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(54) HEAT EXCHANGER, IN PARTICULAR EXHAUST GAS COOLING DEVICE, FOR COOLING EXHAUST GAS FROM AN INTERNAL COMBUSTION ENGINE

(57) The invention concerns a heat exchanger (1), in particular an exhaust gas cooling device, for cooling exhaust gas from an internal combustion engine. The heat exchanger (1) comprises a housing (2) which comprises a circumferential wall (4) and two end housing walls (5a, 5b) which together define a housing interior space (3), the circumferential wall (4) having a coolant inlet (11) for introducing a coolant (K) into the housing interior space (3). The heat exchanger (1) comprises a plurality of tubular bodies extending along a longitudinal direction (L) and arranged in the housing interior for the passage of exhaust gas. The heat exchanger (1) further comprises at least one housing insert (7a, 7b) arranged in the housing interior between the tubular bodies and the peripheral wall (4). An opening (12) through which the coolant (K) can flow is formed in the housing insert (7a, 7b), preferably at a distance from the coolant inlet (11).

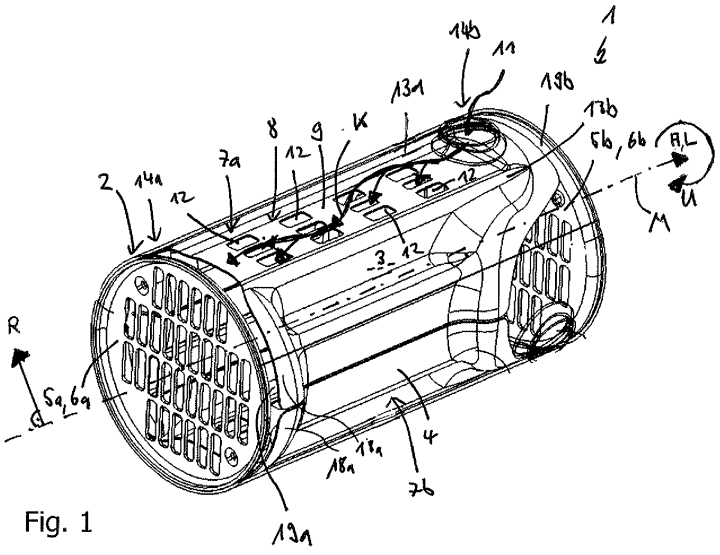

Fig. 1

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Description

[0001] The invention relates to a heat exchanger, in particular an exhaust gas cooling device, for cooling exhaust gas from an internal combustion engine.

[0002] For cooling exhaust gas from an internal combustion engine, heat exchangers are used, through which the exhaust gas to be cooled is fluidically separated and led to a liquid coolant, which can absorb heat from the exhaust gas through thermal interaction, so that the exhaust gas is cooled.

[0003] Such heat exchangers typically comprise a plurality of tubular bodies made of a material with high thermal conductivity - typically a metal - through which the exhaust gas to be cooled is passed inside a heat exchanger housing. A coolant channel or coolant path is formed between the individual pipe bodies, through which the coolant to be cooled is passed, fluidically separated, to the exhaust gas, so that heat can be transferred from the exhaust gas to the coolant through the walls of the pipe bodies without the exhaust gas being mixed with the coolant. In this context, so-called tube bundles - heat exchangers in which a plurality of tube bodies - a so-called bundle - extend along a common longitudinal direction and are arranged at a distance from one another so that the spaces formed between the individual tube bodies form a coolant path through which coolant can flow are particularly well known.

[0004] It is often problematic with such heat exchangers that the liquid coolant is already heated so strongly by the exhaust gas at the first contact with the pipe bodies through heat absorption that it evaporates immediately and can therefore no longer absorb any heat from the exhaust gas. This means that typically only tube body sections of the tube bodies are cooled which are located in the immediate vicinity of the coolant inlet through which the coolant is introduced into the interior of the heat exchanger housing. Tube body sections which are located further away from the coolant inlet in the housing interior of the heat exchanger can no longer be cooled or only insufficiently cooled because no coolant or only an insufficient amount of liquid coolant is available for cooling. This results in reduced efficiency of the heat exchanger acting as an exhaust gas cooler.

[0005] It is therefore an objective of the present invention to show new ways in the development of heat exchangers for cooling exhaust gas from an internal combustion engine. In particular, a heat exchanger or an exhaust gas cooling device is to be created which is characterized by improved efficiency and/or to which the evaporation of coolant is reduced compared to conventional heat exchangers.

[0006] This objective is achieved by a heat exchanger according to independent patent claim 1. Preferred embodiments are the subject of the dependent patent claims.

