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(72) **Inventors: DAHAKÉ, Bhushan**; F-22, Varadhast Society, Link Road, Chinchwadgaon, Maharashtra, Pune 411033 (IN). **PANIC, Predrag**; Buchenweg 12, 71737 Kirchberg an der Murr (DE). **WEISSER, Patrick**; Brühlstr. 5, 71157 Hildrizhausen (DE). **WEITHOFF, Lucas**; Gerberstr. 8b, 70178 Stuttgart (DE).

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(74) **Agent: BRP RENAUD UND PARTNER MBB**; Königstraße 28, 70173 Stuttgart (DE).

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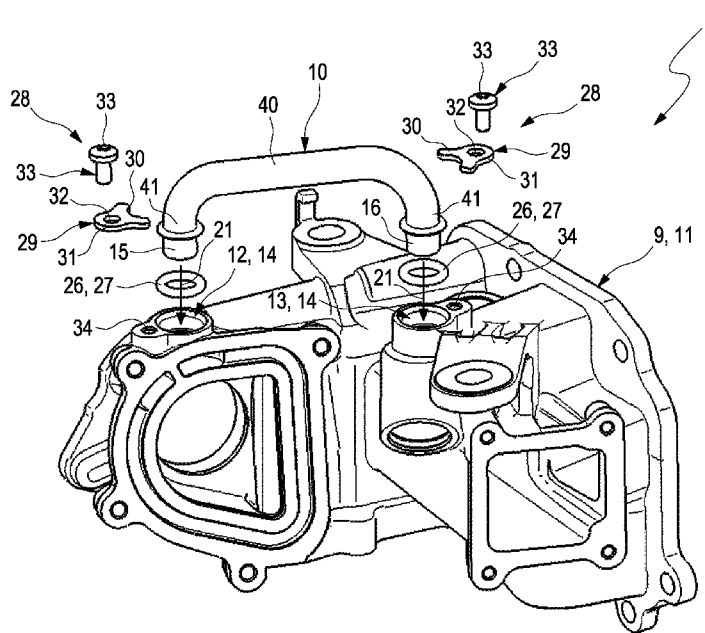


Fig. 5

(57) **Abstract:** The present invention relates to an exhaust gas cooler (1) having a cooler housing (9), through which an exhaust gas path (7) and a cooler path (8) run, with the result that the exhaust gas is cooled during operation, the exhaust gas cooler (1) having a pipe body (10) which is arranged outside the cooler housing (9) and is received by way of pipe ends (15, 16) in associated receptacles (12, 13) of the cooler housing (9). A simplified construction and a simplified assembly of the exhaust gas cooler (1) are achieved by virtue of the fact that at least one of the receptacles (12, 13) has a step (17), whereas the associated pipe end (15, 16) has a widened portion (18), a seal (26) being arranged between the widened portion (18) and the step (17), which seal (26) is compressed by the widened portion (18) and the step (17), the pipe end (15, 16) being fixed by way of a fixing device (28) in the associated receptacle (12, 13). Furthermore, the invention relates to a method for producing an exhaust gas cooler(1)of this type.



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## **Exhaust gas cooler**

The present invention relates to an exhaust gas cooler for an internal combustion engine system. Furthermore, the invention relates to a method for producing an exhaust gas cooler of this type.

Exhaust gas which is usually discharged is produced during operation of an internal combustion engine. There is the requirement here to cool the exhaust gas which is at high temperatures after the exit from the internal combustion engine. An exhaust gas cooler is generally used in an associated internal combustion engine system for this purpose. If, in particular, the exhaust gas of the internal combustion engine is recirculated, exhaust gas coolers of this type are used in an associated exhaust gas recirculation device of the internal combustion engine system.

An exhaust gas cooler of this type can in principle have a cooler housing, through which the exhaust gas flows and through which, in addition, a coolant flows in a manner which is disconnected fluidically from the exhaust gas, with the result that cooling of the exhaust gas with the aid of the coolant occurs during operation.

In the case of many possible uses of an exhaust gas cooler of this type, in particular in an exhaust gas recirculation device, it is desirable to also partially conduct the coolant outside the cooler housing. For this purpose, a pipe body which is arranged outside the cooler housing can be used in principle, which pipe body is received on the end side in respective associated receptacles of the cooler housing, with the result that a coolant path of the coolant leads through the cooler housing and through the receptacles and the pipe body.

In practice, the production of an exhaust gas cooler of this type proves difficult on account of the different mechanical connections in the exhaust gas cooler, for example by way of interference fits and/or integrally joined connections.

The present invention is concerned with the object of specifying improved or at least alternative embodiments for an exhaust gas cooler of the type mentioned at the outset and for a method for producing an exhaust gas cooler of this type, which improved or at least alternative embodiments are distinguished, in particular, by a simplified construction and/or simplified assembly of the exhaust gas cooler.

According to the invention, said object is achieved by way of the subjects of the independent claims. Advantageous embodiments are the subject matter of the dependent claims.

The present invention is based on the general concept, in the case of an exhaust gas cooler having a cooler housing and a pipe body which is arranged outside the cooler housing, of receiving pipe ends of the pipe body in associated receptacles of the cooler housing, at least one of the pipe ends being plugged into the associated receptacle and having a widened portion which interacts with a step of the receptacle, in order to compress a seal which is arranged between the widened portion and the step, and a fixing device being used for fixing the pipe end in the receptacle. Said measures lead to a considerable simplification of the construction and the assembly of the exhaust gas cooler.

