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(54) **HEAT EXCHANGER AND CORRESPONDING MANUFACTURING METHOD**

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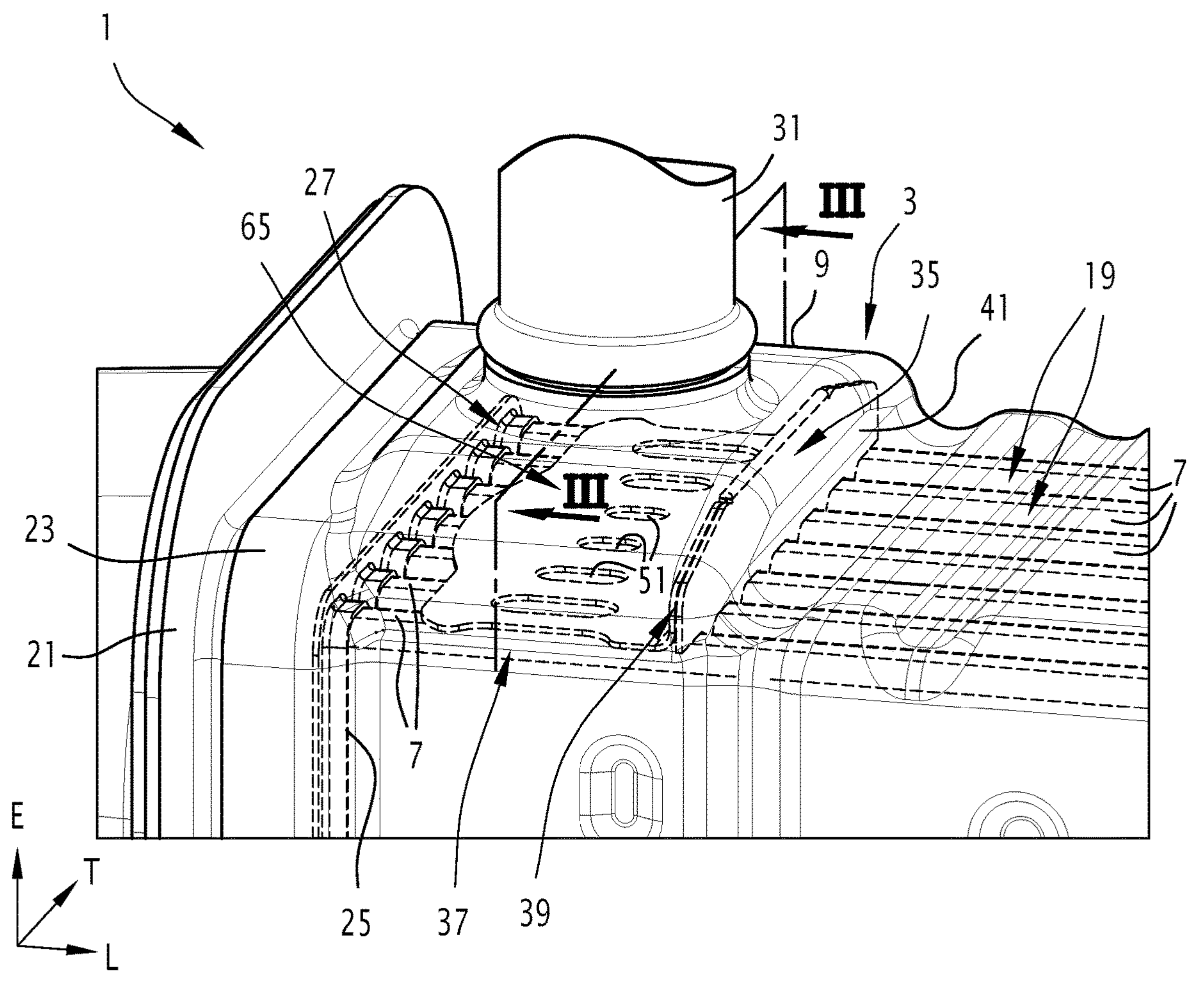
(57) **ABSTRACT**

A heat exchanger for an exhaust gas recirculation system includes an exchanger body delimiting an inner volume, and longitudinal tubes housed in the inner volume and forming a layer of tubes fitting between upper and lower planes. The tubes are separated by passages for circulating a second fluid, the upper plane being across from an upper part of the exchanger body. A second fluid inlet is arranged in the upper part of the exchanger body; and a member guides the second fluid in the inner volume. A deflector at least partially closes off the interstitial space between the upper part and the upper plane.



