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(54) Exhaust gas recirculation system

(57) In one aspect an exhaust gas recirculation system may be provided for an internal combustion engine. The engine may have an air intake system with an upstream part and a downstream part. The EGR-system may include an EGR-module that may be mountable as a single unit in the air intake system between the upstream part and the downstream part. The EGR-module may include an air intake channel having an air intake opening and a mixture outlet opening. The EGR-module may include an exhaust gas intake opening and a mixing assembly that may be configured for mixing exhaust gas introduced in the exhaust gas intake opening and air introduced in the air intake channel via the air intake opening. In another aspect a method for exhaust gas recirculation in an internal combustion engine may be provided.

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Description

Technical Field

[0001] The disclosure relates to an exhaust gas recirculation system for an internal combustion engine.

Background

[0002] Exhaust gas recirculation (EGR) is a technique commonly used for controlling the generation of undesirable pollutant gases and particulate matter in the operation of internal combustion engines, such as internal combustion engines provided with a turbocharger. It is known to remove exhaust gas to be recirculated upstream of an exhaust gas driven turbine associated with the turbocharger. In many EGR-applications, the exhaust gas is diverted directly from the exhaust manifold. Likewise, the recirculated exhaust gas may be reintroduced to the intake air stream downstream of a compressor of the turbocharger and an air-to-air aftercooler. For example, in many EGR-applications the recirculated exhaust gas is reintroduced to the intake manifold.
EP-A-0 869 275 relates to such an EGR-system.

[0003] However, further improvement is desired. The mixing of intake air and recirculated exhaust air may need improvement. Presently, the various components necessary for providing an internal combustion engine with an EGR-system are separate. Consequently, the components often need their own control connection and need to be assembled separately. Packaging of the various EGR-components in the limited space around the engine is frequently a challenge. These space or packaging challenges may even result in a less than optimal positioning of the various components in the air intake system and the EGR-passage which may lead to a less than optimal performance. When mounting the components in the air intake system and the exhaust gas system each component may have its own interfaces with those systems. Each of these interfaces may be a source of leakage.

[0004] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior EGR-systems

Summary of the Invention

[0005] In one aspect an exhaust gas recirculation system may be provided for an internal combustion engine. The engine may have an air intake system with an upstream part and a downstream part. The EGR-system may include an EGR-module that may be mountable as a single unit in the air intake system between the upstream part and the downstream part. The EGR-module may include an air intake channel having an air intake opening and a mixture outlet opening. The air intake opening may be connectable to the upstream part. The mixture outlet opening may be connectable to the downstream part. The EGR-module may include an exhaust gas intake opening and a mixing assembly that may be configured for mixing exhaust gas introduced in the exhaust gas intake opening and air introduced in the air intake channel via the air intake opening.

[0006] In another aspect a method for exhaust gas recirculation in an internal combustion engine having an air intake system with an upstream part and a downstream part may be provided. The method may include providing an EGR-module in the air intake system between the upstream part and the downstream part. The method may further include supplying intake air to an EGR-module, supplying exhaust gas to the EGR-module, mixing the intake air and the exhaust gas in the EGR-module and discharging the mixture from the EGR-module into the downstream part.

[0007] In another aspect an internal combustion engine with such an exhaust gas recirculation system may be provided.

Brief Description of the Drawings

[0008] Fig. 1 is a schematic view of an internal combustion engine with an EGR-system;

[0009] Fig. 2 is a perspective view of a first exemplary embodiment of an EGR-module;

[0010] Fig. 3 is a perspective transverse cross section of the embodiment of Fig. 2;

[0011] Fig. 4 is a perspective longitudinal cross section of the embodiment of Fig. 2;

