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(54) Plastic heat exchanger

(57) A heat exchanger (10) comprises a plurality of plastic cooling tubes (16) extending between a first end plate (12) and a second end plate (14) and a baffle (24) arranged in the heat exchanger (10) and extending at least partially between the first end plate (12) and the second end plate (14). The baffle (24) comprises a plurality of first openings (26) for receiving a respective plastic cooling tube (16), the baffle (24) further comprising a plurality of second openings (28) arranged between the first openings (26). The second openings (28) permit air to flow through the heat exchanger (10) whilst creating turbulence in the air flow which increase the thermal transfer between the air and the tubes (16) increasing the efficiency of the heat exchanger (10).

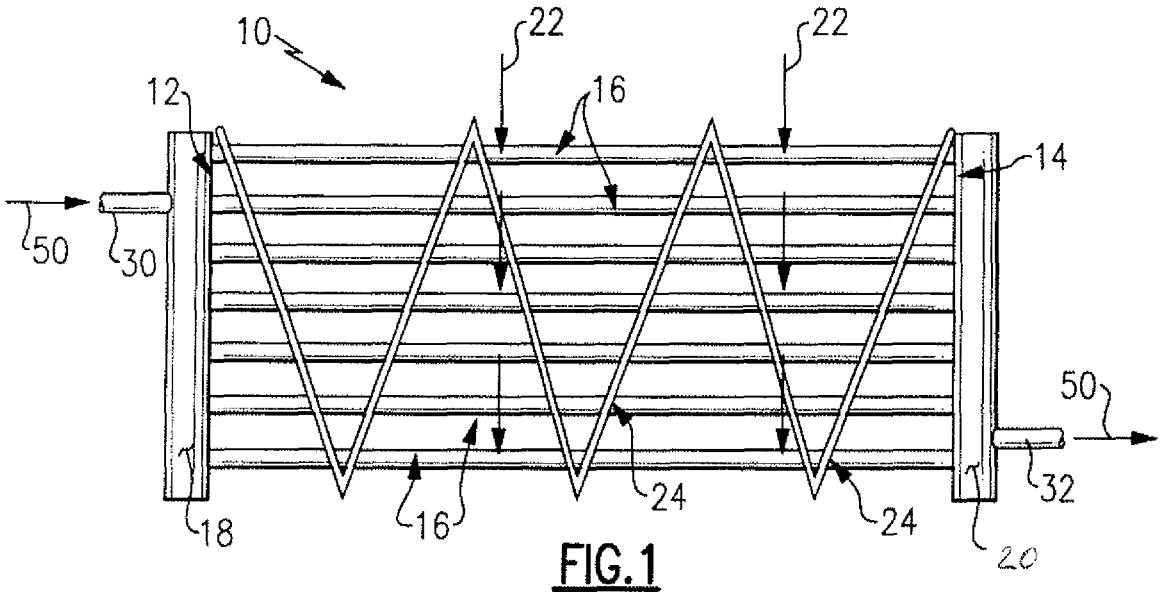

FIG.1

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Description

[0001] This invention generally relates to a heat exchanger for use in a motor vehicle. More particularly, this invention relates to a plastic heat exchanger.

[0002] A heat exchanger is adapted for transferring heat from one fluid to another fluid wherein the fluids are not physically in contact. One example application of a specific example of a heat exchanger is an intercooler which is adapted for cooling the charge air exiting the compressor of an air charging device such as a turbocharger. An intercooler is desired to cool and to reduce the volume of the charge air so that more air can be introduced into the cylinders of an engine. The hot charge air is directed through a plurality of tubes over which cooling air flows.

[0003] A conventional heat exchanger for automotive appliances includes a plurality of tubes that span between manifolds or tanks on each end. The tanks typically comprise an open internal volume in communication with an open end of the plurality of tubes. The tanks include an inlet to provide for a single inlet or outlet for air flow through the heat exchanger. The tubes are typically formed from metals such as aluminium, copper or brass that are welded or brazed to end plates. The end plates are in turn attached to the tanks to provide the desired inlet and outlet for the heat exchanger.