[0007] The basic idea of the invention is therefore to provide the region of a heat exchanger through which the coolant flows with a housing insert which separates this region into an inner and an outer coolant path - preferably into a radially inner and a radially outer coolant path. The two coolant paths communicate fluidically with each other by means of at least one opening provided in the housing insert.

[0008] Thus the heat exchanger can be designed in such a way that the heat transfer from the exhaust gas to the coolant takes place exclusively in the internal coolant path, but not in the external coolant path. In this way, it can be prevented that the entire coolant introduced into the heat exchanger comes into thermal contact with the exhaust gas immediately after introduction and evaporates. Rather, at least that part of the coolant which first flows through the outer coolant path and only later is introduced into the inner coolant path by the inventionally important opening, is not initially brought into thermal contact with the exhaust gas.

[0009] In this way, when the opening is arranged at a distance from the coolant inlet, various sections of the pipe bodies through which the exhaust gas flows can be cooled homogeneously. This advantageous effect can be multiplied by arranging not only a single opening in the housing insert, but several openings along the extension of the two coolant paths at a distance from each other. This means that part of the coolant flowing through the outer coolant path can be successively introduced into the inner coolant path, where heat is then transferred from the exhaust gas to the coolant. As a result, the tubular bodies and thus the exhaust gas can be cooled homogeneously along the extension of the tubular bodies, and an undesired evaporation of coolant is significantly reduced compared to conventional heat transfer, in the ideal case even completely excluded.

[0010] A heat exchanger according to the invention, in particular an exhaust gas cooling device, for cooling exhaust gas from an internal combustion engine, comprises a housing which preferably has a cylindrical geometric shape. The housing of the heat exchanger comprises a circumferential wall and two frontal housing walls which together partially define a housing interior, the circumferential wall having a coolant inlet for introducing a coolant into the housing interior. A coolant outlet for discharging the coolant after flowing through the housing interior - preferably at the peripheral wall - can also be provided. The heat exchanger comprises tubular bodies extending along a longitudinal direction and arranged in the interior of the housing for the passage of exhaust gas. Both the exhaust gas and the coolant are preferably guided along the longitudinal direction through the interior of the housing.

[0011] According to the invention, at least one housing insert is arranged in the housing interior, which is supported at least on the circumferential wall. According to the invention, a opening through which the coolant can flow is formed in the housing insert. Preferred is the opening, in particular along a longitudinal direction of the tubular body, at a distance from the coolant inlet.

This ensures that only coolant flowing through the inner coolant path can absorb heat from the exhaust gas, but not the coolant flowing through the outer coolant path. In this way, the unwanted evaporation of the coolant described above is counteracted.

[0012] In accordance with a preferred embodiment, the housing insert divides the housing interior into an inner and an outer coolant path, which are fluidically connected to each other via the opening. The tube bodies limit the inner coolant path, but not the outer coolant path, or are arranged in the inner coolant path, but not in the outer coolant path.

[0013] In accordance with a preferred embodiment, the housing insert is also supported by at least one tubular body. In this way, the housing insert can be fixed mechanically stable in the interior of the housing.

[0014] According to an advantageous further preferred embodiment, the housing insert forms a partition wall which divides an area of the housing interior between the tube bodies and the circumferential wall into an inner and an outer coolant path. Both coolant paths communicate fluidly with the coolant inlet. The invention-essential, at least one opening is arranged in the partition wall and thus fluidically connects the inner coolant path with the outer coolant path.

[0015] The pipe bodies conveniently limit the inner coolant path or are arranged in the inner coolant path. In this way a particularly good thermal contact between the exhaust gas flowing through the tube bodies and the coolant flowing through the inner coolant path is ensured by the tube body transformations of the tube bodies. On the other hand, there is no direct thermal contact with the coolant flowing through the outer coolant path, so that it cannot evaporate. This has an advantageous effect on the efficiency of the heat exchanger.

[0016] It is advantageous that the area of the housing insert forming the partition wall is arranged between two shoulders formed on the housing insert, by means of which the housing insert is supported on the peripheral wall. The shoulders can be used to limit the outer coolant path.

[0017] According to another preferred embodiment, the two shoulders limit the outer coolant path along a circumferential direction of the housing. The partition limits the outer coolant path radially inside in the radial direction and the inner coolant path radially outside in the radial direction.

[0018] The two shoulders and the partition wall preferably extend along the longitudinal direction of the tube bodies. In this way, the partition wall forms an essentially linear outer coolant path.

[0019] The housing insert expediently extends along the longitudinal direction of the tube bodies and has a cross-section perpendicular to the longitudinal direction with an essentially U-shaped geometry with a U-base and two U-limbs. This variant of the housing insert proves to be particularly mechanically stable.