[0012] Fig. 5 is a perspective view of a second exemplary embodiment; and

Detailed Description

[0013] Fig. 1 schematically shows an internal combustion engine having an engine block 12. The internal combustion engine may have an air intake system and an exhaust system. The air intake system may include an air intake passage 14, 16, 18, 20. The air intake passage may include a compressor 22, a charged air cooler 24, an EGR-module 26 and an intake manifold 28. The exhaust system may include an exhaust passage 30, 32. The exhaust passage may include an exhaust manifold 34 and a turbine 36. The compressor 22 may be connected to the turbine 36 via a turbocharger shaft 38. In another embodiment the compressor 14 may also be driven by another element, for example, a shaft that is driven by an electric motor or by the internal combustion engine 12 via a transmission. In such a case the turbine 36 may not be present. The air intake system may include various additional components. On the other hand, the air intake system may also not include air cooler 24 or compressor 22. The exhaust system may also include various additional components, for example, an exhaust after-treatment system. The exhaust after-treatment system may, for example, include a diesel particulate filter and a diesel oxygen catalyst.

[0014] An exhaust recirculation passage 40 may be

present. An inlet 42 of the exhaust recirculation passage 26 may emanate from the exhaust manifold 34. An outlet of the exhaust gas recirculation passage 40 may emanate in an exhaust gas intake opening 44 of the EGR-module 26. the exhaust recirculation passage 40 may include an EGR-cooler 46.

[0015] The EGR-module 26 may be mountable as a single unit in the air intake system between an upstream part 18 of the air intake passage and a downstream part 20 of the air intake passage of the air intake system. The EGR-module 26 may have an air intake channel 48. The air intake channel 48 may have an air intake opening 50 and a mixture outlet opening 52. The air intake opening 50 may be connectable to the upstream part 18 of the air intake passage of the air intake system. The mixture outlet opening 52 may be connectable to the downstream part 20 of the air intake passage of the air intake system. As stated before, the EGR-module 26 may also have an exhaust gas intake opening 44 that may be connected to an outlet of the exhaust recirculation passage 40. The EGR-module 26 may include an EGR-valve 54 that may control the amount of exhaust gas that may be recirculated. The EGR-module 26 may also include at least one non-return valve 56 that prevents that intake air present in air intake channel 48 flows into the EGR-passage 40. The non-return valves 40 may be of any type. Reed valves are particularly suitable because of the short response time and the low mass of the valve membranes of a reed valve. The EGR-valve 54 and the non-return valves 56 may be in an exhaust gas passage 64 in the EGR-module 26. The air intake channel 48 of the EGR-module 26 may include a throttle valve 58 for controlling the amount of intake air that is passing the air intake channel 48 and is delivered to the downstream part 20 of the air intake system. The EGR-module 26 may also include a mixing assembly 60 that may be configured for mixing exhaust gas introduced in the exhaust gas intake opening 44 and air introduced in the air intake channel 48 via the air intake opening 50. The mixing assembly 60 may be downstream of the non-return valves in the exhaust gas passage 64 of the EGR-module 26. The mixing assembly 60 may be accommodated in a mixing body 62 that may, for example, be a casting. The mixing assembly will be described in more detail with reference to the embodiments of EGR-modules shown in Figs. 2-5.

[0016] Figs. 2-4 show a first embodiment of an EGR-module 126. The EGR-module 126 may include a mixing body 162 that may at least partly define the air intake channel 148. The mixing body 162 may have a throttle valve body flange 166, an EGR-valve body flange 168 and an outlet flange 184 adjacent the mixture outlet opening 152. With the flange 184 a downstream part of the intake system may be connected. The EGR-module 126 may also include a throttle valve body 170 that may be connected to the throttle valve body flange 166 of the mixing body 162. The throttle valve body 170 may include a throttle valve motor 178. The throttle valve may include a valve flap 180 and a valve shaft 182 connected with the valve flap 180 for regulating the position of the valve flap 180 relative to the air intake channel 148. The valve shaft 182 may extend perpendicular to a central axis of the air intake channel 148 at that position. The valve shaft 182 may be driven by the throttle valve motor 178. This may be effected directly or via a transmission. Other types of throttle valves are feasible as well.

[0017] An EGR-valve body 172 may be connected to the EGR-valve body flange 168. The EGR-valve body 172 may have a motor flange 174. An EGR-valve motor 176 may be connected to the motor flange 174 of the EGR-valve body 172. The EGR-valve body 172 may include an EGR-valve member 186 for regulating the amount of exhaust gas that may pass the EGR-module 126. The EGR-valve body 172 may also include an exhaust gas intake opening 144 that may be surrounded by an EGR-passage connecting flange 145 and may be the upstream end of the exhaust gas passage 164 in the EGR-module 126.