In accordance with the concept of the invention, the exhaust gas cooler has the cooler housing, through which an exhaust gas path of exhaust gas and a coolant path, disconnected fluidically from the exhaust gas path, of a coolant lead, with the result that cooling of the exhaust gas with the aid of the coolant occurs during operation, that is to say when exhaust gas flows along the exhaust gas path and

coolant flows along the coolant. The housing has a first receptacle and a second receptacle, an associated pipe end of the pipe body being received in the respective receptacle. The pipe body is otherwise arranged outside the cooler housing. Here, the coolant path leads through the receptacles and the pipe body, with the result that the pipe body connects the receptacles to one another fluidically. At least one of the receptacles, advantageously the respective receptacle, has a step, whereas the associated pipe end has a widened portion and is plugged into the receptacle. In addition, a seal is arranged between the step and the widened portion, a fixing device fixing the pipe end in the associated receptacle and loading the widened portion in the direction of the step mechanically in such a way that the seal is compressed between the widened portion and the step.

The step is expediently configured in such a way that the receptacle has a surface which runs transversely with respect to the plug-in direction on account of the step. Here, the seal is arranged between said surface and the widened portion of the pipe body. On account of the step, the receptacle therefore has a first diameter in an outer section in a plug-in direction of the associated pipe end into the receptacle and a second diameter in an inner section which follows the outer section, the second diameter being smaller than the first diameter.

The respective recess can in principle be of any desired configuration. In particular, the respective recess can be configured as a bore. This allows the recess to be produced in a simplified manner. In the case of a cooler housing of solid configuration, in particular, the recesses can be introduced into the cooler housing in a simplified and precise manner in this way.

The cooler housing can in principle be of any desired configuration as long as the corresponding paths lead through the cooler housing and the cooler housing has

the receptacles. It is conceivable, in particular, to configure the cooler housing as a diffuser of an associated exhaust gas recirculation device.

The exhaust gas cooler is advantageously used in an internal combustion engine system which, in addition to the exhaust gas cooler, has an internal combustion engine, from which the exhaust gas comes which is cooled by the exhaust gas cooler.

The exhaust gas cooler can be used, in particular, in an exhaust gas recirculation device, by way of which exhaust gas which comes from the internal combustion engine is recirculated to the internal combustion engine. The exhaust gas recirculation device is therefore, in particular, a constituent part of an internal combustion engine system.

The step and/or the widened portion are/is advantageously of closed configuration in a circumferential direction. This allows simplified assembly of the exhaust gas cooler and/or homogeneous compression of the seal and therefore an improved tightness of the exhaust gas cooler.

Embodiments prove to be advantageous, in the case of which the step is arranged offset toward the inside with regard to an outer opening of the receptacle, which outer opening delimits the receptacle on the outer side, or in the plug-in direction of the associated pipe end, and is therefore configured as an inner step. In this way, the seal is arranged within the receptacle and is therefore protected in an improved manner. Said measure leads, furthermore, to it being possible for the pipe end to be plugged into the associated receptacle in a more simplified and precise manner. The seal can also be therefore compressed in a simplified manner.

The seal is preferably smaller transversely with respect to the plug-in direction than the receptacle, with the result that the seal is compressed transversely with respect to the plug-in direction between the outer section of the receptacle and the pipe end. This improves the tightness of the exhaust gas cooler and leads to fixing of the pipe end in the receptacle transversely with respect to the plug-in direction, the fixing being resilient and elastic in the case of an elastic configuration of the seal.

Embodiments are advantageous, in which a housing edge of the cooler housing, which housing edge delimits the outer opening of the receptacle, is of chamfered, in particular rounded, configuration. In this way, damage of the seal is prevented or at least reduced during the arrangement of the seal between the step and the widened portion of the pipe end, in particular during the insertion of the seal into the receptacle.

In principle, the widened portion of the respective pipe end can be realized in any desired manner. In particular, the widened portion can be a bead which is of circumferential configuration. In this way, more homogeneous compression of the seal and/or simplified plugging of the pipe end into the receptacle can be realized.

Embodiments prove advantageous, in which an end section of the pipe body, which end section follows the widened portion of the pipe end in the plug-in direction, is arranged in the inner section of the associated receptacle and has an external diameter which is such that movements of the pipe end transversely with respect to the plug-in direction are prevented or at least reduced. For this purpose, the external diameter of the end section can correspond substantially to the second diameter of the inner section.

It is conceivable in principle to provide a common fixing device for the two pipe ends, in particular for the two widened portions, which common fixing device fixes the two pipe ends in the associated receptacle.

Embodiments are advantageous, in which an associated fixing device is provided for the respective pipe end and therefore for the respective widened portion. In this way, the exhaust gas cooler can be assembled in a simplified manner.

The respective fixing device can in principle be of any desired configuration.

Embodiments are preferred, in which the fixing device has a plate which is separate from the pipe body and from the cooler housing and is arranged on that side of the associated widened portion which faces away from the step. Here, the plate is attached to the housing in such a way that it fixes the pipe end on the cooler housing and loads the widened portion in the direction of the step, with the result that the seal is compressed between the widened portion and the step. The outer-side arrangement of the plate makes a considerable simplification of the assembly of the exhaust gas cooler possible. In addition, reliable fixing of the pipe end on the cooler housing takes place in a simple way as a result.

