8

Fig.3

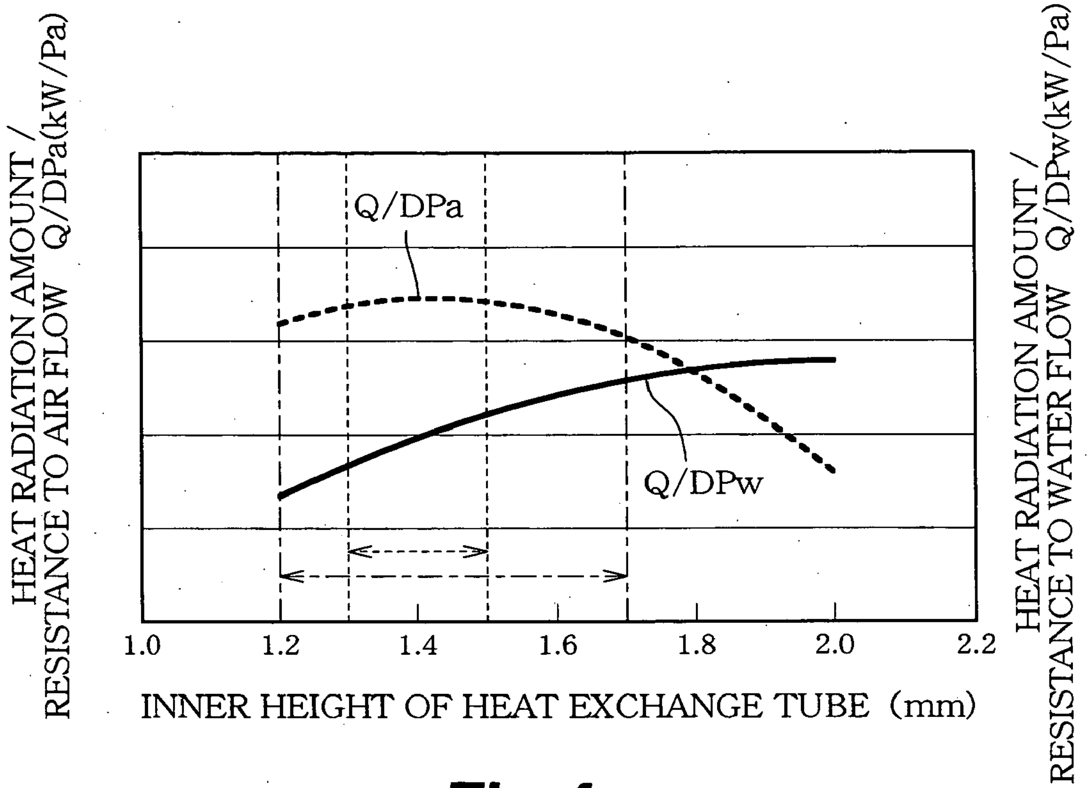

HEAT RADIATION AMOUNT /
RESISTANCE TO AIR FLOW Q/DPa(kW/Pa)
Q/DPa
Q/DPw
1.0
1.2
1.4
1.6
1.8
2.0
2.2
INNER HEIGHT OF HEAT EXCHANGE TUBE (mm)
HEAT RADIATION AMOUNT /
RESISTANCE TO WATER FLOW Q/DPw(kW/Pa)