[0020] Preferably, the U-base in the cross-section perpendicular to the longitudinal direction can be essentially straight and the two U-limbs can be curved. This results in a particularly high mechanical rigidity of the housing insert.

[0021] In accordance with a further advantageous advanced embodiment, the housing insert also has a U-shaped geometric shape with a U-base and two U-arms at its longitudinal ends along the opposite longitudinal direction. In this embodiment, at least one of the longitudinal ends of at least one of the U-arms has a radial recess extending in the circumferential direction for receiving the coolant. By means of this measure an undesired backflow of the coolant to the coolant inlet is counteracted. In the ideal case such an undesired backflow of a part of the coolant is even completely prevented.

[0022] In the cross-section perpendicular to the longitudinal direction, the two shoulders between the U-base and the first or second U-leg are particularly preferred.

[0023] The housing insert can preferably be designed as a half-shell extending along the longitudinal direction.

[0024] According to an advantageous advanced embodiment, the housing comprises two housing inserts which preferably oppose each other in a radial direction of the housing. In this way, the unwanted evaporation of coolant when flowing through the housing interior is counteracted particularly effectively.

[0025] The partition wall can be essentially flat. In this way, the pressure loss in the coolant when flowing through the housing interior can be reduced.

[0026] In accordance with an advantageous further embodiment, at least two openings, preferably a plurality of openings, are arranged at a distance from each other in the partition wall or in the casing insert, preferably along the longitudinal direction of the pipe bodies. The openings in the form of a grid with at least two grid rows and at least two grid gaps are particularly preferred in the partition wall. In this way, it is possible for the coolant flowing through the interior of the housing to be brought into successive contact with various sections of the tube body, which results in uniform cooling of the tube body and thus of the gas flowing through the tube body. This prevents unwanted evaporation of the medium, especially immediately after entering the inside of the housing through the coolant inlet, and thus sections of the tube body with the smallest distance to the coolant inlet are prevented on contact with the tube body for the first time.

[0027] The at least two grid lines preferably extend along the longitudinal direction of the tube bodies.

[0028] According to another advantageous further embodiment, the housing insert has an element length measured along the longitudinal direction which is smaller than a circumferential wall length of the circumferential wall also measured along the longitudinal direction. Thus, a first gap can be formed between the housing insert and the first frontal housing wall and a first or second gap can be formed between the housing insert and the second frontal housing wall, whereby the coolant can flow through both gaps.

[0029] According to another preferred embodiment, the heat exchanger can be designed as a shell-and-tube heat exchanger. Further important characteristics and advantages of the invention result from the subclaims, from the drawings and from the corresponding figure description on the basis of the drawings.

[0030] It goes without saying that the features mentioned above and those to be explained below can be used not only in the combination indicated, but also in other combinations or in a unique position, without leaving the scope of this invention.

[0031] Preferred examples of the execution of the invention are shown in the drawings and are explained in more detail in the following description, whereby identical reference signs refer to identical or similar or functionally identical components.

[0032] They are shown schematically,

Fig. 1 an example of a heat exchanger according to the invention in a perspective view,

Fig. 2 the invention-essential housing insert of the heat exchanger of Fig. 1 in separate perspective representation.

Fig. 3 the components of the heat exchanger of figure 1 in an un-mounted state.

[0033] Figures 1 and 3 show an example of an invention heat exchanger 1 which functions as an exhaust gas cooling device for cooling exhaust gas from an internal combustion engine. The heat exchanger 1 comprises a housing 2, which comprises a cylindrical geometric shape with a circumferential wall 4 and two frontal housing walls 5a, 5b. A central longitudinal axis M of the cylindrical housing extends along an axial direction A. The cylindrical housing 2 has a central longitudinal axis M of the cylindrical housing. The circumferential wall 4 extends along a circumferential direction U, which rotates perpendicular to the axial direction A around the central longitudinal axis. The housing 2 surrounds a housing inner space 3, which is thus partially bounded by the peripheral wall 4 and the two housing walls 5a, 5b. The peripheral wall 4 of the housing 2 is shown transparently in Figure 1, so that components of the heat exchanger 1 arranged in the housing interior 3 and actually concealed in the perspective of Figure 1 can be seen. Heat exchanger 1 can be designed as a shell-and-tube heat exchanger. For this purpose, the two frontal housing walls 5a, 5b are designed as tube plates 6a, 6b, into each of which - in the course of assembling the heat exchanger 1 - a plurality of tube bodies can be inserted and subsequently soldered to the housing walls 5a, 5b. These pipe bodies serve in a known manner for the flow of the exhaust gas to be cooled and extend along a longitudinal direction L, which is identical with the axial direction A. The exhaust gas is cooled in the same way as the exhaust gas. For the sake of clarity, these pipe bodies are omitted from Figure 1.