[0004] Disadvantageously, metal tube construction and fabrication provide a relatively heavy and cumbersome device. Further, the use of metal tubes limits the configuration of the heat exchanger. The constraints on devices installed within vehicles are becoming more demanding as related to cost, weight and flexibility of design. Therefore it has been considered to produce a heat exchanger from plastic whereby the weight of the heat exchanger can be reduced whilst offering improved design flexibility. A disadvantage of using plastic as a material for the heat exchanger is that the heat transfer from plastic to air is relatively low compared to the heat transfer between metal and air. Therefore the efficiency of a plastic heat exchanger is lower than that of an equivalent metal heat exchanger.

[0005] Accordingly, it is desirable to design a plastic heat exchanger with an improved heat transfer between the cooling medium and the medium to be cooled.

[0006] A plastic heat exchanger assembly according to the present invention includes a plurality of plastic tubes that extend between plastic end plates. A baffle is arranged in the heat exchanger which extends across the flow path of the air flowing over plastic tubes. The baffle includes openings which allow the air to flow through the baffle and over the plastic tubes. The baffle introduces turbulence into the air flow and disrupts the boundary layer on the outside of the tube walls. By disrupting this boundary layer the heat transfer between the fluid inside the tubes and the air flowing over the tubes can be improved. The baffle can also serve as a support for the tubes.

[0007] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

[0008] Figure 1 is a schematic view of an example heat exchanger assembly.

[0009] Figure 2 is a schematic view of an heat exchanger baffle.

[0010] Figures 3A-3D are schematic views of example shapes for openings in the heat exchanger baffle.

[0011] Figure 4 is a schematic view of an example square tube.

[0012] Figure 5 is a schematic view of an example twisted square tube.

[0013] Figure 6 is a schematic cross-section of the twisted square tube.

[0014] Referring to Figure 1, a heat exchanger assembly 10 includes a first end plate 12 and a second end plate 14. Extending between the end first end plate 12 and the second end plate 14 are a plurality of plastic tubes 16. The plastic tubes 16 are secured to the end plates 12, 14 to provide the desired seal between the end plates 12, 14 and the ends of the tubes 16. This can be achieved by laser welding or another suitable method.

[0015] A first tank 18 is attached to the first end plate 12 and a second tank 20 is attached to the second end plate 14. The first tank 18 includes an inlet opening 30 providing an inlet for a cooling fluid 50 and the second tank 20 includes an outlet opening 32 providing an outlet for the cooling fluid 50. The cooling fluid 50 follows a path through the first tank 18, the plastic tubes 16 and the second tank 20.

[0016] The air which is to be cooled (or charge air) flows over the plastic tubes 16 in a direction indicated with arrows 22 perpendicular to the fluid flowing through the tubes 16. As the charge air flows over the plastic tubes 16 heat is transferred through the plastic tubes 16 to the cooling fluid 50 inside the tubes 16. In order to improve the heat transfer between the fluid 50 inside the plastic tubes 16 and the air flow over the plastic tubes 16 a deflector or baffle 24 is introduced into the heat exchanger 10. The baffle 24 extends preferably between the endplates 12, 14 of the heat exchanger 10. The baffle 24 has preferably a concertina form, in particular a zigzag form as shown or a wave form. The concertina form extends through multiple rows of tubes 16. The concertina form provides for the baffle 24 to be angled relative to both charge air flow 22 and the plastic tubes 16. The specific angle of the baffle parts is provided to disrupt air flow 22, but not generate back pressure or reduce desired air flow.

[0017] Referring to Figure 2, a portion of the baffle 24 is shown with first openings 26 or oval shaped openings 26 which each accommodate a corresponding one of the plurality of plastic tubes 16. The plastic tubes 16 have a circular cross section. It is however also possible for the tubes 16 to have a non-circular cross section, e.g. oval or square, in order to increase the surface area of the

tube and therefore improve the heat transfer between the cooling fluid and the charger air.

[0018] Between the oval shaped openings 26, second openings 28 or turbulence generating openings 28 are provided in the baffle 24. The turbulence generating openings 28 allow the air flowing over the plastic tubes 16 in the direction 22 to flow past the baffle 24 and, in doing so, the air flow is disturbed. The disturbed air creates turbulence that disrupts the boundary layer flow on the outer surface of the plastic tubes 16. Through disturbing the boundary layer flow the heat transfer between the plastic tubes 16 and the charge air flowing over the plastic tubes 16 can be increased.