[0018] In one embodiment, the non-return valve 140 may have the form of at least one reed valve 140. The at least one reed valve 140 may have a reed valve body 190 with a reed valve flange 192 that may be positioned between the EGR-valve body 172 and the mixing body 162. Thus, the non-return valve may be clamped in between the EGR-valve body 172 and the mixing body 162. This is clearly visible in Figs. 3 and 4. The reed valves 140 may include membranes 188 that are connected with one end to the reed valve body 190. Also other solutions to mount non-return valves 140 in the exhaust gas passage 164 are feasible.

[0019] The mixing assembly 140 may include at least one mixing tube 194 having a mixing tube wall with a plurality of mixing tube ports 196. The at least one mixing tube 194 may have a central axis that extends parallel to the mixing tube wall. The air intake channel 148 that is at least partly bounded by the mixing body 162, may have a central axis that extends parallel to a wall bounding the air intake channel 148. The central axis of the mixing tube 194 may be perpendicular to the central axis of the air intake channel 148 adjacent the mixing tube 194 so that, in use, the flow of air in the air intake channel adjacent the mixing tube 194 is substantially perpendicular to the exhaust gas leaving the mixing tube ports 196. The valve shaft 182 of the throttle valve 150 has a longitudinal axis that may be parallel to the central axis of the at least one mixing tube 194. The mixing tube ports 196 may be orientated relative to the valve flap 180 of the throttle valve 150 so, that, when the valve flap 180 is in the entirely opened position (as shown in Fig. 4) exhaust gas leaving the mixing tube ports 196 may have a flow direction perpendicular to the main flow direction of the intake air adjacent the mixing tube 194.

[0020] The mixing tube 194 may have a mixing tube flange 198 and the mixing body 162 may have a mixing tube mounting surface 200 for accommodating the mixing tube flange 198. The mixing body 162 may have a circlip groove 202 adjacent the mixing tube mounting sur-

face 200. Thus the mixing tube 192 may be connected to the mixing body 162 by a circlip 201. The circlip 201 may be a flexible ring member with an interruption in the ring member, the interruption being bounded by two ends of the ring. The circumference of the ring member may be diminished by flexing the ends of the ring adjacent the interruption towards each other. Other mixing assemblies are also feasible. Any elements that introduce turbulence in the area around the mixing assembly where the intake air and the recirculated exhaust gas are brought into contact with each other may be feasible for obtaining a good mixture between the intake air and the recirculated exhaust gas. Those elements may, for example, include baffles and fixed or moveable swirl elements that may change the direction of flow of the intake air and/or the exhaust gas adjacent the mixing assembly. The mixing tube 194 may have an exhaust gas inlet adjacent the mixing tube flange 198. The other end of the mixing tube may be closed off by an end wall 195. Such an embodiment is shown in Figs. 2-4. Alternatively, the mixing tube 194 may be closed off adjacent the end that is connected with the mixing tube flange 198. In such an embodiment, the end of the mixing tube 194 remote from the mixing tube flange 198 may be open and form an exhaust gas inlet.

[0021] The EGR-module 126 may include various sensors. For example a temperature sensor 204 and a pressure sensor 206. In the embodiment shown in Figs. 2-4 those sensors are positioned near the mixture outlet opening 152 of the EGR-module 126. Also more than one temperature sensor and more than one pressure sensor may be present. Also other sensors, for example, sensors for measuring the concentration of constituents of the mixture may be present.

[0022] Fig. 5 shows a second embodiment 226 that is mounted on an engine block 212. The EGR-module may have a mixing body 162, in which a mixing assembly 160 may be accommodated. The mixing assembly 160 may include a mixing tube 194. The mixing tube in Fig. 5 may be closed off adjacent the end that is connected with the mixing tube flange 198. The end of the mixing tube 194 remote from the mixing tube flange 198 may be open and form the inlet of the mixing tube 194.