[0034] According to Figure 1, a coolant inlet 11 is provided in the circumferential wall 4, by means of which coolant K can be led into the interior 3 of the housing, so that it can cool it there by heat transfer from the exhaust gas A, which is led through the pipe bodies arranged in the interior 3 of the housing.

[0035] As Figure 1 also shows, a first and a second housing insert 7a, 7b are arranged in the housing interior 3, both of which are supported on the circumferential wall 4. The two housing inserts 7a, 7b lie opposite each other in a radial direction R, which extends perpendicularly to both the circumferential direction U and the axial direction A away from the central longitudinal axis M. The two housing inserts 7a, 7b are located opposite each other in a radial direction R, which extends perpendicularly both to the circumferential direction U and to the axial direction A away from the central longitudinal axis M. The two housing inserts 7a, 7b are located opposite each other in the radial direction R. The two housing inserts 7a, 7b can each also be supported by the tube bodies (not shown). The two housing inserts 7a, 7b can each also be supported by the housing 2.

[0036] In the following, reference is made to the housing insert 7a, which is shown in separate perspective in Figure 2. The following explanations of housing insert 7a apply mutatis mutandis also to housing insert 7b.

[0037] As figures 1 and 2 illustrate, an area 9 of the housing insert 7a forms a partition 8. The partition 8, in turn, divides an area of the housing interior 3 between the tubular bodies and the peripheral wall 4 into a radially inner coolant path 10i and a radially outer coolant path 10a, both of which communicate fluidly with the coolant inlet 11. The coolant K introduced into the housing interior 3 via the coolant inlet 11 can thus flow along the longitudinal direction L either through the inner coolant path 10i or through the outer coolant path 10a.

[0038] The tubular bodies through which the exhaust gas to be cooled flows limit the inner coolant path 10i so that the heat from the exhaust gas to the coolant flowing through the inner coolant path can pass through the tubular body walls of the tubular bodies. This means that only coolant flowing through the inner coolant path 10i can enter into thermal interaction with the exhaust gas flowing through the tube body and absorb heat from it to cool the exhaust gas. After flowing through the inner or outer coolant path 10i, 10a, the coolant can escape again from the inside of the housing 3 into the outer surroundings of the heat exchanger 1 via a coolant outlet provided on the housing, in particular on the circumferential wall 4 (not shown in the figures).

[0039] As both Figure 1 and Figure 2 illustrate, a plurality of openings 12 is formed in the partition 8 of the housing insert 7a, through which the inner coolant path 10i can communicate with the outer coolant path 10a. The inner coolant path 10i communicates with the outer coolant path 10a through the openings 12. The openings 12 are conveniently spaced, preferably along the longi-

tudinal direction L of the tubular bodies, from the coolant inlet 11. The coolant K entering the housing interior 3 via the coolant inlet 11 first flows through the outer coolant path 10a, where it can enter the inner coolant path 10i via one of the openings 12 and flush around the pipe bodies through which the exhaust gas flows. The arrangement described above thus ensures that the coolant K flowing successively through the outer coolant path 10a is successively transferred via one of the openings 12 into the inner coolant path 10, where the thermal interaction with the exhaust gas can then take place. This prevents the entire coolant K introduced via the coolant inlet 11 into the housing interior 3 from immediately entering into thermal interaction with the exhaust gas to be cooled, so that the risk of evaporation of the coolant mentioned above exists.

[0040] In the following, the structure of the housing insert 7a shown in Figure 2 is described. The housing insert 7a can be designed in the form of a half-shell 17 extending along the longitudinal direction L. The housing insert 7a extends along the longitudinal direction L of the tube bodies as shown in Figure 2 and has a cross-section perpendicular to the longitudinal direction L of a substantially U-shaped geometry with a U-base 15 and two U-limbs 16a, 16b. The U-base 15 is arranged between the two U-limbs 16a, 16b. In the cross-section perpendicular to the longitudinal direction L, the U-base 15 is essentially linear and the two U-limbs 16a, 16b are curved. In the cross-section perpendicular to the longitudinal direction L the two shoulders 13a, 13b are arranged between the U-base 15 and the first and second U-leg 16a, 16b respectively.

[0041] As can be seen in Figure 2, the area 9 of the housing insert 7a forming the partition 8 is arranged between two shoulders 13a, 13b formed on the housing insert 7a, which support the housing insert 7a on the circumferential wall 4. The partition wall 8 with the openings 12 is essentially flat.