[0019] The area of the baffle 24 with turbulence generating openings 28 is large enough that no considerable back pressure is created within the heat exchanger 10 which would significantly reduce the air flow volume through the heat exchanger 10 and consequently adversely affect the cooling efficiency. The example baffle 24 can be a mesh e.g. a wire mesh whereby the plastic tubes 16 are inserted through openings in the wire mesh and openings adjacent to the plastic tubes serve as the turbulence generating openings.

[0020] Alternate example shapes of the openings 28 are shown in Figures 3A-3D. Figure 3A illustrates a star shaped cross-section 34. Figure 3B illustrates a triangle shaped tube cross-section 36. Figure 3C illustrates a cross shaped cross-section 38. Figure 3D illustrates a pentagon shaped cross-section 40. Other shapes which produce a large turbulence of the air flowing past the baffle 24 can also be used. It is particularly preferable for the shape to have a large edge length to surface area ratio.

[0021] Referring back to Figure 1, the baffle 24 can be used as a support for the plastic tubes 16 at the same time as providing the turbulence producing effect. This simplifies the manufacture in that the tubes 16 can be maintained together in a block using the baffle 24 as a support whilst the endplates 12, 14 are being attached. The example baffle 24 is shown to have five folds. It would however also be possible for the baffle 24 to be longer or shorter and to have more or less folds dependent on the size or shape of the heat exchanger 10. The baffle 24 can also be used as a conductor to conduct heat from the charge air to the cooling fluid. The baffle 24 can be made from any suitable material including metal, plastic or card.

[0022] Due to the low heat transfer between air and plastic it is preferable to have a liquid as the cooling fluid flowing through the plastic tubes 16. It is however possible in applications where no cooling liquid is available to have the charge air flowing through the plastic tubes 16 and the cooling air flowing in the direction of the arrows 22 over the plastic tubes 16. In the case where the charge air is flowing through the plastic tubes 16 it is advantageous to create turbulence within the plastic tubes 16. This can be achieved by producing non-circular shaped twisted tubes.

[0023] Referring to Figures 4-6, a plastic tube 42 with a square cross section can be produced e.g. by extrusion. By then twisting the square tube 42 along its length and about the axis 52 a twisted tube 44 is provided. The twisted tube 44 provides that the cross-sectional shape is twisted about the axis 52 at least once along a length between the endplates. The twisted tube 44 generates an internal air flow that follows the twists in the corners 48 (Figure 6). Much of the airflow will try to continue straight down a middle flow area 46 of the twisted tube 44 and creates turbulence where it interfaces with the air 48 from the corners which is twisting.

[0024] Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

[0025] The heat exchanger 10 is preferably adapted to provide an intercooler for cooling charge air. The heat exchanger 10 may alternatively be adapted to provide a cooler for cooling batteries of an electric vehicle or a cooler for cooling a fuel cell, e.g. for cooling a fuel cell, of a vehicle, in particular a fuel cell vehicle. In general, the heat exchanger 10 can be adapted to provide a cooler for cooling fluids, i.e. liquids and/or gases, in a vehicle, in particular in an electric vehicle.

[0026] An electric vehicle uses at least one electric motor for generating drive power. It may also have an internal combustion engine (hybrid vehicle) or may not (pure electric vehicle). A fuel cell vehicle is a kind of an electric vehicle provided with at least one fuel cell for generating electric power to power at least one electric motor and/or to charge at least one battery of the electric vehicle.

Claims

1. A heat exchanger comprising:

   a plurality of plastic cooling tubes (16) extending between a first end plate (12) and a second end plate (14); and
   a baffle (24) arranged in the heat exchanger (10) and extending at least partially between the first end plate (12) and the second end plate (14), the baffle (24) comprising a plurality of first openings (26) for receiving a respective plastic cooling tube (16) and a plurality of second openings (28) arranged between the first openings (26).

2. The heat exchanger according to claim 1, wherein the baffle (24) has one or more folds or waves to form a concertina shape.

3. The heat exchanger according to claim 1 or 2, wherein the cross section of the plastic tubes (16) is substantially circular and the first openings (26) in the

baffle (24) for receiving the plastic tubes (16) are oval shaped.