Embodiments are advantageous, in which the plate has a U-shaped handle section which reaches around the pipe end and is arranged on that side of the widened portion which faces away from the step. It is therefore possible to push the plate onto the pipe body in a simple way, in particular in the region of the widened portion, with the result that a further simplification of the assembly of the exhaust gas cooler occurs.

In principle, the plate can be attached permanently to the cooler housing.



Embodiments are advantageous, in which the plate is attached releasably to the cooler housing. In this way, both assembly and dismantling of the exhaust gas cooler are possible in a simplified manner. The releasable attachment of the plate to the cooler housing is realized, for example, in a positively locking and/or non-positive manner.

Advantageous embodiments provide a fixing device of this type which has a screw which is screwed into the cooler housing, a screw head of the screw being arranged on that side of the plate which faces away from the cooler housing, and therefore loading the plate in the direction of the cooler housing. At the same time, a fixing device of this type makes simplified and reliable fixing of the plate on the cooler housing and therefore of the associated pipe end in the receptacle possible.

If the plate has a U-shaped handle section, it can be provided that the plate additionally has a fixing section with a recess for guiding through the screw, the screw head acting on the fixing section, in particular lying on it.

The respective seal can in principle be of any desired configuration.

Embodiments prove advantageous, in which the seal is configured as an annular seal. An improved sealing action and simplified assembly of the exhaust gas cooler can therefore be realized.

The pipe body can have any desired course between the two pipe ends. It is conceivable, in particular, that the pipe body has a main section, from which the two pipe ends project.

It is advantageous here if the two pipe ends have the same orientation, in particular project from the main section with an identical orientation, in such a way that they can be received, in particular plugged, jointly in the respective associated

receptacle. The assembly of the exhaust gas cooler is therefore simplified considerably.

It goes without saying that, in addition to the exhaust gas cooler, a method for producing the exhaust gas cooler also belongs to the scope of this invention.

In the case of the method, the associated seal is inserted into at least one of the receptacles, with the result that the seal lies on the step. Subsequently, the associated pipe end is plugged into the receptacle, with the result that the seal is arranged between the step and the widened portion. Following this, the pipe end is fixed by way of the fixing device in the receptacle, with the result that the widened portion is loaded in the direction of the step and the seal is compressed between the widened portion and the step.

In principle, one of the pipe ends can be introduced into the associated receptacle, in particular can be plugged in, and can subsequently be fixed by way of the fixing device. It is preferred if the two pipe ends are plugged into the respective associated receptacle and are subsequently fixed therein by means of in each case one associated fixing device.

It is advantageous here if the associated seal has been previously inserted into the respective receptacle, the two pipe ends are subsequently plugged into the respective associated receptacle, and the respective pipe end is then fixed in the receptacle by way of an associated fixing device.

Further important features and advantages of the invention result from the subclaims, from the drawings, and from the associated description of the figures using the drawings.

It goes without saying that the features which are mentioned in the preceding text and are still to be described in the following text can be used not only in the respective specified combination, but rather also in other combinations or on their own, without departing from the scope of the present invention.

Preferred exemplary embodiments of the invention are shown in the drawings and will be described in greater detail in the following description, identical designations relating to identical or similar or functionally identical components.

In the drawings, in each case diagrammatically:

- Figure 1 shows a greatly simplified, circuit diagram-like illustration of an internal combustion engine system having an exhaust gas cooler,
- Figure 2 shows an isometric view of a part of the exhaust gas cooler having a cooler housing and a pipe body,
- Figure 3 shows a section through the exhaust gas cooler in the region of the pipe body,
- Figure 4 shows an enlarged illustration of the part which is denoted by IV from figure 3, and
- Figure 5 shows the view from figure 2 in an exploded illustration.

An exhaust gas cooler 1, as shown in figure 1, is usually a constituent part of an internal combustion engine system 2 which is shown in a greatly simplified and circuit diagram-like manner in figure 1. A constituent part of the internal combustion engine system 2 is, furthermore, an internal combustion engine 3 which is supplied with fresh air via a fresh air system 4, exhaust gas being

produced during operation of the internal combustion engine 3, which exhaust gas is discharged with the aid of an exhaust gas system 5. In the example which is shown, the exhaust gas cooler 1 is a constituent part of an exhaust gas recirculation device 6, by way of which the exhaust gas is fed to the internal combustion engine 3. For this purpose, the exhaust gas recirculation device 6 branches off from the exhaust gas system 5 and opens into the fresh air system 4. Cooling of the exhaust gas takes place by way of the exhaust gas cooler 1, an exhaust gas path 7 of the exhaust gas leading through the cooler 1. In addition, a coolant path 8, disconnected fluidically from the exhaust gas path 7, of a coolant leads through the exhaust gas cooler 1, with the result that the coolant cools the exhaust gas during operation. The coolant can be one which circulates in a coolant circuit (not shown). The coolant can likewise be air.

Figure 2 shows an isometric view of the exhaust gas cooler 1 in the region of a cooler housing 9 and a pipe body 10 which is arranged outside the cooler housing 9. Figure 3 shows a section through the exhaust gas cooler 1 in the region of the pipe body 10, whereas figure 4 shows an enlarged view of the region which is denoted by IV in figure 3. Figure 5 shows an exploded illustration of the view which is shown in figure 2.