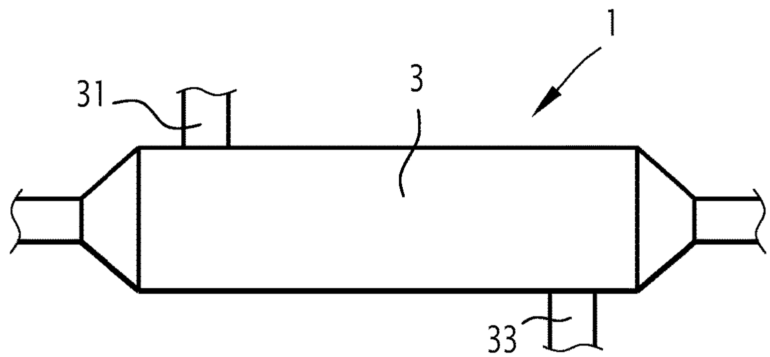


FIG.1

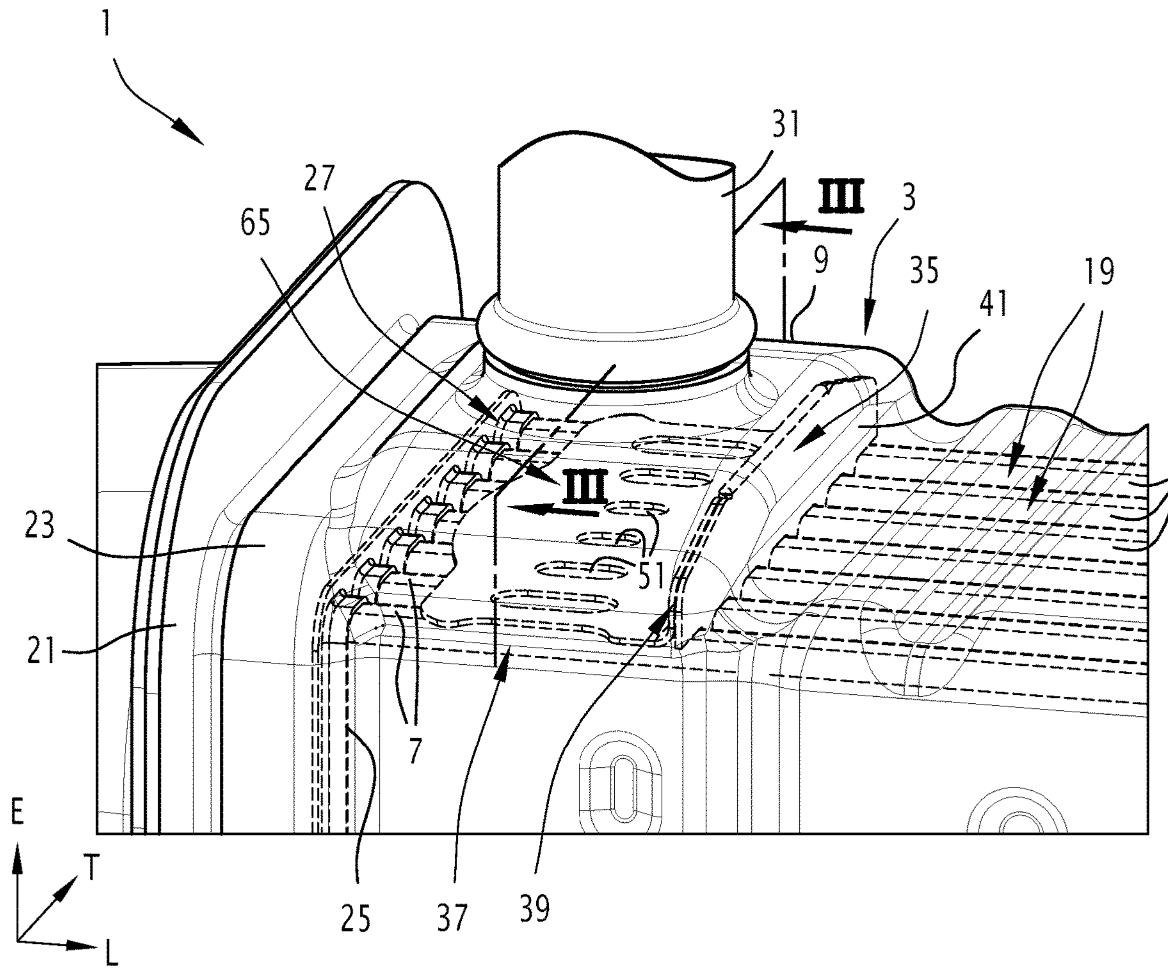


FIG.2

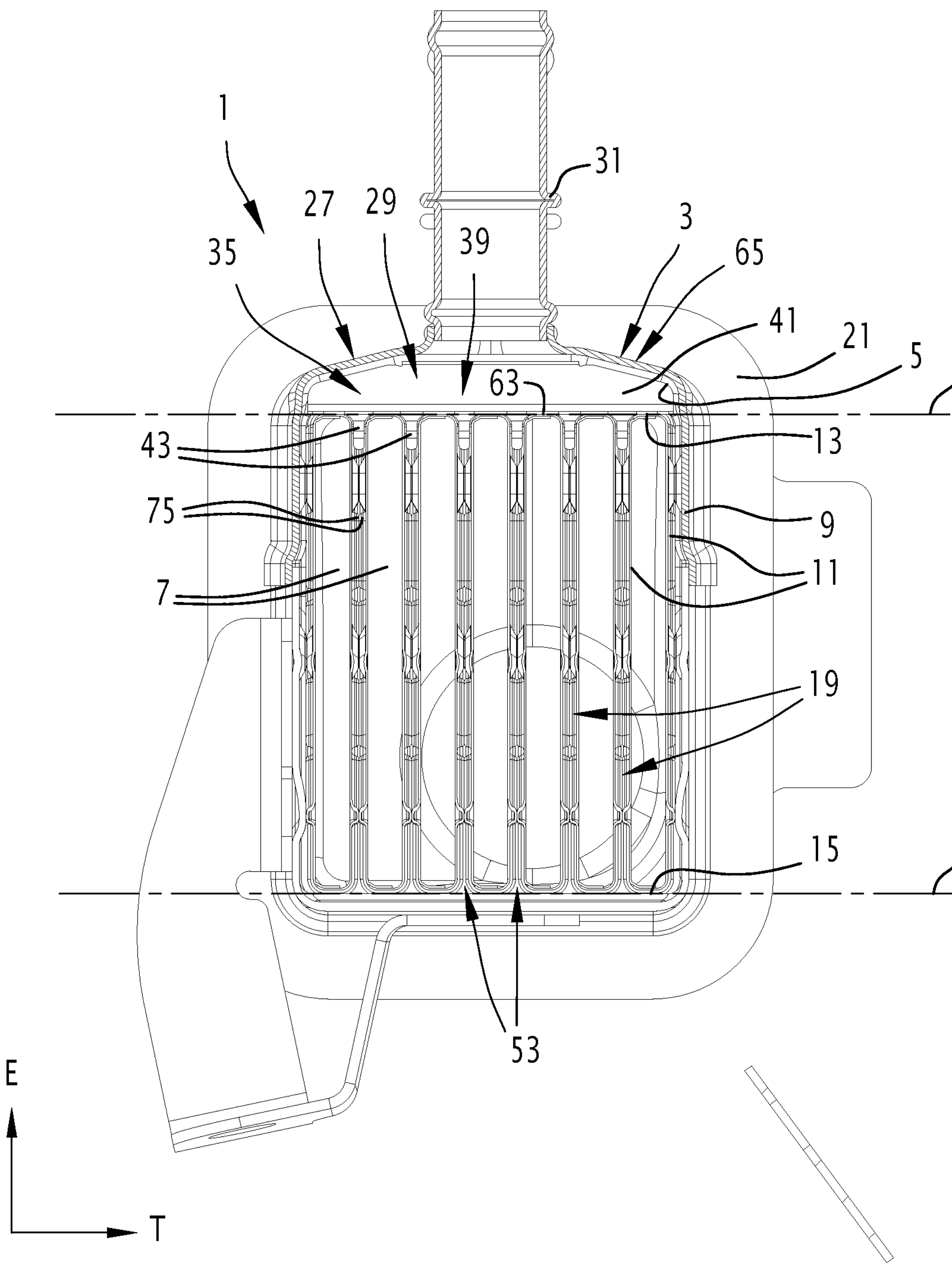


FIG.3

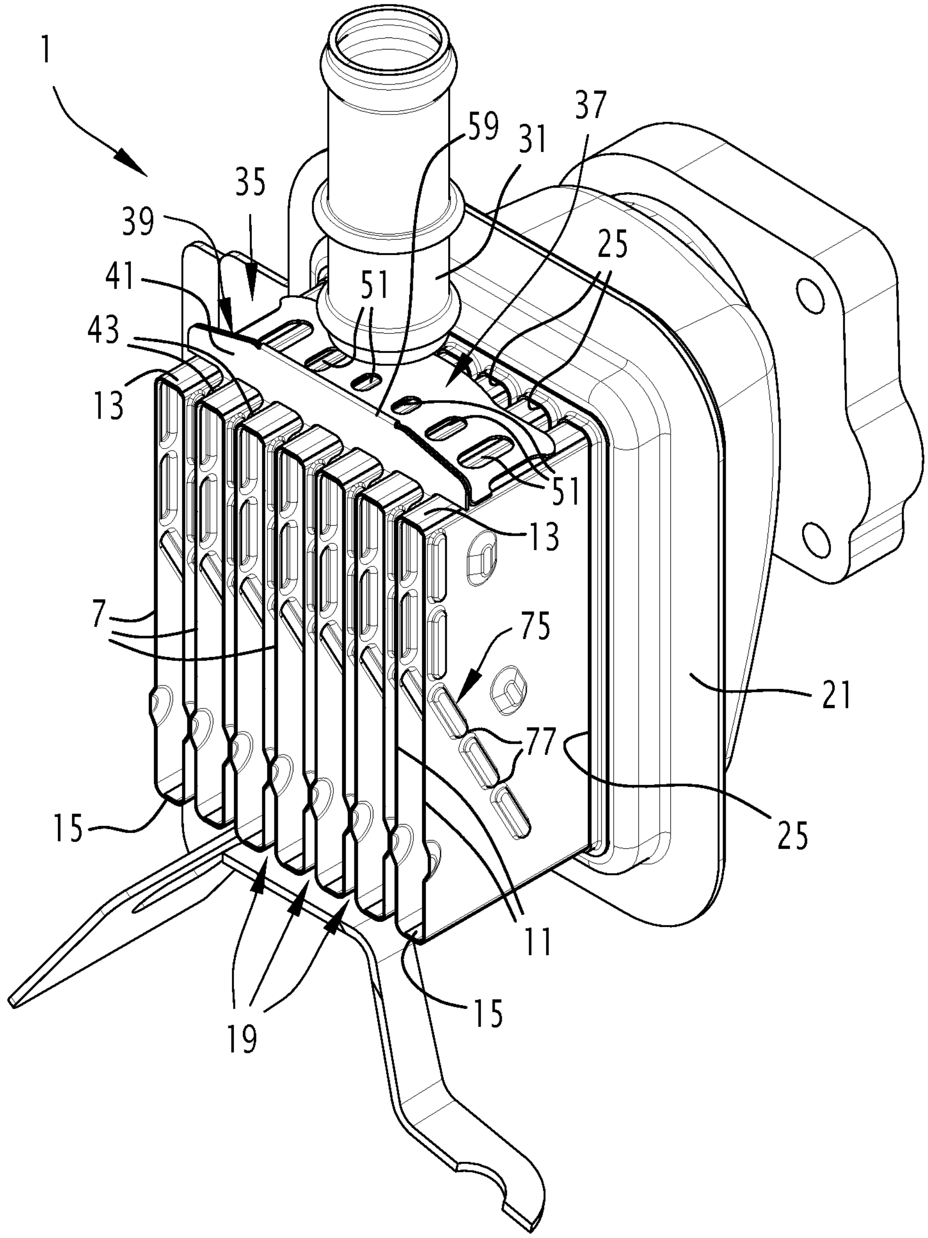


FIG.4

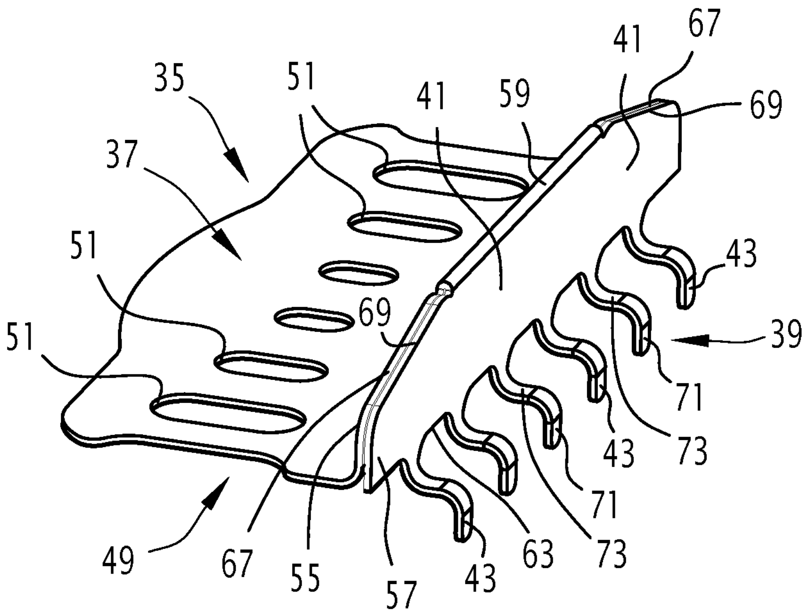

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FIG.5

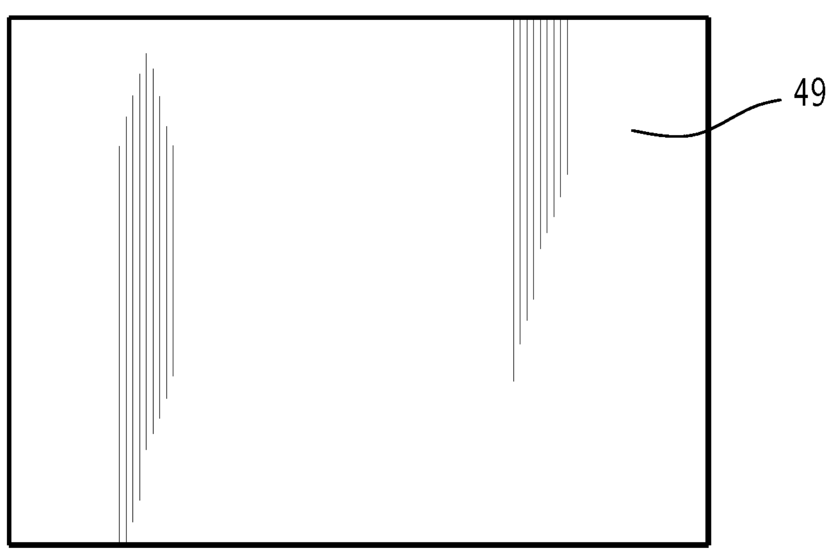
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FIG.6

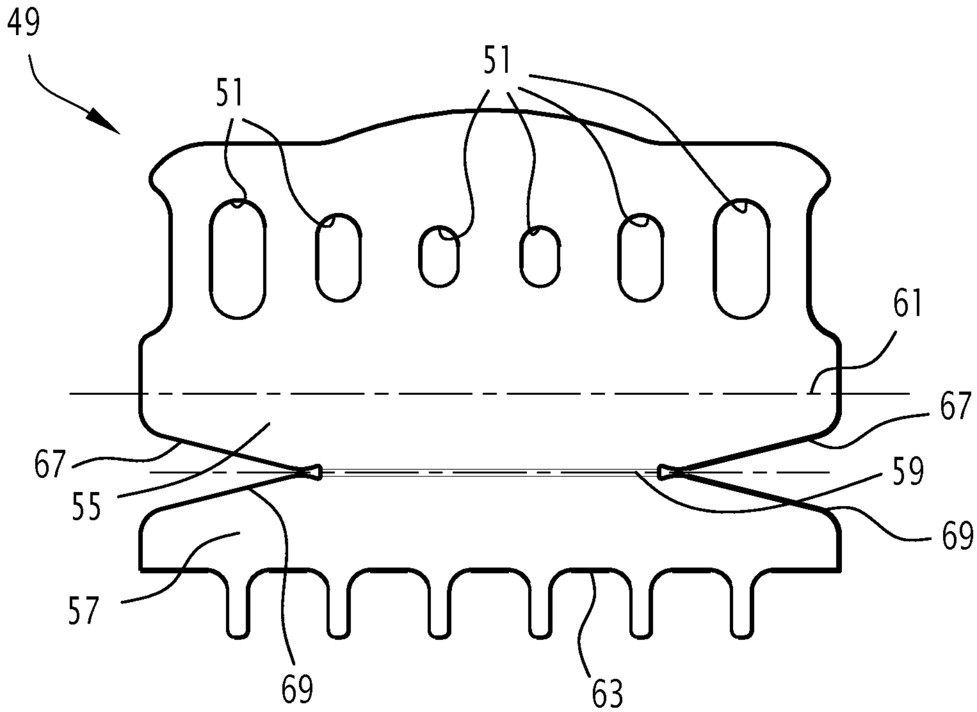

FIG.7

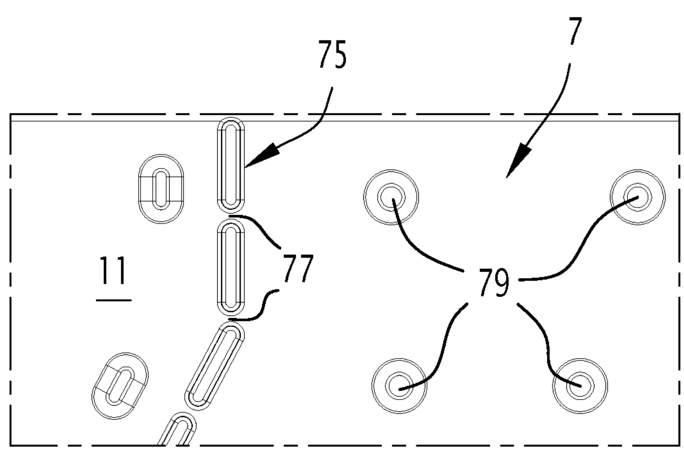

FIG.8

HEAT EXCHANGER AND CORRESPONDING MANUFACTURING METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a U.S. non-provisional application claiming the benefit of French Application No. 18 56830, filed on Jul. 24, 2018, which is incorporated herein by its entirety.

FIELD OF INVENTION

[0002] The present invention relates in general to heat exchangers, in particular for motor vehicle exhaust lines.

BACKGROUND OF THE INVENTION

[0003] Such exchangers can include an exchanger body delimiting an inner volume and a plurality of longitudinal tubes housed in the inner volume, provided for the circulation of a first fluid, for example the exhaust gases. A second fluid, for example a coolant, circulates in the exchanger body, around tubes, from an inlet to an outlet.

[0004] A constant problem in this type of exchanger lies in preventing the second fluid from following the shortest path from the inlet to the outlet. If a large portion of the second fluid follows this short-circuit path, some areas of the tubes can be poorly cooled.