4. The heat exchanger according to claim 1 or 2, wherein the plastic tubes (16) have a non-circular cross section.

5. The heat exchanger according to claim 4, wherein the tubes (16) furthermore have a twisted form along their length.

6. The heat exchanger according to any one of the claims 1 to 5, wherein the second openings (28) in the baffle (24) are circular.

7. The heat exchanger according to any one of the claims 1 to 6, wherein the baffle (24) is made from plastic, metal or card.

8. The heat exchanger according to any one of the claims 1 to 7, wherein the first end plate (12) is included into a first tank (18); the second end plate (14) is included into a second tank (20); the plastic tubes (16) being in communication on distal ends with each of the first tank (18) and the second tank (20).

9. The heat exchanger according to any one of the claims 1 to 8, wherein the heat exchanger (10) is adapted for providing at least one of the following:

an intercooler for cooling charge air, a cooler for cooling batteries of an electric vehicle,
a cooler for cooling a fuel cell, a cooler for cooling a fuel cell in a vehicle, in particular a fuel cell vehicle, a cooler for cooling liquid and/or gaseous fluids in a vehicle, in particular in an electric vehicle and/or in a fuel cell vehicle.

10. A heat exchanger comprising:

a first tank (18) including a first end plate (12);
a second tank (20) including a second end plate (14); and
a plurality of plastic tubes (16) extending between the first and second end plates (12, 14) and in communication on distal ends with each of the first tank (18) and the second tank (20), the plastic tubes (16) including a non-arcuate cross-sectional shape.

11. The heat exchanger as recited in claim 10, wherein the cross-sectional shape comprises a rectangle.

12. The heat exchanger as recited in claim 10, wherein the cross-sectional shape comprises a square.

13. The heat exchanger as recited in any one of the claims 10 to 12, wherein the cross-sectional shape is twisted at least once between the first end plate (12) and the second end plate (14).

14. The heat exchanger as recited in any one of the claims 10 to 13, wherein the cross-sectional shape is disposed along an axis and is rotated at least once about the axis.

15. The heat exchanger as recited in any one of the claims 10 to 14, including a baffle (24) for disrupting fluid flow over the plurality of plastic tubes (16).

16. The heat exchanger as recited in claim 15, wherein the baffle (24) includes a plurality of first openings (26) through which extend the plurality of tubes (16), and a plurality of second openings (28) through which fluid flows.

17. The heat exchanger as recited in claim 15 or 16, wherein the baffle (24) is disposed at an angle relative to the direction of fluid flow over the plurality of plastic tubes (16).

18. The heat exchanger as recited in any one of the claims 10 to 17, wherein the heat exchanger (10) is adapted for providing at least one of the following:

an intercooler for cooling charge air, a cooler for cooling batteries of an electric vehicle,
a cooler for cooling a fuel cell, a cooler for cooling a fuel cell in a vehicle, in particular a fuel cell vehicle, a cooler for cooling liquid and/or gaseous fluids in a vehicle, in particular in an electric vehicle and/or in a fuel cell vehicle.