[0023] The mixing body 162 may have a throttle valve body flange 166. On the throttle valve body flange 166 a throttle valve body 170 may be mounted. The throttle valve body 170 may define the air intake opening 150 of the EGR-module 226. The air intake opening 150 may be connected to an upstream part 218 of the air intake system. The mixing assembly 160 may be connected to an exhaust gas passage 264 of the EGR-module 226. Near an upstream end of that exhaust gas passage 264 an EGR-valve body flange 168 may be provided. An EGR-valve body 172 may be connected to the EGR-valve body flange 168. The exhaust gas passage 264 of the EGR-module 226 may include non-return valve 140. In the embodiment of Fig. 5 two sets reed valves 140 are accommodated in the EGR-module 226. However, it is contemplated that a different number of reed valves is accommodated in the EGR-module. The number may depend on the amount of exhaust gas that may be recirculated. An exhaust gas recircualtion passage connecting flange 145 that may be provided on the EGR-valve body 172 and may be connected to an exhaust gas recirculation passage 240. The EGR-valve body 172 may also include an EGR-valve member 186 that may be controlled by an EGR-valve motor 176.

Industrial Applicability

[0024] An EGR-system including an EGR-module 26, 126, 226 as described may be applied in any internal combustion engine. To that end a method for exhaust gas recirculation in an internal combustion engine having an air intake system with an upstream part and a downstream part, may be provided. The method may include providing an EGR-module 26, 126, 226 in the air intake system between the upstream part 18, 218 and the downstream part 20, 220. The method may also include supplying intake air 250 to an EGR-module 26, 126, 226 and supplying exhaust gas 252 to the EGR-module 26, 126, 226. This has been indicated in Figs. 2, 5 and 6 by the arrows 250, 252. In the EGR-module 26, 126, 226, the intake air 250 and the exhaust gas 252 may be mixed. The mixture 254 may be discharged form the EGR-module 26, 126, 226 into the downstream part 20, 220 of the air intake system.

[0025] For a more elaborate description of the manner in which the EGR-system may operate reference will be made to Fig. 1 in which the engine block 12 of an internal combustion engine is shown. Exhaust gas leaving the engine block 12 via the exhaust manifold 34 and exhaust passage 30 may drive a turbine 36 of a turbocharger. The exhaust gas may leave the turbine 36 via exhaust passage 32. The exhaust gas may be subjected to aftertreatment in the exhaust system downstream of the turbine 36. The turbine 36 may drive a shaft 38 that may drive a compressor 22.

[0026] A part 252 of the exhaust gas may be recirculated via exhaust gas recirculation passage 40. That part 252 of the exhaust gas may be cooled in the EGR-cooler 46. The cooled exhaust gas may enter the EGR-module 26 via the exhaust gas intake opening 44. The amount of exhaust gas 252 taken in by the EGR-module 26 may be regulated by an EGR-valve 54 in the EGR-module 26. The exhaust gas taken in by EGR-module 26 may pass a non-return valve 56 and may then be supplied to the mixing assembly 60 that may be accommodated in the mixing body 62. The non-return valve 56 may prevent flowing back of exhaust gas 252 when the intake air pressure is higher than the exhaust gas pressure adjacent the non-return valve 56.

[0027] Intake air may enter the air intake system via air intake passage 14. Subsequently the intake air may be compressed by the compressor 22. The compressed air may flow via air intake passage 16 to air cooler 24.

From the air cooler 24, the intake air may flow via intake air passage 18 to the EGR-module 26. The EGR-module 26 has an intake air opening 50 and an air intake channel 48. The amount of intake air 250 taken in by the EGR-module 26 may be regulated by the throttle valve 58 in the EGR-module 26. The intake air 250 may also be supplied to the mixing assembly 60. At the mixing assembly 60, the exhaust gas and the intake air may mix. The mixture 254 thus obtained may leave the EGR-module 26 via mixture outlet opening 52. The mixture 254 may be supplied via the downstream part 20 of the air intake system to the intake manifold 28 and may subsequently be supplied to the combustion chambers of the internal combustion engine.