Both the exhaust gas path 7 and the coolant path 8 run through the cooler housing 9, with the result that a heat exchange between the coolant and the exhaust gas and therefore cooling of the exhaust gas occur in the cooler housing 9. In the example which is shown, the cooler housing 9 is configured as a diffuser 11. For the pipe body 10, the cooler housing 9 has a first receptacle 12 and a second receptacle 13 which are made in each case as a bore 14 in the cooler housing 9. An associated pipe end 15, 16 of the pipe body 10 is received in the respective receptacle 12, 13. That is to say, a first pipe end 15 of the pipe body 10 is received in the first receptacle 12, and a second pipe end 16 of the pipe body 10 is received in the second receptacle 13. At least one of the receptacles 12, 13 is of stepped

configuration, that is to say has a step 17, whereas the associated pipe end 15, 16 has a widened portion 18. In the example which is shown, the two receptacles 12, 13 have an associated step 17, and the two pipe ends 15, 16 have a widened portion 18. The respective step 17 is arranged offset toward the inside with regard to an outer opening 19 or external opening 19 of the receptacle 12, 13, which outer opening 19 delimits the associated receptacle 12, 13 on the outer side, and is therefore configured as an inner step 20. That is to say, the inner step 20 is arranged behind the outer opening 19 in a plug-in direction 21 of the associated pipe end 15, 16. As a result of the step 17, in particular the inner step 20, as can be gathered from figure 4, in particular, the respective receptacle 12 has, in the plug-in direction 21, an outer section 22 with a first diameter 23 and an inner section 24 which follows the outer section 22 and has a second diameter 25, the second diameter 25 being smaller than the first diameter 23. A seal 26 is arranged between the widened portion 18 of the respective pipe end 15, 16 and the step 17 of the associated receptacle 12, 13, which seal 26 is configured as an annular seal 27 in the example which is shown. The seal 26 lies on the step 17 and is loaded by way of the widened portion 18 in the direction of the step 17, with the result that the seal 26 is compressed between the widened portion 18 and the step 17, in particular in the plug-in direction 21. For this purpose and in order to fix the respective pipe end 15, 16 in the associated receptacle 12, 13, the exhaust gas cooler 1 has a respective associated fixing device 28.

Furthermore, it can be gathered from figure 4, in particular, that the seal 26 is larger transversely with respect to the plug-in direction 21 than the first diameter 23 of the outer section 22 of the associated receptacle 12, 13, with the result that the seal 26 is compressed between the associated pipe end 15, 16 and the associated outer section 22 transversely with respect to the plug-in direction 21.

In the example which is shown, the respective fixing device 28 has a plate 29 with a U-shaped handle section 30 and a fixing section 31 which adjoins the latter. The

handle section 30 reaches around the pipe body 10 on that side of the widened portion 18 which faces away from the associated receptacle 12, 13 and the associated step 17, and lies on the widened portion 18. The fixing section 31 has a through opening 32, through which a screw 33 of the fixing device 28 is guided and is screwed into an associated internal thread 34 of the cooler housing 9. The screw 33 has a screw head 35 which lies on that side of the fixing section 31 which faces away from the cooler housing 9, and therefore loads the plate 29 in the direction of the widened portion 18 and loads the widened portion 18 in the direction of the step 17, with the result that the seal 26 is compressed. Therefore, the plate 29 is additionally fixed on the cooler housing 9, and the pipe end 15, 16 is fixed in the associated receptacle 12, 13.

As can be gathered from figures 2 and 5, in particular, the respective widened portion 18 is configured as a circumferential bead 36.

It can be gathered from figure 4 that a housing edge 37 which delimits the outer opening 19 of the respective receptacle 12, 13 is of chamfered, in particular rounded, configuration. As a result, damage is prevented or at least reduced during the insertion of the seal 26 into the associated receptacle 12, 13.

It can be gathered from figures 3 and 4 that an end section 38 of the associated pipe end 15, 16 is plugged into the inner section 24 of the associated receptacle 12, 13 behind the widened portion 18 in the plug-in direction 21. It can be seen that an external diameter 39 of the end section 38 corresponds substantially to the second diameter 25, with the result that movements of the associated pipe end 15, 16 transversely with respect to the plug-in direction 21 are prevented or at least reduced.

A simplified construction and simplified assembly of the exhaust gas cooler 1 are realized by way of the construction which is shown. Here, centering of the pipe

end 15, 16 in the associated receptacle 12, 13 takes place at the same time by way of the respective pipe end 15, 16 being plugged into the associated receptacle 12, 13.

As can be gathered from all the figures, the pipe body 10 has a main section 40, from which two end sections 41 project on opposite sides, the respective end section 41 comprising one of the pipe ends 15, 16. The two end sections 41 and therefore the two pipe ends 15, 16 have the same orientation and run substantially in parallel. Therefore, the plug-in directions 21 of the two pipe ends 15, 16 run in parallel and with an identical orientation, with the result that the two pipe ends 15, 16 can be plugged jointly into the respective associated receptacle 12, 13. This leads to a further simplification of the assembly of the exhaust gas cooler 1.