Fig.4

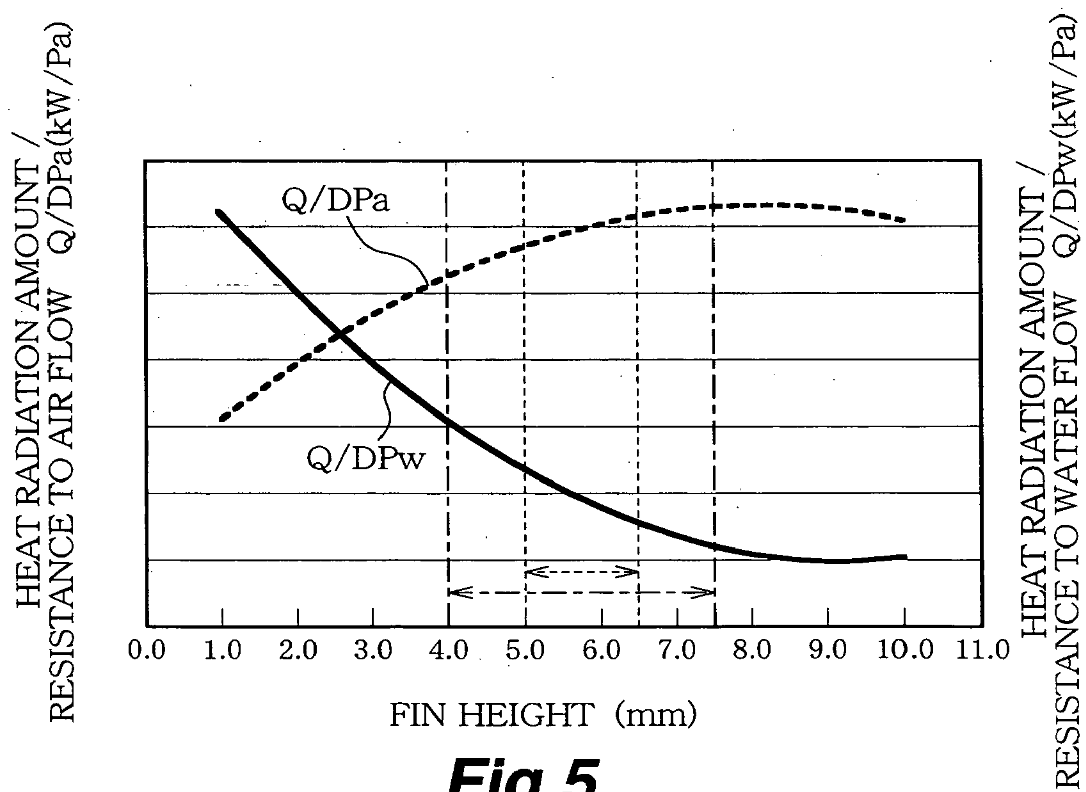

HEAT RADIATION AMOUNT /
RESISTANCE TO AIR FLOW Q/DPa(kW/Pa)
Q/DPa
Q/DPw
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
FIN HEIGHT (mm)
HEAT RADIATION AMOUNT /
RESISTANCE TO WATER FLOW Q/DPw(kW/Pa)

Fig.5

HEAT EXCHANGER

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a heat exchanger preferably used as, for example, a heater core to be incorporated into a car air conditioner.

[0002] Herein and in the appended claims, the term "aluminum" encompasses aluminum alloys in addition to pure aluminum.

[0003] A conventionally known heater core for use in a car air conditioner includes a pair of header tanks spaced apart from each other, a plurality of flat heat exchange tubes which are disposed between the two header tanks at predetermined intervals along a longitudinal direction of the header tanks with their width direction coinciding with an air flow direction and whose opposite end portions are connected to the corresponding header tanks, and a plurality of corrugate fins each including wave crest portions, wave trough portions, and flat connection portions connecting together the corresponding wave crest portions and wave trough portions, and each disposed between the adjacent heat exchange tubes. In this heater core, the tube height of the heat exchange tube (thickness along the longitudinal direction of a header) is 1.4 mm to 1.8 mm; the thickness of an elongated aluminum sheet used to form the heat exchange tube, or the tube wall thickness of the heat exchange tube, is 0.4 mm; the inner height of the heat exchange tube (tube height−tube wall thickness×2) is 0.6 mm to 1.0 mm; the width of the corrugate fin as measured in the air flow direction is 21 mm to 32 mm; and the fin height of the corrugate fin, or the direct distance between the wave crest portion and the wave trough portion, is 2.5 mm to 5.0 mm (refer to Japanese Patent No. 3459271).

[0004] In recent years, heater cores have required further improvement in performance. The heater core disclosed in the above-mentioned patent exhibits excellent heat radiation performance, but has high resistance to air flow and water flow. Therefore, the heater core fails to have the required performance as a whole.