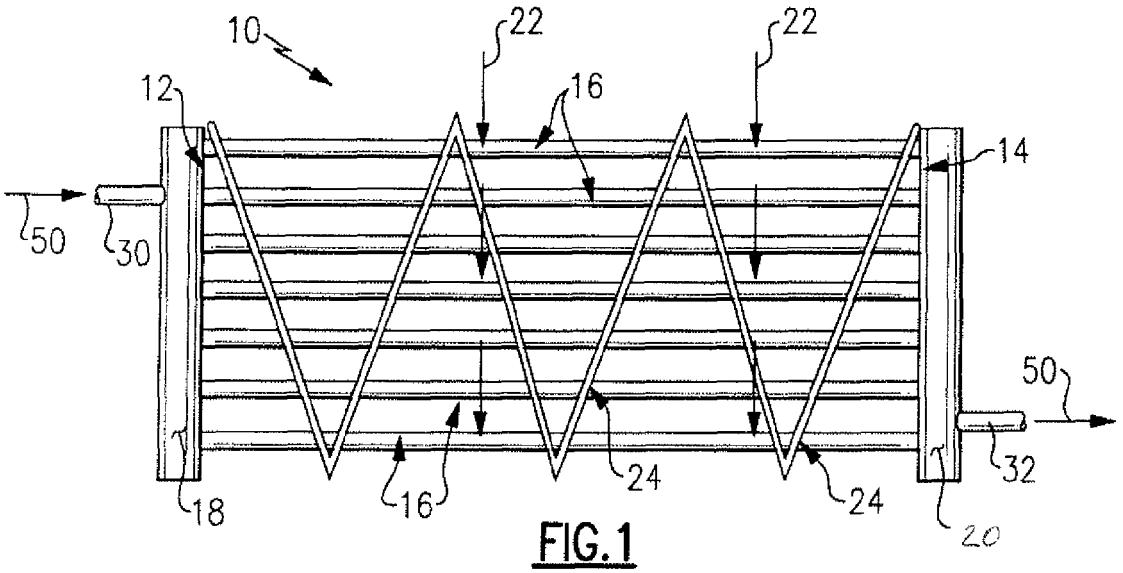

FIG.1

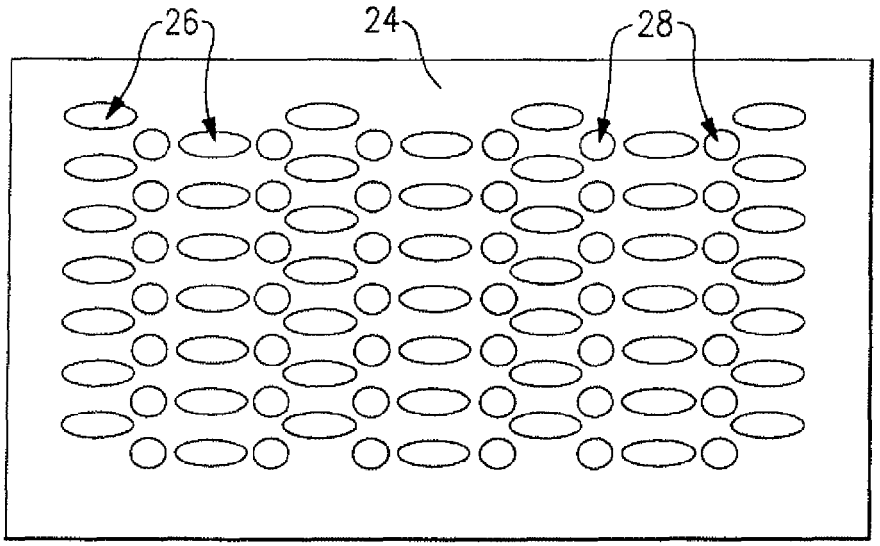

FIG.2

FIG.3A

FIG.3B

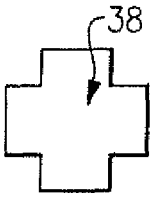

FIG.3C

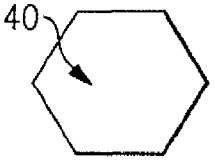

FIG.3D

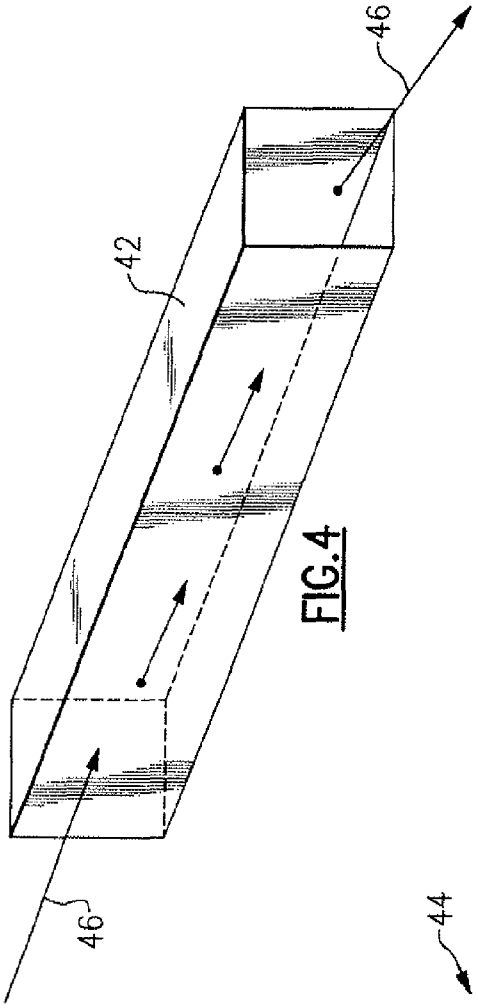

FIG.4

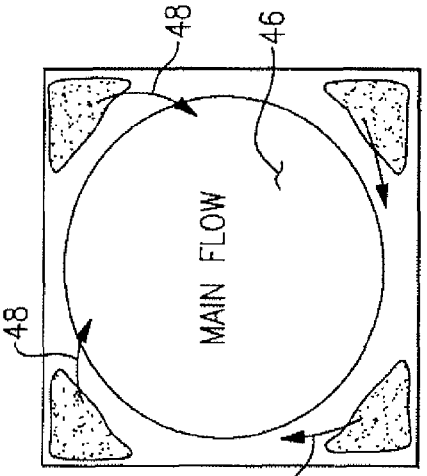

FIG.6

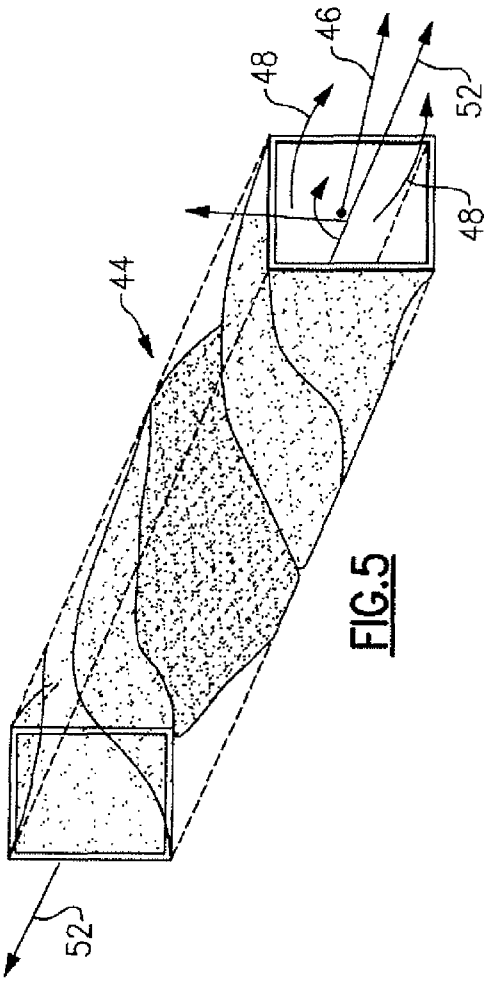

FIG.5

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EUROPEAN SEARCH REPORT

Application Number
EP 08 16 0592

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
E	US 2008/173436 A1 (BAYLIS BOBBYE KAYE [CA] ET AL) 24 July 2008 (2008-07-24) * the whole document *	1-18	INV. F28F21/06 F28F1/04 F28F1/12
Y	US 2005/247442 A1 (DALY PAUL [US]) 10 November 2005 (2005-11-10) * the whole document *	1-9	F28F1/32 F28F1/34 ADD.
Y	US 3 804 159 A (SEARIGHT E ET AL) 16 April 1974 (1974-04-16) * column 1, lines 1-35 * * column 2, line 50 - column 4, line 16; figures 1-4 *	1-9, 15-17	F28D1/053 F28D7/16 F28F9/013 F28F13/12
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Y	* abstract; figures 1,2,9-13 *	15-17	F28F
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X	EP 0 582 835 A (STEYR NUTZFAHRZEUGE [AT]) 16 February 1994 (1994-02-16) * the whole document *	10,18	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	8 January 2009	Leclaire, Thomas

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 08 16 0592

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 08 16 0592

The Search Division considers that the present European patentapplication does not comply with the requirements of unity of invention and relates to severalinventions or groups of inventions, namely:

1. claims: 1-9

heat exchanger comprising a plurality of plastic tubes and a baffle, the baffle comprising a plurality of first and second openings

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2. claims: 10-18

heat exchanger comprising two tanks with end plates and a plurality of plastic tubes, the plastic tubes including a non-arcuate cross-sectional shape

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 16 0592

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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08-01-2009

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82