[0028] As stated before, the non-return 56 valve may be embodied as a reed valve 140 as shown in the embodiments of Figs. 2-6. The reed valve membranes 188 of the reed valves 140 may flex when the pressure upstream from the reed valve 140 is higher then the pressure downstream of reed valve 140. Such a flexing opens the reed valve 140. Because the membranes 188 are light and flex easily, reed valves 140 have a very short response time and even small pressure differences are sufficient for opening and closing the reed valves 140. Thus, the amount of exhaust gas that may be recirculated may be optimal.

[0029] The mixing of intake air 250 and exhaust gas 252 may be performed with any suitable mixing assembly. A good mixing may be obtained by supplying multiple streams of exhaust gas in an intake air stream in the EGR-module with an exhaust gas flow direction that may be substantially perpendicular to the intake air flow direction in the EGR-module at that position. Such a flow pattern may be obtained with the mixing tube 194 as shown in the first and the second embodiment shown in Figs. 3-5. The mixing tube axis and the valve shaft axis may be parallel. Such an orientation may be beneficial for the flow rate of the intake air and may also be beneficial for the mixing performance.

[0030] The position of the throttle valve 58 that may be embodied as the valve flap 180 connected to a valve shaft 182, may be controlled by the throttle valve motor 178. The throttle valve motor 178 may receive a throttle positioning signal outputted by a controller that may receive various input signals. One of the input signals for the controller may be the load to be driven by the internal combustion engine or a position of a fuel control lever that may be operated by a user.

[0031] The position of the EGR-valve 58 may be controlled by the EGR valve motor 176 and may be determined by a controller on the basis of various input signals of the controller. The input signals may also include signals obtained from the temperature sensor 204 and the pressure sensor 206 in the EGR-module 126. Also other sensors and signals available in the internal combustion engine, such as load sensors, speed sensors, injector steering signals, may be used for determining the position of the throttle valve 58, 180 and the EGR-valve 58, 186.

[0032] The EGR-system with the EGR-module as described may result in an improved mixing of intake air and recirculated exhaust air. Especially because the dimensions of the exhaust gas passages and the intake air passages in the EGR-module adjacent the mixing assembly are clearly defined, the mixing behavior of the EGR-system may be predictable and may be optimized. Because all components that regulate the exhaust gas supply and intake air supply are integrated in an EGR-module configured as a unit, a single control connection may be feasible for controlling both the exhaust gas recirculation valve 58, 186 and the throttle valve 58, 180. A single control connection may be less vulnerable to malfunction. The EGR-module may be supplied by an external supplier as a unit. Consequently, the assembling effort for incorporating an EGR-system in an internal combustion engine may be reduced. Because the EGR-module may be compact, packaging of the EGR-system in the limited space around the engine may be easier while maintaining or even improving the positioning of the various components relative to each other in the air intake system in view of optimal performance. The mixing assembly 60, 160 may be configured so that an optimal mixing result may be obtained in a limited space. The length of the passages that form the fluid connection between EGR-valve and the outlet ports and the inlet ports of the combustion chambers of the engine may be relevant for the pressure difference between intake air and the exhaust gas at the EGR-valve. For optimizing the pressure difference it may be desired to place the EGR-valve and the non-return valve close to the intake manifold. However, for optimizing mixing, a longer channel between the mixing position of the exhaust gas and the intake air on the one hand and the intake manifold on the other hand may be desired. By virtue of the mixing assembly 60, 160 in the EGR-module 26, 126, 226 and the optimized mixing circumstances that may be created in the EGR-module, the EGR-module may be placed at a position near the intake manifold. Consequently, an optimal pressure difference between exhaust gas and intake air may be obtained while still keeping a good mixing performance. Thus, a higher degree of exhaust gas recirculation may be obtained.

[0033] Because all major components of the EGR-system in a disclosed embodiment may now be integrated in the EGR-module that may be configured as a single unit, all these parts may be serviced simultaneously and may be kept in stock as a single unit. From a servicing point of view and from a logistic point of view that may be advantageous. When mounting the EGR-module in the air intake system and the exhaust gas system, in the embodiment shown only three interfaces may be formed. Thus, the number of leakage sources may be reduced.