[0005] In order to optimize heat radiation amount, resistance to air flow, and resistance to water flow, which are performance factors of a heater core, the inventors of the present invention focused on the inner height of each heat exchange tube and the fin height of a corrugate fin and have achieved the present invention.

SUMMARY OF THE INVENTION

[0006] An object of the present invention is to solve the above problem and to provide a heat exchanger which, when used as a heater core, exhibits excellent heat radiation performance and has low resistance to air flow and water flow.

[0007] To achieve the above object, the present invention comprises the following modes.

[0008] 1) A heat exchanger comprising:

[0009] a pair of header tanks spaced apart from each other;

[0010] a plurality of flat heat exchange tubes which are disposed between the two header tanks at predetermined intervals along a longitudinal direction of the header tanks with their width direction coinciding with an air flow direction and whose opposite end portions are connected to the corresponding header tanks; and

[0011] a plurality of corrugate fins each comprising wave crest portions, wave trough portions, and flat connection portions connecting together the corresponding wave crest portions and wave trough portions, and each disposed between the adjacent heat exchange tubes;

[0012] wherein each heat exchange tube has an inner height of 1.2 mm to 1.7 mm and a width of 18 mm to 24 mm as measured in the air flow direction, and each corrugate fin has a fin height of 4.0 mm to 7.5 mm, the fin height being the direct distance between the wave crest portion and the wave trough portion.

[0013] 2) A heat exchanger according to par. 1), wherein the inner height of each heat exchange tube is 1.3 mm to 1.5 mm.

[0014] 3) A heat exchanger according to par. 1), wherein the fin height of each corrugate fin is 5.0 mm to 6.5 mm.

[0015] 4) A heat exchanger according to par. 1), wherein each heat exchange tube comprises a pair of flat walls facing each other, two side walls extending between opposite side ends of the two flat walls, and a reinforcement wall extending between widthwise intermediate portions of the two flat walls;

[0016] one of the two flat walls comprises a first flat-wall-forming portion;

[0017] the other flat wall comprises two second flat-wall-forming portions which are formed integrally with the corresponding opposite side ends of the first flat-wall-forming portion via the side walls and whose side ends located opposite the corresponding side walls butt against each other;

[0018] the reinforcement wall comprises two reinforcement-wall-forming portions which are formed integrally with the corresponding butting side ends of the two second flat-wall-forming portions and in such a manner as to project toward the first flat-wall-forming portion and whose projecting end portions abut the first flat-wall-forming portion; and

[0019] two bend portions are formed integrally with corresponding projecting ends of the two reinforcement-wall-forming portions and in such a manner as to extend toward the corresponding side walls, and are joined to the first flat-wall-forming portion.

[0020] 5) A heat exchanger according to par. 4), wherein the inner height of each heat exchange tube is the direct distance between an inner surface of the first flat-wall-forming portion and an inner surface of the second flat-wall-forming portion.

[0021] The above-mentioned heat exchanger is used as, for example, a heater core of a car air conditioner.

[0022] The heat exchanger of par. 1), when used as a heater core of a car air conditioner, exhibits excellent heat radiation performance and implements prevention of an increase in resistance to air flow and water flow.

[0023] The heat exchanger of par. 2) or 3) enhances the effect yielded by the heat exchanger of par. 1).

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. **1** is a front view showing the overall configuration of a heater core for a car air conditioner to which a heat exchanger of the present invention is applied;

[0025] FIG. **2** is an enlarged sectional view taken along line A-A of FIG. **1**;

[0026] FIG. **3** is a sectional view taken along line B-B of FIG. **2**;

[0027] FIG. **4** is a graph of the inner height Ht of a heat exchange tube vs. the ratio Q/DPa between heat radiation amount and resistance to air flow and the ratio Q/DPw between heat radiation amount and resistance to water flow; and

[0028] FIG. **5** is a graph of the fin height Hf vs. the ratio Q/DPa between heat radiation amount and resistance to air flow and the ratio Q/DPw between heat radiation amount and resistance to water flow.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] An embodiment of the present invention will next be described in detail with reference to the drawings. The present embodiment is an application of a heat exchanger of the present invention to a heater core of a car air conditioner.