[0005] It is known to insert two combs around the tubes, oriented in opposite directions, to form a baffle forcing the second fluid to adopt an S-shaped journey from the inlet to the outlet.

[0006] Such an arrangement makes it possible to obtain a good quality heat exchange between the two fluids, but is mechanically complex.

[0007] In this context, the invention aims to propose a heat exchanger making it possible to obtain a good quality heat exchange between the two fluids, but which is mechanically less complex.

SUMMARY OF THE INVENTION

[0008] A heat exchanger for an exhaust gas recirculation system includes an exchanger body delimiting an inner volume; a plurality of longitudinal tubes housed in the inner volume, provided to circulate a first fluid, at least some of the tubes being transversely juxtaposed and forming a layer of tubes fitting between upper and lower planes, the tubes of said layer of tubes being separated from one another by passages for circulating a second fluid, at least the upper plane containing the longitudinal and transverse directions, the upper plane being directly across from an upper part of the exchanger body and being separated from the latter by an interstitial space; a second fluid inlet emerging in the inner volume, arranged in the upper part of the exchanger body; and a guide member for guiding the second fluid in the inner body, including a deflector having a transverse zone at least partially closing off the interstitial space between the upper part and the upper plane.

[0009] The deflector prevents the second fluid from adopting an essentially longitudinal flow at the mouth of the second fluid inlet. It deflects the second fluid depthwise in the passages, which contributes to obtaining a satisfactory thermal exchange quality between the fluids.

[0010] The heat exchanger may also have one or more of the features below, considered individually or according to any technical possible combination(s):

[0011] the guide member comprises a grid for distributing the second fluid, arranged in the interstitial space between the upper part and the upper plane, across from the second fluid inlet;

[0012] the deflector of the guide member comprises teeth engaged in the passages;

[0013] the distribution grid, the transverse zone and the teeth are integral with one another;

[0014] the distribution grid, the transverse zone and the teeth are formed in a same metal plate;

[0015] the distribution grid extends over substantially the entire width of the layer of tubes and has, across from each passage, at least one hole, the second fluid inlet being placed across from at least one central passage from among the passages, the at least one hole having a passage section increasing transversely from the at least one central passage;

[0016] each tooth extends transversely over the entire width of the corresponding passage;

[0017] each passage extends over a determined height along an elevation direction substantially perpendicular to the longitudinal and transverse directions, the corresponding tooth extending over a height comprised between 5% and 50% of said determined height;

[0018] at least one of the two tubes surrounding said passage has a rib protruding in the passage, extending the tooth in the elevation direction, the rib preferably having interruptions;

[0019] According to a second aspect, the invention relates to a method for manufacturing a heat exchanger having the features above, comprising the following steps: forming the guide member for guiding the second fluid, by cutting and shaping a metal plate; placing the longitudinal tubes and the guide member in the exchanger body; and fastening the longitudinal tubes, the guide member and the exchanger body to one another.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Other characteristics and advantages of the invention will emerge from the detailed description given below, by way of indication and without limitation, with reference to the annexed figures, including:

[0021] FIG. **1** is a simplified schematic illustration of a heat exchanger according to the invention;

[0022] FIG. **2** is a partial perspective view of the heat exchanger of FIG. **1**, the body being shown translucent so that the tubes and the guide member for guiding the second fluid are visible;

[0023] FIG. **3** is a sectional view of the heat exchanger of FIG. **2** in a plane perpendicular to the longitudinal direction, considered along the incidence of arrows III;

[0024] FIG. **4** is a partial perspective view of the heat exchanger of FIG. **2**, the body being shown translucent so that the tubes and the guide member for guiding the second fluid are visible;

[0025] FIG. **5** is a perspective view of the guide member for guiding the second fluid of FIG. **2**;

[0026] FIG. **6** illustrates the plate from which the guide member for guiding the second fluid is manufactured;

[0027] FIG. **7** illustrates the state of the plate of FIG. **6** after the cutting operation and before the shaping operation; and

[0028] FIG. **8** is an elevation view of a zone of a tube delimiting one of the second fluid passages, showing the rib extending the tooth engaged in said passage.

DETAILED DESCRIPTION

[0029] The heat exchanger **1** shown in FIG. **1** is intended to be inserted into a vehicle exhaust line, in particular of a motor vehicle such as a car or truck.

[0030] This heat exchanger is, for example, inserted on the EGR (Exhaust Gas Recycling) line, which makes it possible to recycle part of the exhaust gases toward the inlet of the combustion chamber of the engine, mixed with fresh air.

[0031] In a variant, the heat exchanger is integrated into an EHRS (Exhaust Heat Recovery System) device or into any other system of the exhaust line.

[0032] According to another variant, the heat exchanger is integrated into another circuit of the vehicle, or even into a static system, which is not on board a vehicle.

[0033] The heat exchanger **1** is provided to place a first fluid and a second fluid in thermal contact.

[0034] The first fluid is, for example, the exhaust gases of the vehicle, the second fluid being a heat transfer fluid intended to cool the exhaust gases. The second fluid is, for example, a liquid such as water with potential additives.

[0035] In a variant, both fluids are of any other type.

[0036] The heat exchanger **1** includes an exchanger body **3** delimiting an inner volume **5** and a plurality of longitudinal tubes **7** housed in the inner volume **5** (FIGS. **2** and **3**).

[0037] The tubes **7** are provided to circulate the first fluid.

[0038] The exchanger body **3** includes a tubular wall **9**, with a longitudinal central axis. In the illustrated example, the tubular wall **9** is a cylinder with a substantially rectangular straight section.

[0039] The tubes **7** are typically all identical. They are rectilinear, with a substantially rectangular section. They are parallel to one another.

[0040] Each tube **7**, considered in section in a plane perpendicular to the longitudinal direction, is thus delimited by two opposite side faces **11** that are opposite one another, an upper face **13** and a lower face **15**. The upper and lower faces **13**, **15** connect the side faces **11** to one another.

[0041] The side faces **11** are substantially planar and perpendicular to a transverse direction. The transverse direction is perpendicular to the longitudinal direction.