In accordance with the exploded illustration in figure 5, the assembly of the exhaust gas cooler 1 can take place in such a way that first of all the respective seal 26 is inserted into the associated receptacle 12, 13. Subsequently, the two pipe ends 15, 16 are plugged into the respective associated receptacle 12, 13, with the result that the seal 26 is arranged between the widened portion 18 and the step 17. Afterward, the attachment of the respective fixing device 28 by way of the attachment of the respective plate 29 to the associated pipe end 15, 16 takes place in such a way that the handle section 30 reaches around the pipe body 10 on that side of the associated widened portion 18 which faces away from the associated step 17, and the through opening 32 is flush with the associated internal thread 34. Afterward, the screw 33 is screwed into the associated internal thread 32.

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## Claims

1. An exhaust gas cooler (1) for an internal combustion engine system (2),
  - having a cooler housing (9), through which an exhaust gas path (7) of exhaust gas and a coolant path (8), disconnected fluidically from the exhaust gas path (7), of a coolant lead, in such a way that the coolant cools the exhaust gas during operation,
  - the cooler housing (9) having a first receptacle (12) and a second receptacle (13), in which in each case one associated pipe end (15, 16) of a pipe body (10) which is arranged outside the cooler housing (9) is received,
  - the coolant path (8) leading through the receptacles (12, 13) and the pipe body (10),
  - at least one of the receptacles (12, 13) having a step (17), and the associated pipe end (10) having a widened portion (18) and being plugged into the receptacle (12, 13),
  - having a seal (26) which is arranged between the step (17) and the widened portion (18),
  - having a fixing device (28) which fixes the pipe end (15, 16) in the associated receptacle (12, 13) and which loads the widened portion (18) in the direction of the step (17) in such a way that the seal (26) is compressed between the widened portion (18) and the step (17).
  
2. The exhaust gas cooler as claimed in claim 1,  
characterized  
in that the step (17) is configured as an inner step (20) which is arranged



offset toward the inside with regard to an outer opening (19) of the receptacle (12, 13), which outer opening (19) delimits the associated receptacle (12, 13) on the outer side.

3. The exhaust gas cooler as claimed in claim 1 or 2, characterized  
in that an outer opening (19) of the receptacle (12, 13), which outer opening (19) delimits the receptacle (12, 13) on the outer side, is delimited by a housing edge (37) of the cooler housing (9), which housing edge (37) is of chamfered, in particular rounded, configuration.
4. The exhaust gas cooler as claimed in one of claims 1 to 3, characterized  
in that the widened portion (18) is configured as a circumferential bead (36).
5. The exhaust gas cooler as claimed in one of claims 1 to 4, characterized
  - in that, on account of the step (17) in a plug-in direction (21) of the associated pipe end (15, 16) into the receptacle (12, 13), the receptacle (12, 13) has an outer section (22) with a first diameter (23) and adjacently an inner section (24) with a second diameter (25) which is smaller than the first diameter (23),
  - in that an end section (38) of the pipe body (10), which end section (38) follows the widened portion (18) of the pipe end (15, 16) in the plug-in direction (21), is arranged in the inner section (24) and has an external diameter (39) which corresponds with the second diameter (25).
6. The exhaust gas cooler as claimed in one of claims 1 to 5, characterized  
in that the fixing device (28) has a plate (29) which is separate from the pipe

body (10) and from the cooler housing (9), is arranged on that side of the widened portion (18) which faces away from the step (17), and is attached to the cooler housing (9) in such a way that the plate (29) fixes the associated pipe end (15, 16) on the cooler housing (9) and loads the widened portion (18) in the direction of the step (17).

7. The exhaust gas cooler as claimed in claim 6, characterized in that the plate (29) has a U-shaped handle section (30) which reaches around the pipe end (15) and is arranged on that side of the widened portion (18) which faces away from the step (17).
8. The exhaust gas cooler as claimed in claim 6 or 7, characterized in that the plate (29) is attached releasably to the cooler housing (9).
9. The exhaust gas cooler as claimed in one of claims 6 to 8, characterized in that the fixing device (28) has a screw (33) which is screwed into the cooler housing (9), a screw head (35) of the screw (33) being arranged on that side of the plate (29) which faces away from the cooler housing (9) and loading the plate (29) in the direction of the widened portion (18).
10. The exhaust gas cooler as claimed in one of claims 1 to 9, characterized in that the seal (26) is configured as an annular seal (27).
11. The exhaust gas cooler as claimed in one of claims 1 to 10, characterized in that the pipe body (10) has a main section (40) and two end sections (41)

which project from the main section (40), the respective end section (41) having one of the pipe ends (15, 16).

12. A method for producing an exhaust gas cooler (1) as claimed in one of claims 1 to 11,
  - the associated seal (26) being inserted into at least one of the receptacles (12, 13),
  - the associated pipe end (15, 16) being plugged into the receptacle (12, 13) in such a way that the seal (26) is arranged between the step (17) and the widened portion (18),
  - the pipe end (15, 16) being fixed by way of the fixing device (28) in the associated receptacle (12, 13) in such a way that the widened portion (18) is loaded in the direction of the step (17) and the seal (26) is compressed between the widened portion (18) and the step (17).
  