[0030] The upper, lower, left-hand, and right-hand sides of FIG. **1** will be referred to as "upper,""lower,""left," and "right," respectively. The far side of the paper on which FIG. **1** appears (the upper side of FIG. **2**) is referred to as the "front," and the opposite side as the "rear.

[0031] FIG. **1** shows the general configuration of a heater core for a car air conditioner to which a heat exchanger of the present invention is applied. FIGS. **2** and **3** show the configuration of essential portions of the heater core.

[0032] In FIG. **1**, a heater core **1** includes an upper header tank **2** and a lower header tank **3** which are made of aluminum, are vertically spaced apart from each other, and are elongated in the left-right direction, and a heat exchange core section **4** provided between the upper and lower header tanks **2** and **3**.

[0033] Left end portions of the upper and lower header tanks **2** and **3** project leftward beyond the heat exchange core section **4**. An outlet pipe **5** is connected to a leftward-projecting portion of the upper header tank **2**, and an inlet pipe **6** is connected to a leftward-projecting portion of the lower header tank **3**.

[0034] The heat exchange core section **4** includes a plurality of flat heat exchange tubes **7** made of aluminum which are disposed at predetermined intervals along the left-right direction with their width direction coinciding with the front-rear direction (air flow direction) and whose upper and lower end portions are connected to the upper and lower header tanks **2** and **3**, respectively; a plurality of corrugate fins **8** made of aluminum which are each disposed between the adjacent heat exchange tubes **7** and outside the leftmost and rightmost heat exchange tubes **7** and are brazed to the heat exchange tubes **7**; and two side plates **9** disposed outside and brazed to the corresponding leftmost and rightmost corrugate fins **8**. The upper and lower end portions of the heat exchange tubes **7** are brazed to the upper and lower header tanks **2** and **3**, respectively, while being inserted into corresponding tube insertion holes (not shown) formed in the upper and lower header tanks **2** and **3**.

[0035] As shown in FIGS. **2** and **3**, each heat exchange tube **7** is formed by tubularly bending an elongated aluminum brazing sheet having a brazing material layer on at least one side thereof, in such a manner that the brazing material comes outside. The heat exchange tube **7** includes left and right walls **11** and **12** facing each other (a pair of flat walls); front and rear side walls **13** and **14** extending between the front side ends and between the rear side ends, respectively, of the left and right walls **11** and **12**; and a reinforcement wall **15** extending between central portions with respect to a width direction of the left and right walls **11** and **12**. The right wall **12** is formed of a single right-wall-forming portion **12**A. The left wall **11** is formed of two left-wall-forming portions **11**A and **11**B. The left-wall-forming portions **11**A and **11**B are integral with the front and rear side ends, respectively, of the right-wall-forming portion **12**A via the front and rear side walls **13** and **14**, respectively. Side ends, located on a side opposite the side walls **13** and **14**, of the left-wall-forming portions **11**A and **11**B butt against each other. The reinforcement wall **15** is formed of two reinforcement-wall-forming portions **15**A which are formed integrally with the corresponding butting side ends of the left-wall-forming portions **11**A and **11**B and in such a manner as to project rightward and whose projecting end portions abut and are brazed to the right-wall-forming portion **12**A. Two bend portions **15**B are formed integrally with corresponding projecting ends (right ends) of the two reinforcement-wall-forming portions **15**A and in such a manner as to extend toward the corresponding side walls **13** and **14**, and are brazed to the right-wall-forming portion **12**A.

[0036] The width Wt of the heat exchange tube **7** as measured in the front-rear direction is 18 mm to 24 mm. The inner height Ht of the heat exchange tube **7**; i.e., the direct distance between the inner surfaces of the left and right walls **11** and **12** as measured in a region where the bend portions **15**B are absent, is 1.2 mm to 1.7 mm. Preferably, the inner height Ht of the heat exchange tube **7** is 1.3 mm to 1.5 mm. The wall thickness of the heat exchange tube **7** is 0.1 mm to 0.4 mm; for example, 0.2 mm. The wall thickness of the heat exchange tube **7** is determined in consideration of manufacture constraints and strength requirements.