[0042] At least a portion of the tubes **7** is transversely adjacent and forms a layer of tubes fitting between upper and lower planes P**1** and P**2** (FIG. **3**). The tubes **7** of said layer are separated from one another by circulation passages **19** for the second fluid.

[0043] In the illustrated example, all of the tubes **7** are juxtaposed in a single layer.

[0044] The tubes **7** are arranged such that their side faces **11** are placed opposite one another. Each passage **19** is thus delimited by the faces **11** of two adjacent tubes in the layer.

[0045] The layer typically includes a large number of tubes, for example at least 5.

[0046] Each tube **7** has a large height, considered in an elevation direction, compared with its width considered in the transverse direction. The elevation direction E is substantially perpendicular to the longitudinal and transverse directions L and T. These directions are shown by arrows in FIGS. **2** and **3**.

[0047] The tubes **7** extend over substantially the entire longitudinal length of the tubular wall **9**.

[0048] The exchanger body **3** includes two end plates **21**, engaged in the two opposite longitudinal ends of the tubular wall **9** (FIGS. **2** to **4**). The tubular wall **9** has, at each of its longitudinal ends, an edge with a closed contour **23**, fastened sealably to the corresponding end plate **21**.

[0049] Each end plate **21** has a plurality of oblong orifices **25**, transversely juxtaposed. Each tube **7** has a longitudinal end fastened sealably to the peripheral edge of one of the oblong orifices of the first of the two plates, its opposite longitudinal end being sealably fastened to the peripheral edge of one of the oblong orifices of the other of the two plates (FIG. **4**).

[0050] Thus, the inner volume **5** provided for the circulation of the second fluid is delimited by the tubular wall **9** and the end plates **21**.

[0051] The upper plane P**1** typically corresponds to a plane containing the longitudinal and transverse directions, tangent to at least one of the tubes **7** without intersecting the other tubes. It is shown in FIG. **3**. It is tangent to the upper face **13** of at least one tube **7**. In the illustrated example, the upper faces **13** of the tubes **7** fit in the upper plane P**1**.

[0052] The lower plane P**2** is also typically a plane containing the longitudinal and transverse directions, tangent to at least one of the tubes **7** without intersecting the other tubes. It is shown in FIG. **3**. It is tangent to the lower face **15** of at least one tube **7**. In the illustrated example, the lower faces **15** of the tubes **7** fit in the lower plane P**2**.

[0053] The upper plane P**1** is directly across from an upper part **27** of the exchanger body **3** and is separated therefrom by an interstitial space **29**.

[0054] The interstitial space **29** typically extends over the entire transverse width of the layer of tubes and over the entire longitudinal length of the layer of tubes. It constitutes a favored leak path for the second fluid.

[0055] A second fluid inlet **31** opening out into the inner volume **5** is arranged in the upper part **27** of the exchanger body **3** (FIG. **1**).

[0056] A second fluid outlet **33** opening out into the inner volume **5** is also arranged in the exchanger body **3**.

[0057] As shown in FIG. **1**, the second fluid inlet **31** is arranged on a first longitudinal half of the exchanger body **3**, the second fluid outlet **33** being arranged on a second longitudinal half of the exchanger body **3** opposite the first half.

[0058] The heat exchanger **1** further includes a guide member **35** for guiding the second fluid in the inner volume **5**, including:

[0059] a grid **37** for distributing the second fluid, arranged in the interstitial space **29** between the upper part **27** and the upper plane P**1**, across from the second fluid inlet **31**;

[0060] a deflector **39** having a transverse zone **41** at least partially closing off the interstitial space **29** between the upper part **27** and the upper plane P**1**, and teeth **43** engaged in the passages **19**.

[0061] This guide member is in particular shown in FIG. **5**.

[0062] It is provided to guide the second fluid circulating in the inner volume **5**, from the second fluid inlet **31** to the second fluid outlet **33**, so as to improve the distribution of second fluid in the passages **19**.

[0063] The distribution grid **37**, the transverse zone **41** and the teeth **43** are integral with one another.

[0064] More specifically, the distribution grid **37**, the transverse zone **41** and the teeth **43** are formed in a same metal plate **49**, as shown in FIGS. **5** to **7**.

[0065] The distribution grid **37** is a planar zone of the metal plate **49**, typically extending in a longitudinal and transverse plane, for example the upper plane P**1**. It extends over the entire width of the layer of tubes. It is typically placed on the upper faces **13** of the tubes **7** and rigidly fastened to the tubes **7**.

[0066] The distribution grid **37** has, opposite each passage **19**, at least one hole **51** (FIG. **4**). Typically, it has a single hole **51** opposite each passage **19**. The holes **51** are therefore transversely aligned.

[0067] The second fluid inlet **31** is placed opposite at least one central passage, here referenced **53**, among the passages **19**.

[0068] In the illustrated example, two so-called central passages **53** are located across from the inlet **31**, as shown in FIG. **3**.

[0069] The inlet **31**, in the transverse direction, is substantially at the center of the layer of tubes.

[0070] The at least one hole **51** has a passage section increasing transversely from the at least one central passage **53**.

[0071] The considered passage section is the total section, offered collectively to the second fluid by the hole(s) **51** associated with the second fluid passage **19**.

[0072] This means that the passage section offered to the second fluid is relatively smaller for the hole(s) **51** associated with the central passages **53**. The passage section offered to the second fluid is slightly bigger for the hole(s) **51** associated with the two second fluid passages **19** adjoining the central passages **53**. The passage section of the holes increases gradually as one moves transversely away from the central passages.

[0073] Such an arrangement makes it possible to distribute the second fluid arriving through the inlet **31** uniformly in the passages **19**.

[0074] The transverse zone **41** is defined by a solid part of the plate **49**. It includes two flaps **55**, **57**, of the same shape, pressed on one another. The two flaps **55**, **57** are exactly superimposed on one another, as shown in FIG. **5**.

[0075] The flaps **55** and **57** are connected to one another by an upper bending line **59** of the plate **49**, oriented transversely. The flap **55** is connected to a transverse edge of the grid **37** by a lower bending line **61**, oriented transversely (FIG. **7**).