[0042] The two shoulders 13a delimit the outer coolant path 10a along a circumferential direction U of the housing 2 as shown in Figure 2. The partition 8 delimits the outer coolant path 10a in the radial direction R radially inside and the inner coolant path 10i in the radial direction R radially outside. The circumferential wall 4 limits the outer coolant path 10a in the radial direction R radially outside. Since the housing insert 7a extends along the longitudinal direction L of the tube body, this also applies to the two shoulders 13a, 13b as well as to the partition wall 8 as shown in Figure 2. Thus, the coolant K can flow along the longitudinal direction through the inner or outer coolant path 10i, 10a.

[0043] The spacer element 7a also has a U-shaped geometric shape with a U-base 15 and two U-limbs 16a, 16b at its longitudinal ends 14a, 14b which lie opposite each other along the longitudinal direction L. The U-shaped geometric shape of the spacer element 7a is based on a U-base 15 and two U-limbs 16a, 16b.

[0044] At the longitudinal end 14a remote from the coolant inlet 11, the two U-limbs 16a, 16b form a circumferentially extending radial recess 18a and 18b respectively, which serves to receive coolant K. The U-limbs 16a and 16b form a radial recess 18a and 18b respectively at the longitudinal end 14a remote from the coolant inlet 11. In the area of the recess 18a, 18b, the housing insert 7a is offset inwards along the radial direction R in relation to the areas of the housing insert 7a adjacent to the recess 18a, 18b.

[0045] Preferably, the plurality of openings 12 formed in the partition 8 or in the housing insert 7a is arranged preferably in the form of a grid 20 with three grid lines and four grid columns as shown in Figures 1 and 2, the three grid lines each extending expediently along the longitudinal direction L of the tubular bodies. It goes without saying that a different number of grid lines and grid columns can be provided in the variant of the example.

[0046] In the following, reference is again made to Figure 1. In the example of Figure 1 the housing insert 7a has an element length which is measured along the longitudinal direction L and which is smaller than a circumferential wall length of the circumferential wall 4 which is also measured along the longitudinal direction L. the circumferential wall 4 is arranged between the two end housing walls 5a, 5b in such a way that between the circumferential wall 4 and the first and second end housing walls 5a, 5b respectively a first and second intermediate space 19a, 19b through which the coolant K can flow is formed.

[0047] According to Figure 3, the house inserts 7a, 7b comprises several welding zones 22 in which the house inserts 7a, 7b are materially bonded to the housing 2 by means of resistance spot welding.

Claims

1. Heat exchanger (1), in particular exhaust gas cooling device, for cooling exhaust gas from an internal combustion engine,

   - with a housing (2), preferably having a cylindrical geometrical shape, which comprises a peripheral wall (4) and two end housing walls (5a, 5b) which together define a housing interior space (3), the peripheral wall (4) having a coolant inlet (11) for introducing a coolant (K) into the housing interior space (3),
   - with a plurality of tubular bodies extending along a longitudinal direction (L) and arranged in the interior of the housing (3) for flow-through with exhaust gas,
   - with at least one housing insert (7a, 7b) arranged in the housing interior space between the tubular bodies and the peripheral wall (4),
   - wherein at least one opening (12) through which the coolant (K) can flow is formed in the housing insert (7a, 7b), preferably at a distance

from the coolant inlet (11).

2. Heat exchanger according to claim 1, **characterized in that**

- the at least one housing insert (7a, 7b) divides the housing interior (3) into an inner and an outer coolant path (10i, 10a) which are fluidically connected to one another via the at least one opening (12),
- the tubular bodies define the inner coolant path (10i) but not the outer coolant path (10a) or are disposed in the inner coolant path (10i) but not in the outer coolant path (10a).

3. Heat exchanger according to claim 1 or 2, **characterized in that**

- the at least one housing insert (7a, 7b) forms a partition wall (8) which divides a region of the housing interior space (3) between the tubular bodies and the peripheral wall (4) into the, preferably radial, inner and the, preferably radial, outer coolant path (10i, 10a),
- the at least one opening (12) is arranged in said partition wall (8) and thus connects said inner coolant path with said outer coolant path.

4. Heat exchanger according to any of claims 1 to 3, **characterized in that**
the tubular bodies are arranged in the inner coolant path (10i).

5. Heat exchanger according to claim 3 or 4, **characterized in that**
a region of the at least one housing insert (7a, 7b) forming the partition wall (8) is arranged between two shoulders (13a, 13b) formed on the housing insert (7a, 7b) by means of which the housing insert (7a, 7b) is supported on the peripheral wall (4).