[0037] The corrugate fin **8** is formed in a corrugated form from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof. The corrugate fin **8** includes wave crest portions **8***a*, wave trough portions **8***b*, and flat horizontal connection portions **8***c* each connecting together the wave crest portion **8***a* and the wave trough portion **8***b*. A plurality of louvers **16** are formed at the connection portions **8***c* in such a manner as to be juxtaposed in the front-rear direction. The width of the corrugate fin **8** as measured in the front-rear direction is equal to the width of the heat exchange tube **7** as measured in the front-rear direction. The wave crest portions **8***a* and the wave trough portions **8***b* of the corrugate fins **8** are brazed to the heat exchange tubes **7** and the side plates **9**.

[0038] The fin height Hf of the corrugate fin **8**; i.e., the direct distance between the wave crest portion **8***a* and the wave trough portion **8***b*, is 4.0 mm to 7.5 mm, preferably 5.0

mm to 6.5 mm. When P represents the pitch of the adjacent wave crest portions **8***a* of the corrugate fin **8**, the fin pitch Pf is equal to P/2; specifically, 0.8 mm to 3.0 mm, preferably 1.5 mm. The wall thickness of the corrugate fin **8** is 0.02 mm to 0.1 mm; for example, 0.06 mm. The fin pitch Pf and wall thickness of the corrugate fin **8** are determined in consideration of manufacture constraints, strength requirements, and resistance to air flow.

[**0039**] The inner height Ht of the heat exchange tube **7** is set to 1.2 mm to 1.7 mm from the results of computer simulation shown in FIG. **4**. This computer simulation was performed under the following conditions while the inner height Ht of the heat exchange tube **7** was varied: the height of the heat exchange core section **4** is 140 mm; the width of the heat exchange core section **4** as measured in the left-right direction is 145 mm; the width Wt of the heat exchange tube **7** as measured in the front-rear direction is 21 mm; the wall thickness of the heat exchange tube **7** is 0.2 mm; the fin height Hf of the corrugate fin **8**, or the direct distance between the wave crest portion **8***a* and the wave trough portion **8***b*, is 5.7 mm; the fin pitch Pf of the corrugate fin **8**, or the pitch of the connection portions **8***c*, is 1.5 mm; and the wall thickness of the corrugate fin **8** is 0.06 mm.

[**0040**] The vertical axis of the graph shown in FIG. **4** represents the ratio Q/DPa between heat radiation amount and resistance to air flow and the ratio Q/DPw between heat radiation amount and resistance to water flow. In order to improve the performance of the heater core **1**, both of the ratios Q/DPa and Q/DPw must be increased. In order to increase Q/DPa through reduction in resistance to air flow, the fin height Hf must be increased through reduction in the inner height Ht of the heat exchange tube **7**. However, in this case, resistance to water flow increases. In order to increase Q/DPw through reduction in resistance to water flow, the inner height Ht of the heat exchange tube **7** must be increased through reduction in the fin height Hf. However, in this case, resistance to air flow increases. From the simulation results represented by the graph of FIG. **4**, the inner height Ht of the heat exchange tube **7** is set to a range of 1.2 mm to 1.7 mm in which both of Q/DPa and Q/DPw assume respectively preferable values. As is apparent from FIG. **4**, the inner height Ht of the heat exchange tube **7** is preferably 1.3 mm to 1.5 mm. The lower limit of the inner height Ht of the heat exchange tube **7** is set to 0.7 mm, since the heat exchange tube **7** having an inner height Ht of less than 0.7 mm is difficult to manufacture.

[**0041**] The fin height Hf of the corrugate fin **8** is set to 4.0 mm to 7.5 mm from the results of computer simulation shown in FIG. **5**. This computer simulation was performed under the following conditions while the fin height Hf of the corrugate fin **8** was varied: the height of the heat exchange core section **4** is 140 mm; the width of the heat exchange core section **4** as measured in the left-right direction is 145 mm; the width Wt of the heat exchange tube **7** as measured in the front-rear direction is 21 mm; the inner height Ht of the heat exchange tube **7** is 1.4 mm; the wall thickness of the heat exchange tube **7** is 0.2 mm; the fin pitch Pf of the corrugate fin **8**, or the pitch of the connection portions **8***c*, is 1.5 mm; and the wall thickness of the corrugate fin **8** is 0.06 mm.