[0034] It will be apparent to those having ordinary skill in the art that various modifications and variations can be made to the EGR-system as disclosed herein. Other embodiments will be apparent to those having ordinary

skill in the art from consideration of the specification. It is intended that the specification and examples are considered as exemplary only. Other aspects, features and advantages will be apparent upon an examination of the attached drawings and appended claims.

Claims

1. An exhaust gas recirculation system for an internal combustion engine having an air intake system with an upstream part and a downstream part, the EGR-system comprising:

   - an EGR-module mountable as a single unit in the air intake system between the upstream part and the downstream part, the EGR-module including:
   - an air intake channel having an air intake opening and an mixture outlet opening;
   - the air intake opening being connectable to the upstream part;
   - the mixture outlet opening being connectable to the downstream part;
   - an exhaust gas intake opening; and
   - a mixing assembly configured for mixing exhaust gas introduced in the exhaust gas intake opening and air introduced in the air intake channel via the air intake opening.

2. The exhaust gas recirculation system according to claim 1, the EGR-module including:

   - a throttle valve for regulating the amount of air passing the air intake channel.

3. The exhaust gas recirculation system according to claim 1 or 2, the EGR-module including:

   - an exhaust gas recirculation valve for regulating the amount of exhaust gas introduced in the air intake channel.

4. The exhaust gas recirculation system according to any of the preceding claims, the EGR-module including:

   - at least one non-return valve arranged downstream of the exhaust gas intake opening and upstream of the mixing assembly.

5. The exhaust gas recirculation system according to any of the preceding claims, wherein the mixing assembly includes at least one mixing tube having a mixing tube wall with a plurality of mixing tube ports.

6. The exhaust gas recirculation system according to claim 5, wherein the at least one mixing tube has a central axis that extends parallel to the mixing tube surface and the air intake channel has a central axis that extends parallel to a wall bounding the air intake channel, wherein the central axis of the mixing tube is perpendicular to the central axis of the air intake channel adjacent the mixing tube so that, in use, the flow of air in the air intake channel adjacent the mixing tube is substantially perpendicular to the exhaust gas leaving the mixing tube ports.

7. The exhaust gas recirculation system according to the combination of claims 2 and 6, wherein the throttle valve includes a valve flap and a valve shaft connected with the valve flap for regulating the position of the valve flap relative to the air intake channel, wherein a longitudinal axis of the valve shaft is parallel to the central axis of the at least one mixing tube.

8. The exhaust gas recirculation system according any of the preceding claims, wherein the EGR-module includes:

   - a mixing body at least partly defining the air intake channel and having:
   - a throttle valve body flange;
   - a EGR-valve body flange;

   wherein the EGR-module also includes:

   - a throttle valve body connected to the throttle valve body flange;
   - an EGR-valve body connected to an EGR-valve body flange; and
   - an EGR-valve motor connected to the EGR-valve body.

9. The exhaust gas recirculation system according to claim 8 in combination with claim 4, wherein the at least one non-return valve includes a valve flange that is connected to the mixing body adjacent the EGR-valve body flange, so that the valve flange is positioned between the mixing body and the EGR-valve body.

10. The exhaust gas recirculation system according to claim 8 in combination with claim 5, wherein the mixing tube has a mixing tube flange and the mixing body as a mixing tube mounting surface for accommodating the mixing tube flange.

11. The exhaust gas recirculation system according to claim 10, the mixing body including a circlip groove adjacent the mixing tube mounting surface, the mixing tube being connected to the mixing body by a circlip.

12. An internal combustion engine having an exhaust gas recirculation system according to any of the pre-

ceding claims.

13. A method for exhaust gas recirculation in an internal combustion engine having an air intake system with a upstream part and a downstream part, the method including:

- providing an EGR-module in the air intake system between the upstream part and the downstream part;
- supplying intake air to the EGR-module;
- supplying exhaust gas to the EGR-module;
- mixing the intake air and the exhaust gas in the EGR-module; and
- discharging the mixture from the EGR-module into the downstream part.