6. Heat exchanger according to claim 5, **characterized in that**

- the two shoulders (13a, 13b) delimit the outer coolant path (10a) along a circumferential direction (4) of the housing (2),
- the partition wall (7) delimits the outer coolant path (10a) in radial direction (R) radially inside and the inner coolant path (10i, 10a) in radial direction (R) radially outside.

7. Heat exchanger according to claim 5 or 6, **characterized in that**
the two shoulders (13a, 13b) and the partition (8) extend along the longitudinal direction (L) of the tubular bodies.

8. Heat exchangers according to one of the preceding claims, **characterized in that**

- the at least one housing insert (7a, 7b) extends along the longitudinal direction (L) of the tubular bodies;
- in a cross-section perpendicular to the longitudinal direction (L) has a substantially U-shaped geometry with a U-base (15) and two U-limbs (16a, 16b).

9. Heat exchanger according to claim 8, **characterized in that**
in the cross-section perpendicular to the longitudinal direction (L), the U-base (15) is substantially straight-lined and the two U-limbs (16a, 16b) are curved.

10. Heat exchanger according to one of the preceding requirements, **characterized in that**

- the at least one housing insert (7a, 7b) (also) has at its longitudinal ends (14a, 14b) opposite along the longitudinal direction (L) a U-shaped geometric shape with a U-base (15) and two U-limbs (16a, 16b); and that
- at least at the longitudinal end (14a) remote from the coolant inlet (11) of at least one of the U-limbs (16a, 16b) has a, preferably radial, recess (18a, 18b) extending in the circumferential direction (U) for temporarily receiving the coolant (K).

11. Heat exchanger according to claim 10, **characterized in that**
in the cross-section perpendicular to the longitudinal direction (L), the two shoulders (13a, 13b) are arranged between the U-base (15) and the first and second U-limbs (16a, 16b), respectively.

12. Heat exchanger according to one of the preceding claims, **characterized in that**
the at least one housing insert (7a, 7b) is formed in the manner of a half-shell (17) extending along the longitudinal direction (L).

13. Heat exchanger according to one of the preceding claims, **characterized in that**

- the heat exchanger (1) comprises two housing inserts (7a, 7b),
- preferably the two housing inserts (7a, 7b) lie opposite one another in a radial direction (R) of the housing (2).

14. Heat exchanger according to one of the preceding requirements,
characterized in that
at least two openings (12), preferably a plurality of openings (12), are arranged in the at least one housing insert (7a, 7b) or in the partition wall (8), preferably along the longitudinal direction (L), of the tubular bodies, preferably in the form of a grid (10) with at least two grid rows and with at least two grid gaps.

15. Heat exchanger according to claim 14,
characterized in that
the at least two grid rows each extend along the longitudinal direction (L) of the tubular bodies.

16. Heat exchanger according to one of the preceding claims,
characterized in that

- the at least one housing insert (7a, 7b) has an element length which is measured along the longitudinal direction (L) and is smaller than a circumferential wall length of the circumferential wall (4) which is also measured along the longitudinal direction (L), so that a first and/or a second intermediate space (19a, 19b) through which the coolant (K) can flow is formed between the housing insert (7a, 7b) and the first and second end face housing wall (5a, 5b), respectively.