[**0042**] The vertical axis of the graph shown in FIG. **5** represents the ratio Q/DPa between heat radiation amount and resistance to air flow and the ratio Q/DPw between heat radiation amount and resistance to water flow. In order to improve the performance of the heater core **1**, both of the ratios Q/DPa and Q/DPw must be increased. In order to increase Q/DPa through reduction in resistance to air flow, the fin height Hf must be increased through reduction in the inner height Ht of the heat exchange tube **7**. However, in this case, resistance to water flow increases. In order to increase Q/DPw through reduction in resistance to water flow, the inner height Ht of the heat exchange tube **7** must be increased through reduction in the fin height Hf. However, in this case, resistance to air flow increases. From the simulation results represented by the graph of FIG. **5**, the fin height Hf of the corrugate fin **8** is set to a range of 4.0 mm to 7.5 mm in which both of Q/DPa and Q/DPw assume respectively preferable values. As is apparent from FIG. **5**, the fin height Hf of the corrugate fin **8** is preferably 5.0 mm to 6.5 mm.

[**0043**] In the above-described heater core **1**, high-temperature engine-cooling water is transferred from an engine into the lower header tank **3** through the inlet pipe **6**. The high-temperature engine-cooling water which has flowed into the lower header tank **3** dividedly flows into the heat exchange tubes **7**, flows upward through the heat exchange tubes **7**, and then enters the upper header tank **2**. The high-temperature engine-cooling water which has flowed into the upper header tank **2** flows out through the outlet pipe **5** and then returns to the engine. Notably, the high-temperature engine-cooling water may be transferred from the engine to the heater core **1** and an radiator or may be transferred from the engine to the radiator only.

What is claimed is:

1. A heat exchanger comprising:

a pair of header tanks spaced apart from each other;

a plurality of flat heat exchange tubes which are disposed between the two header tanks at predetermined intervals along a longitudinal direction of the header tanks with their width direction coinciding with an air flow direction and whose opposite end portions are connected to the corresponding header tanks; and

a plurality of corrugate fins each comprising wave crest portions, wave trough portions, and flat connection portions connecting together the corresponding wave crest portions and wave trough portions, and each disposed between the adjacent heat exchange tubes;

wherein each heat exchange tube has an inner height of 1.2 mm to 1.7 mm and a width of 18 mm to 24 mm as measured in the air flow direction, and each corrugate fin has a fin height of 4.0 mm to 7.5 mm, the fin height being the direct distance between the wave crest portion and the wave trough portion.

2. A heat exchanger according to claim 1, wherein the inner height of each heat exchange tube is 1.3 mm to 1.5 mm.

3. A heat exchanger according to claim 1, wherein the fin height of each corrugate fin is 5.0 mm to 6.5 mm.

4. A heat exchanger according to claim 1, wherein each heat exchange tube comprises a pair of flat walls facing each other, two side walls extending between opposite side ends of the two flat walls, and a reinforcement wall extending between widthwise intermediate portions of the two flat walls;

one of the two flat walls comprises a first flat-wall-forming portion;

the other flat wall comprises two second flat-wall-forming portions which are formed integrally with the corresponding opposite side ends of the first flat-wall-forming portion via the side walls and whose side ends located opposite the corresponding side walls butt against each other;

the reinforcement wall comprises two reinforcement-wall-forming portions which are formed integrally with the corresponding butting side ends of the two second flat-wall-forming portions and in such a manner as to project toward the first flat-wall-forming portion and whose projecting end portions abut the first flat-wall-forming portion; and

two bend portions are formed integrally with corresponding projecting ends of the two reinforcement-wall-forming portions and in such a manner as to extend toward the corresponding side walls, and are joined to the first flat-wall-forming portion.

5. A heat exchanger according to claim 4, wherein the inner height of each heat exchange tube is the direct distance between an inner surface of the first flat-wall-forming portion and an inner surface of the second flat-wall-forming portion.

* * * * *