13. The method as claimed in claim 12, characterized
  - in that the associated seal (26) is inserted into the respective receptacle (12, 13),
  - in that both pipe ends (15, 16) are plugged into the respective associated receptacle (12, 13), and
  - in that the respective pipe end (15, 16) is subsequently fixed by way of an associated fixing device (28) in the associated receptacle (15, 16).

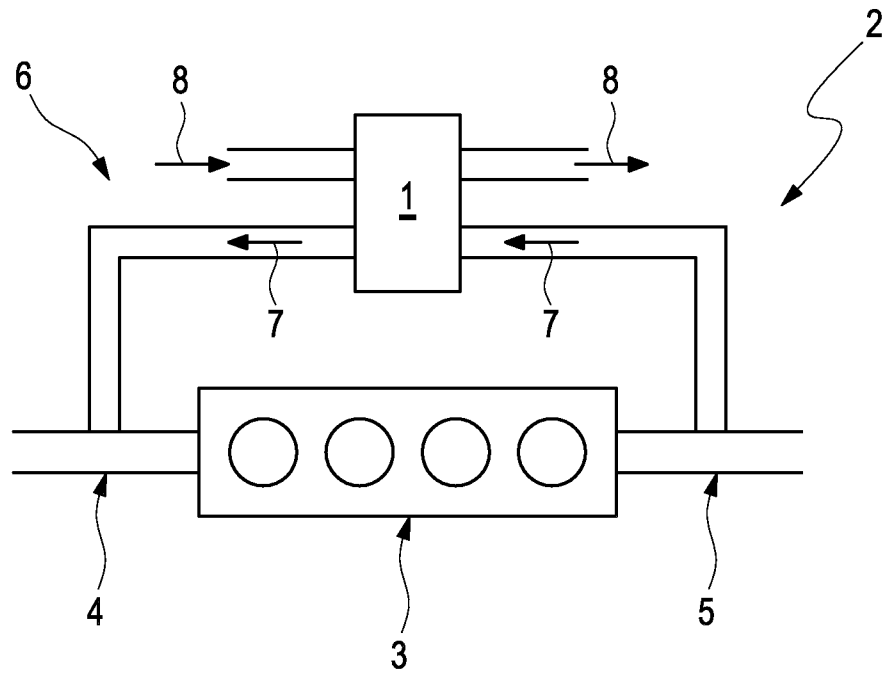


Fig. 1

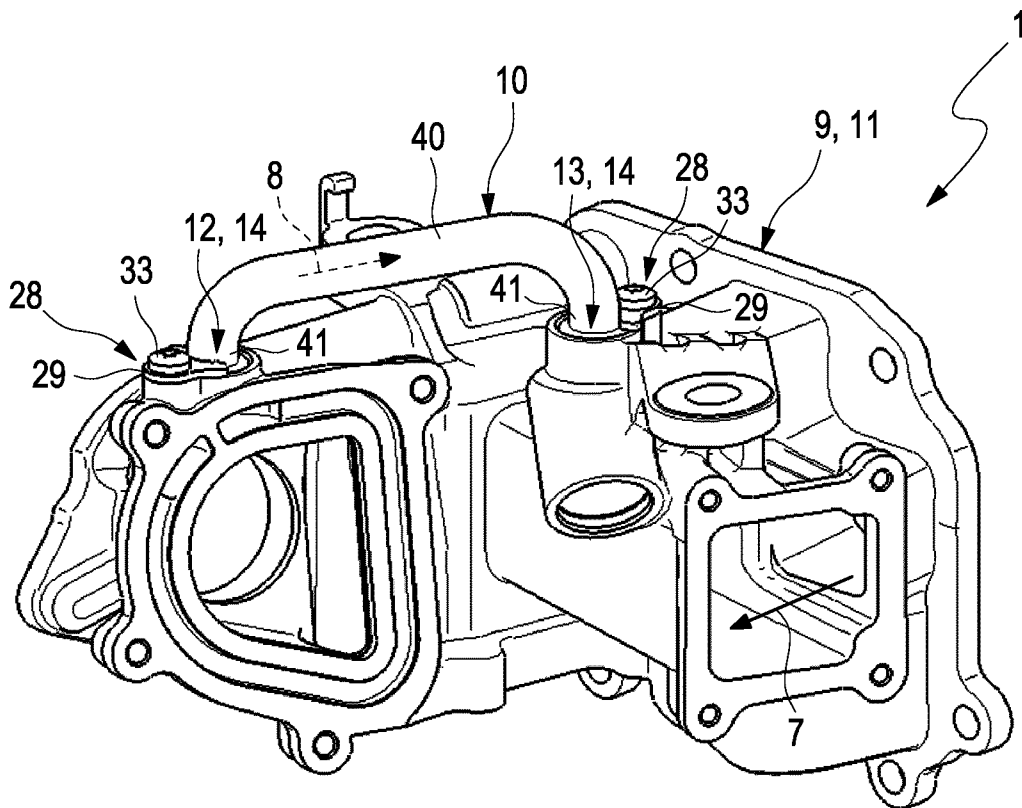


Fig. 2

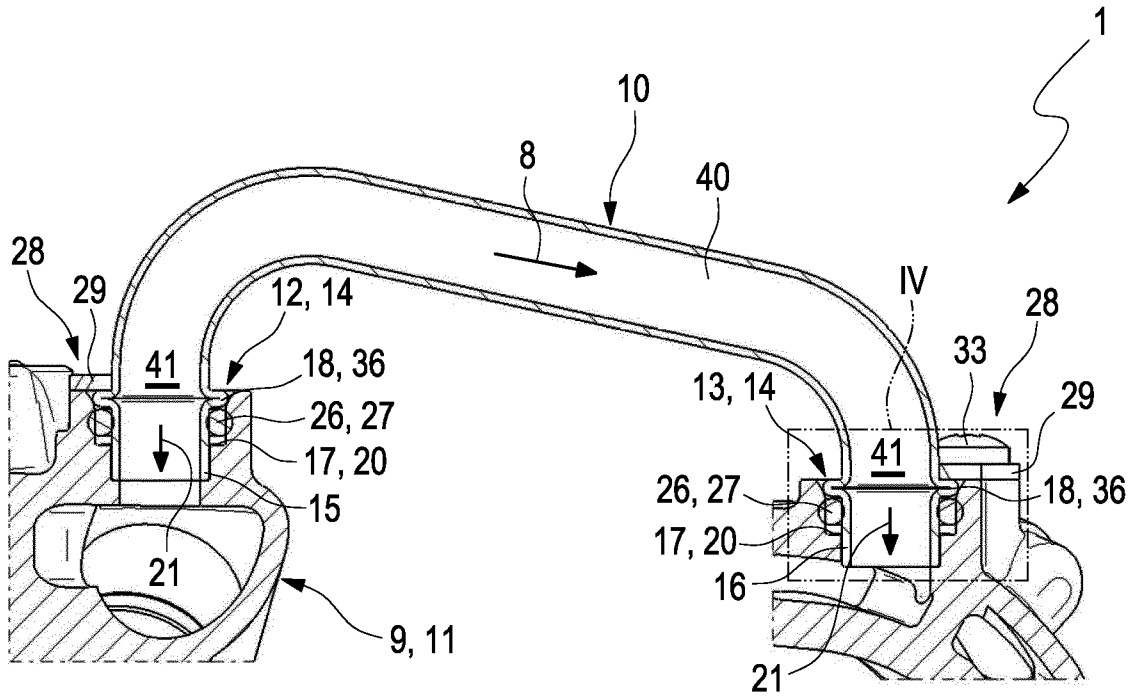


Fig. 3

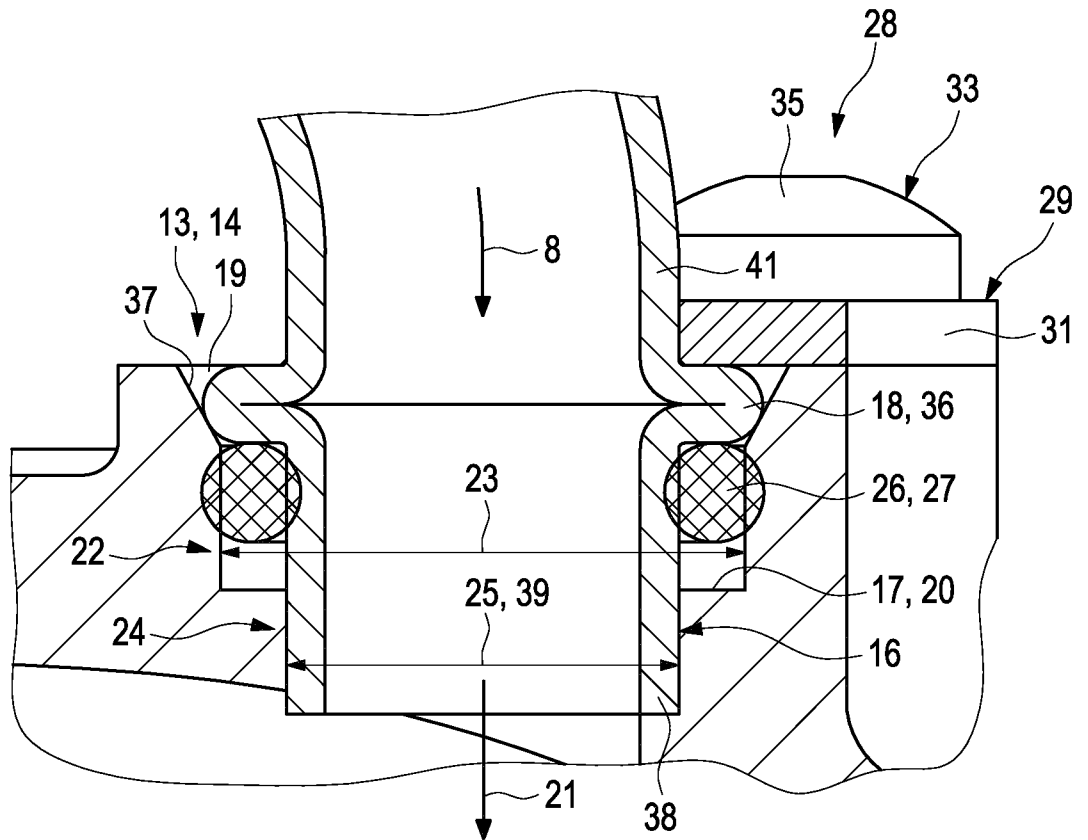


Fig. 4

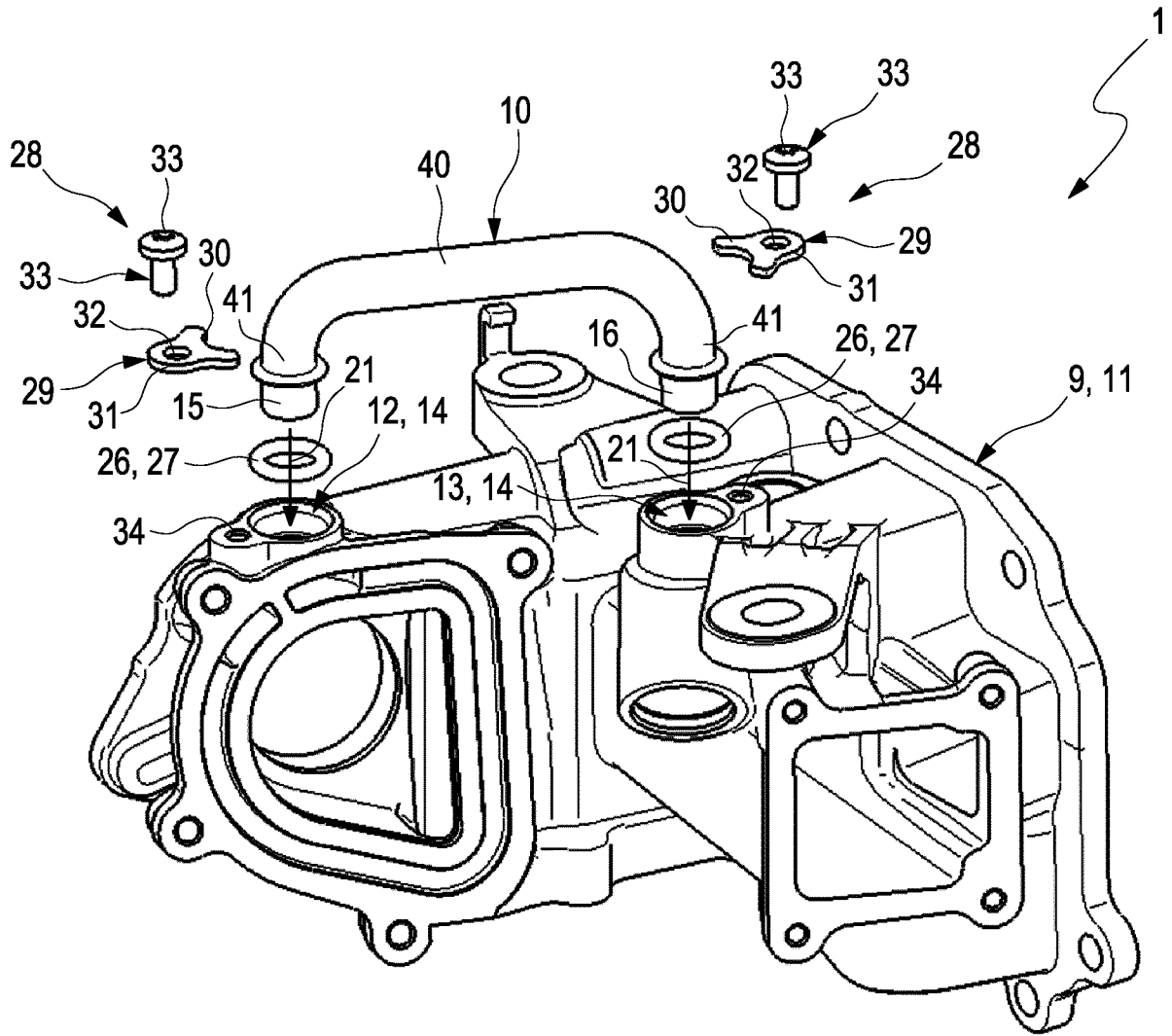


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2019/055582

A. CLASSIFICATION OF SUBJECT MATTER					