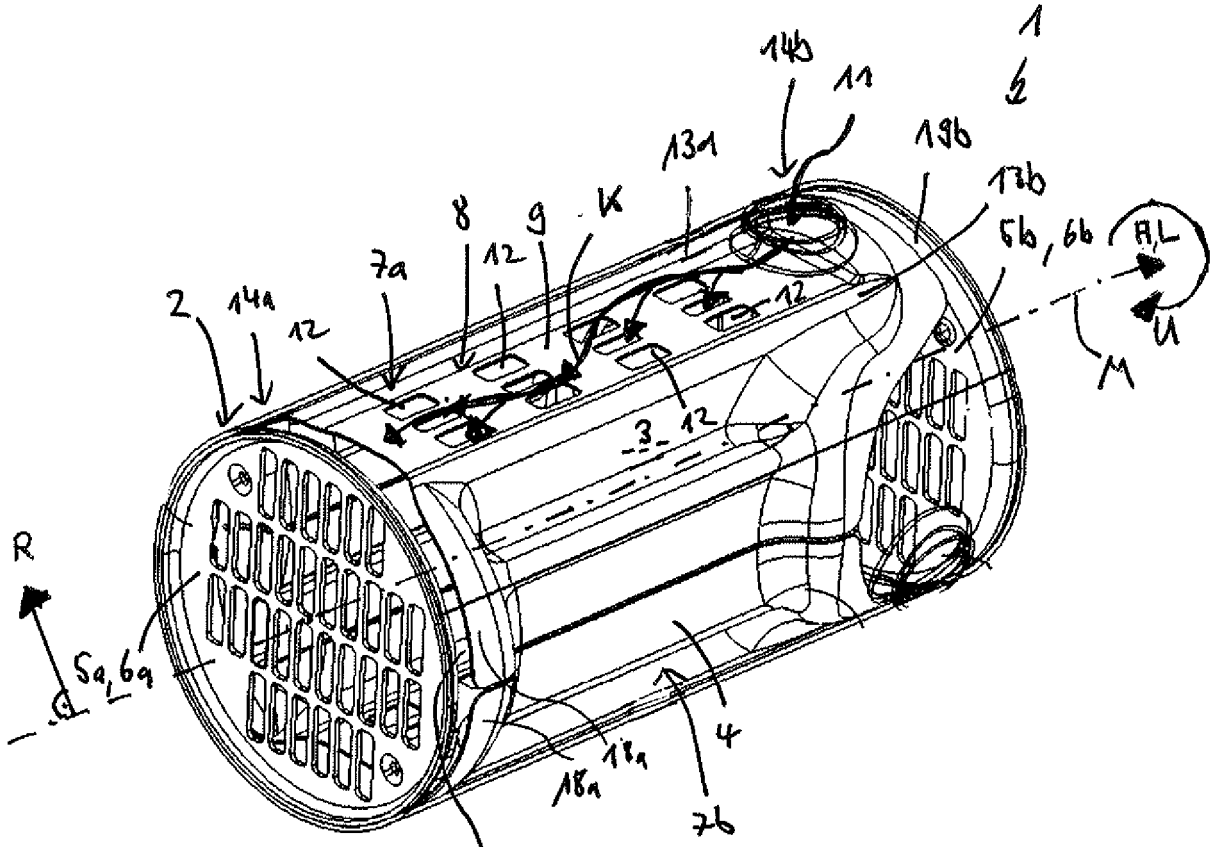
1
14b
11
13a
19b
13b
8
9
K
7a
12
2
14a
5b, 6b
A, L
U
M
3
R
5a, 6a
4
18a
7b
19a

Fig. 1

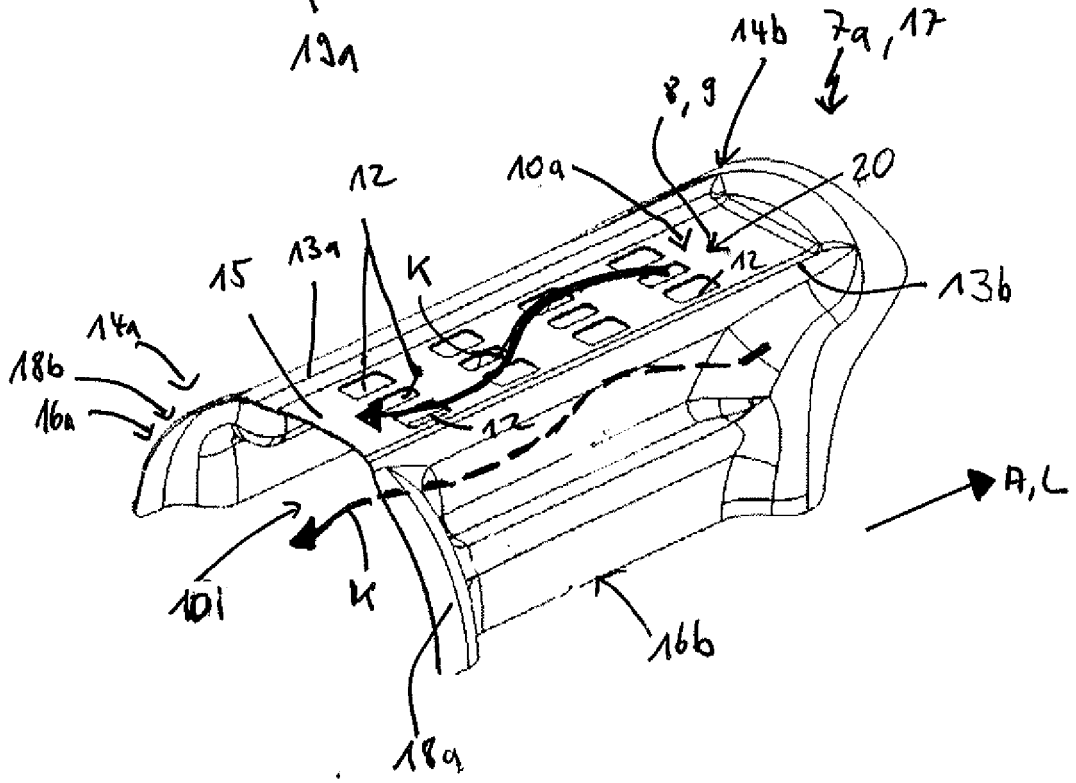
14b
7a, 17
8, 9
10a
20
12
13a
15
K
13b
14a
18b
16a
A, L
10i
16b
19a