[0076] The teeth **43** are secured to a transverse edge **63** of the flap **57**, opposite the upper bending line **59**.

[0077] The flaps **55** and **57** extend in a plane containing the elevation direction and the transverse direction. They are substantially perpendicular to the distribution grid **37**.

[0078] The transverse zone **41** closes off at least 90% of the cross-section of the interstitial space **29**, preferably at least 95% of said cross-section, still more preferably at least 98% of said cross-section.

[0079] As illustrated in FIG. **3**, the cross-section **41** fits in a determined transverse plane. The interstitial space **29** has a determined inner section in said transverse plane. The outer section of the transverse zone **41** is substantially conjugated with the inner section of the interstitial space **29** in said plane.

[0080] The second fluid inlet **31** is arranged on a boss **65** formed in the exchanger body **3** (FIGS. **2** and **3**).

[0081] This boss **65** is convex toward the outside of the exchanger body **3**. The inlet **31** is formed at the apex of the boss **65**.

[0082] The transverse zone **41** typically fits in a transverse plane intersecting the boss **65**. It therefore has a truncated pyramid shape, as illustrated in FIG. **3**.

[0083] The upper bending line **59** constitutes the upper edge of the transverse zone **41** and points toward the upper zone **27** of the exchanger body **3**. It is shorter in the transverse direction than the lower bending line **61** and the transverse edge **63**.

[0084] The upper bending line **59** is connected to the lower bending line **61** by oblique edges **67** of the flap **55**. It is connected to the transverse edge **63** by oblique edges **69** of the flap **57**, which are superimposed exactly on the oblique edges **67**.

[0085] The transverse zone **41** is inserted longitudinally between the second fluid inlet **31** and the second fluid outlet **33**.

[0086] The teeth **43** are all attached to the transverse zone **41**.

[0087] They come from the transverse edge **63** of the flap **57**. They are regularly spaced apart along the transverse edge **63**.

[0088] Each second fluid circulation passage **19** receives one of the teeth **43**.

[0089] According to one embodiment variant that is not shown, one of the teeth **43** is inserted between the exchanger body **3** and the tube **7** located at the first transverse end of the layer. Another one of the teeth **43** is inserted between the exchanger body **3** and the tube **7** located at the second transverse end of the layer.

[0090] Each tooth **43** extends transversely over the entire width of the corresponding passage **19**.

[0091] The teeth **43** are for example L-shaped, with a free segment **71** oriented along the elevation direction, and an intermediate segment oriented substantially longitudinally connecting the free segment **73** to the transverse zone **41**.

[0092] Each passage **19** extends over a determined height in the elevation direction. The corresponding tooth **43** extending over a height of between 5% and 50% of said determined height, preferably between 10% and 30% of said determined height, still more preferably between 10% and 20% of said determined height.

[0093] Preferably, at least one of the two tubes **7** surrounding said passage **19** has a rib **75** protruding in the passage **19**, extending the tooth **43** in the elevation direction. The rib **75** is in particular visible in FIG. **8**. It is formed on the side face **11** of the tube.

[0094] Typically, the two tubes **7** surrounding said passage **19** each have a rib **75** protruding in the passage **19**. These ribs are substantially identical.

[0095] Each rib **75** typically extends at least from the upper face **13** over at least 50% of the height of the tube **7** considered along the elevation direction E.

[0096] In the example illustrated in FIG. **4**, the rib **75** extends first, from the upper face **13**, along the elevation direction, then along an inclined direction oriented longitudinally toward the end plate **21** and along the elevation direction toward the lower face **15**.

[0097] The two ribs **75** are placed opposite one another along the transverse direction. Together, they close off the passage **19** over substantially its entire transverse width. To that end, each rib **75** protrudes relative to the side face **11** of the corresponding tube **7** over a height such that it practically touches the rib **75** opposite it.

[0098] The rib **75** preferably has interruptions **77**, typically regularly spaced apart. This makes it possible to create a flow of second fluid in the passage immediately behind the rib **75**, which makes it possible to obtain a more uniform temperature field along the tube.

[0099] FIG. **8** shows that each tube **7** includes reliefs **79** in pad form, formed by deformation of the side wall **11** of the tube. These reliefs are spacers making it possible to guarantee the separation between the tubes **7**, and therefore the width of the passage **19**.

[0100] The operation of the heat exchanger will now be described.

[0101] The first fluid penetrates the heat exchanger by a longitudinal end of the tubes **7**. It circulates along the tubes **7** and leaves the heat exchanger at the other longitudinal end of the tubes **7**.

[0102] The second fluid penetrates the heat exchanger through the second fluid inlet **31**. It flows in the inner volume **5**.

[0103] The second fluid, upon leaving the inlet **31**, is found in the interstitial space **29**. It cannot flow longitudinally along the interstitial space **29** toward the outlet **33**, due to the presence of the transverse zone.

[0104] It is therefore forced to pass through the distribution grid **37** and penetrate inside the circulation passages **19**.

[0105] The hole(s) **51** covering the central passage(s) **53**, located opposite the inlet **31**, are relatively smaller and offer a relatively greater resistance to the flow of the fluid. On the contrary, the hole(s) **51** covering the passage(s) **19** transversely offset relative to the inlet **31** are relatively larger and offer a relatively weaker resistance to the flow of the fluid.

[0106] As a result, the second fluid is distributed substantially uniformly in the different passages **19**, the different passages **19** receiving respective fluid flow rates close to one another.

[0107] The teeth **43** prevent the second fluid from circulating, in a same passage **19**, essentially longitudinally in the zone located immediately below the interstitial space **9**.

[0108] The teeth **43** deflect the second fluid toward the lower face of the tube, depthwise in the passage **19**.

[0109] The ribs **75** extend this movement, and deflect the second fluid even more depthwise in the passages **19**, in a direction opposite the interstitial space **9**. A low flow rate of second fluid passes through the interruptions **77**.

[0110] When the second fluid reaches the end of the ribs **75**, it flows longitudinally toward the second fluid outlet **33**.