INV.	F02M26/32	F02M26/22	F02M26/12	F02M26/11	F01N3/04
	F02M26/30	F01P11/04	F28F9/02	F16L41/08	
ADD.					
According to International Patent Classification (IPC) or to both national classification and IPC					

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols) F02M F01N F01P F28F F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2010 014845 A1 (PIERBURG GMBH [DE]) 13 October 2011 (2011-10-13)	1-5, 10-13
Y	paragraphs [0001], [0005], [0028], [0029]; figures 1, 2	6-9
Y	----- US 2005/023827 A1 (WALTERSCHEID WADE J [US] ET AL) 3 February 2005 (2005-02-03)	6,8,9
A	paragraphs [0003], [0038] - [0049]; figures 1-4	1-5, 10-13
Y	----- US 5 271 460 A (O'BRIEN STEPHEN W [US]) 21 December 1993 (1993-12-21)	6-9
A	column 2, line 45 - column 3, line 55; figures 1, 3-5	1-5, 10-13
Y	----- US 2006/131874 A1 (FRANK LUCAS [US] ET AL) 22 June 2006 (2006-06-22)	6-9
A	paragraphs [0014] - [0019]; figures 1-3	1-5, 10-13
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Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search  23 October 2019	Date of mailing of the international search report  04/11/2019
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Karstens, Thede
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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No

PCT/EP2019/055582

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 2378092 A2	19-10-2011
		ES 2495865 T3	17-09-2014
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