Fig. 2

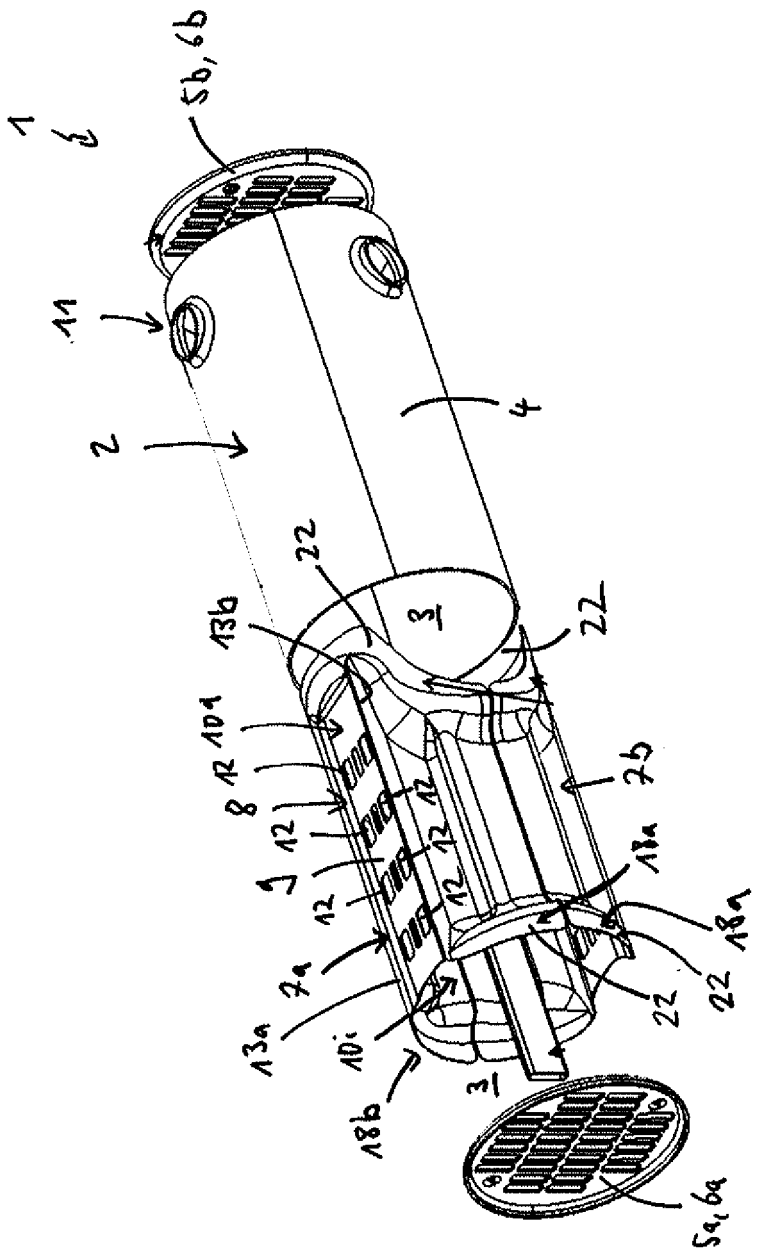

Fig. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 15 8826

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/335263 A1 (FABER CHRISTIAN [DE] ET AL) 22 November 2018 (2018-11-22) * figures 1,2,6-8 * -----	1-16	INV. F02M26/28 F28F9/02 F28D7/16
X	US 2015/027666 A1 (HISANAGA TORU [JP] ET AL) 29 January 2015 (2015-01-29) * figures 9-11 * -----	1-12, 14-16	F28D21/00 F28F9/00 ADD.
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X	WO 2013/022072 A1 (USUI KOKUSAI SANGYO KK [JP]; TAKIKAWA KAZUNORI [JP] ET AL.) 14 February 2013 (2013-02-14) * figures 12-16, 28-37 * -----	1,3,4,16	
A	CN 104 110 329 A (CATERPILLAR INC) 22 October 2014 (2014-10-22) * figure 14 * -----	1-16	

TECHNICAL FIELDS SEARCHED (IPC)

F02M
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	14 July 2020	Vassoille, Bruno

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
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