[0111] The invention also relates to a method for manufacturing a heat exchanger **1** having the above features.

[0112] The manufacturing method comprises the following steps:

[0113] Forming the guide member **39** of the second fluid, by cutting and shaping a metal plate;

[0114] Placing the longitudinal tubes **7** and the guide member **39** in the exchanger body **3**;

[0115] Fastening the longitudinal tubes **7**, the guide member **39** and the exchanger body **3** together.

[0116] The metal plate **49** from which the guide member is manufactured is illustrated in FIG. **6**.

[0117] It is typically flat, and has a thickness of between 0.2 and 1 mm, advantageously between 0.3 and 0.8 mm, and still more advantageously 0.4 mm. It is made from steel, preferably austenitic steel.

[0118] The cutting and shaping step comprises an operation for cutting the plate **49**, so as to delimit the contour of the distribution grid and create the holes **51**.

[0119] The cutting also makes it possible to create the oblique edges **67**, **69**, and the teeth **43**.

[0120] The state of the plate **49** after the cutting operation is illustrated in FIG. **7**.

[0121] The cutting and shaping step comprises a shaping operation, during which the plate **49** is bent substantially at 90° around the lower bending line **61**, and 180° around the upper bending line **59**.

[0122] The shaping operation also makes it possible to shape the teeth **43**.

[0123] The shaping operation is done after or at the same time as the cutting operation.

[0124] The bending and shaping step is, for example, a stamping step.

[0125] The fastening of the longitudinal tubes **7**, the guide member **39** and the exchanger body **3** to one another is typically done by brazing, in a furnace.

[0126] In the present description, reference has been made to upper and lower faces or directions. The upper face and the upper direction are not necessarily oriented toward the top and can be oriented in any direction. The same comment applies to the lower face and the lower direction.

[0127] The heat exchanger can have multiple variants.

[0128] According to one variant, the tubes are arranged in several layers, superimposed on one another in the elevation direction.

[0129] The two ribs protruding in the second fluid circulation passage, arranged opposite one another, can be replaced by a single rib, carried by one of the two tubes.

[0130] The exchanger body and the tubes have any appropriate shapes.

[0131] The inlet is not necessarily formed on a boss. In a variant, it is formed in a zone that does not protrude on the exchanger body.

[0132] The invention has multiple advantages.

[0133] The guide member is particularly easy and inexpensive to manufacture because the distribution grid, the transverse zone and the teeth are formed in a same metal plate.

[0134] The fact that the transverse zone closes off at least 90% of a cross-section of the interstitial space contributes to obtaining a good distribution of the second fluid in the inner volume of the exchanger body, due to the absence of short-circuit path from the inlet to the outlet.

[0135] The fact that the transverse zone is inserted longitudinally between the second fluid inlet and the second fluid outlet also contributes to the good distribution of the second fluid.

[0136] When the second fluid inlet is arranged on a boss formed in the exchanger body, the distribution of the second fluid from the inlet is made easier. The transverse zone blocks the circulation of the fluid longitudinally in the interstitial space as close as possible to the inlet.

[0137] The teeth block the circulation of the second fluid longitudinally in the upper part of the passages, immediately below the interstitial space. It is not possible to form ribs on the tubes in this location, since these ribs would be too close to the junction edge between the side face and the upper face of the tubes.

[0138] Using protruding ribs formed in the tubes in the extension of the teeth makes it possible to deflect the second fluid conveniently. These ribs are inexpensive to produce and easy to implement.

[0139] Although an 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 disclosure. For that reason, the following claims should be studied to determine the true scope and content of this disclosure.

1. A heat exchanger for an exhaust gas recirculation system, comprising:

an exchanger body delimiting an inner volume;

a plurality of longitudinal tubes housed in the inner volume and provided to circulate a first fluid, at least some of the longitudinal tubes being transversely juxtaposed and forming a layer of longitudinal tubes fitting between upper and lower planes, the longitudinal tubes of said layer of longitudinal tubes being separated from one another by passages for circulating a second fluid, at least the upper plane including longitudinal and transverse directions, the upper plane being directly across from an upper part of the exchanger body and being separated from the exchanger body by an interstitial space;

a second fluid inlet opening out into the inner volume and arranged in the upper part of the exchanger body; and

a guide member to guide the second fluid in the inner volume, and including a deflector having a transverse zone at least partially closing off the interstitial space between the upper part and the upper plane.

2. The heat exchanger according to claim **1**, wherein the guide member comprises a grid that distributes the second fluid, the grid being arranged in the interstitial space between the upper part and the upper plane, across from the second fluid inlet.

3. The heat exchanger according to claim **2**, wherein the distribution grid extends over substantially an entire width of the layer of longitudinal tubes and has, across from each passage, at least one hole, the second fluid inlet being placed across from at least one central passage from among the passages, the at least one hole having a passage section increasing transversely from the at least one central passage.

4. The heat exchanger according to claim **2**, wherein the deflector of the guide member comprises teeth engaged in the passages.

5. The heat exchanger according to claim **4**, wherein the distribution grid, the transverse zone, and the teeth are integral with one another.

6. The heat exchanger according to claim **4**, wherein the distribution grid, the transverse zone, and the teeth are formed in a same metal plate.

7. The heat exchanger according to claim **4**, wherein each tooth extends transversely over an entire width of the corresponding passage.

8. The heat exchanger according to claim **4**, wherein each passage extends over a determined height along an elevation direction substantially perpendicular to the longitudinal and transverse directions, the corresponding tooth extending over a height comprised between 5% and 50% of said determined height.

9. The heat exchanger according to claim **8**, wherein at least one of two longitudinal tubes surrounding said passage has a rib protruding in the passage, extending the tooth in the elevation direction, the rib preferably having interruptions.

10. A method for manufacturing a heat exchanger according to claim **1**, the manufacturing method comprising the following steps:

Forming the guide member that guides the second fluid, by cutting and shaping a metal plate;

Placing the longitudinal tubes and the guide member in the exchanger body; and

Fastening the longitudinal tubes, the guide member, and the exchanger body together.

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