14. The method of claim 13, wherein the amount of intake air taken in by the EGR-module is regulated in the EGR-module.

15. The method of claim 13, wherein the amount of exhaust gas taken in by the EGR-module is regulated in the EGR-module.

16. The method of claim 13, wherein the exhaust gas taken in by EGR-module passes a non-return valve in the EGR-module so as to prevent flowing back of exhaust gas when the intake air pressure is higher than the exhaust gas pressure.

17. The method of claim 13, wherein the mixing of intake air and exhaust gas is performed by supplying multiple streams of exhaust gas in an intake air stream in the EGR-module with an exhaust gas flow direction that is substantially perpendicular to the intake air flow direction in the EGR-module at that position.

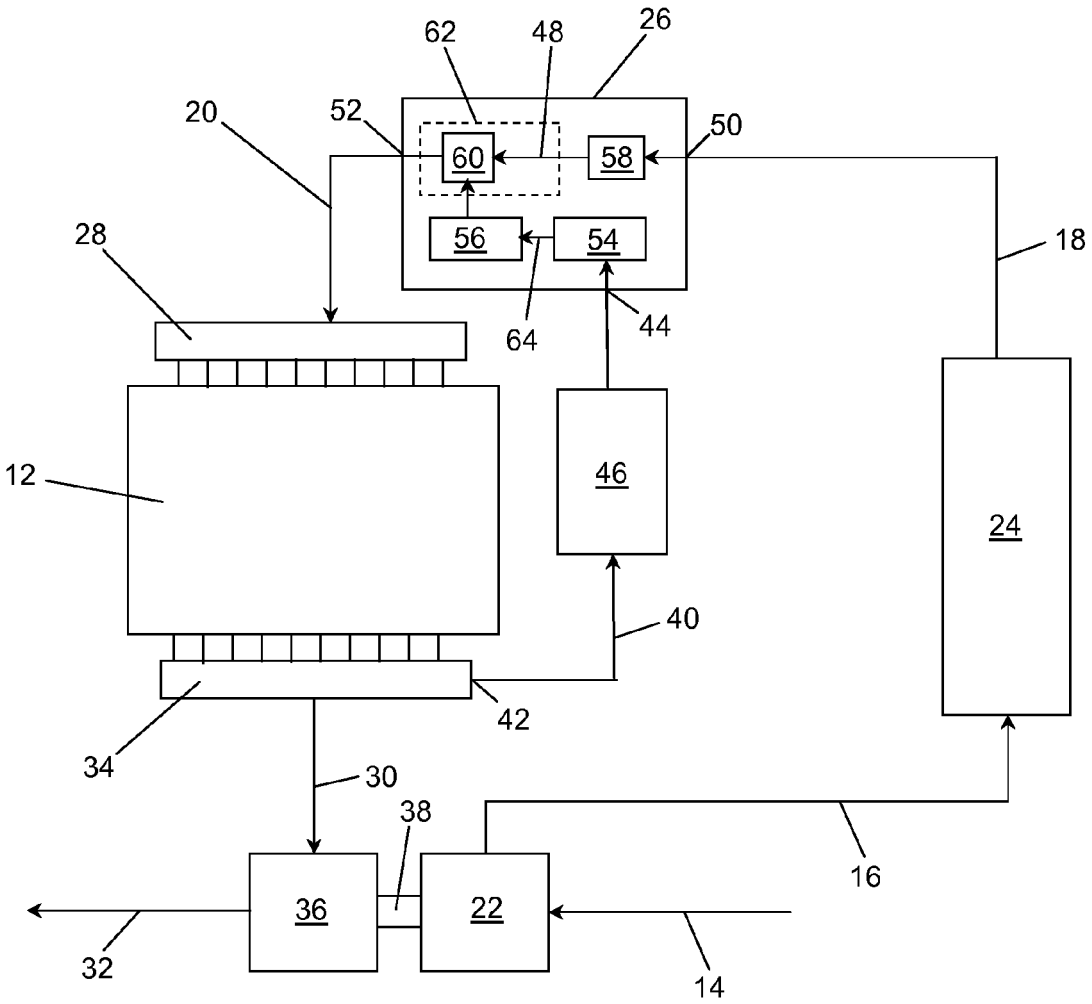
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Fig. 1

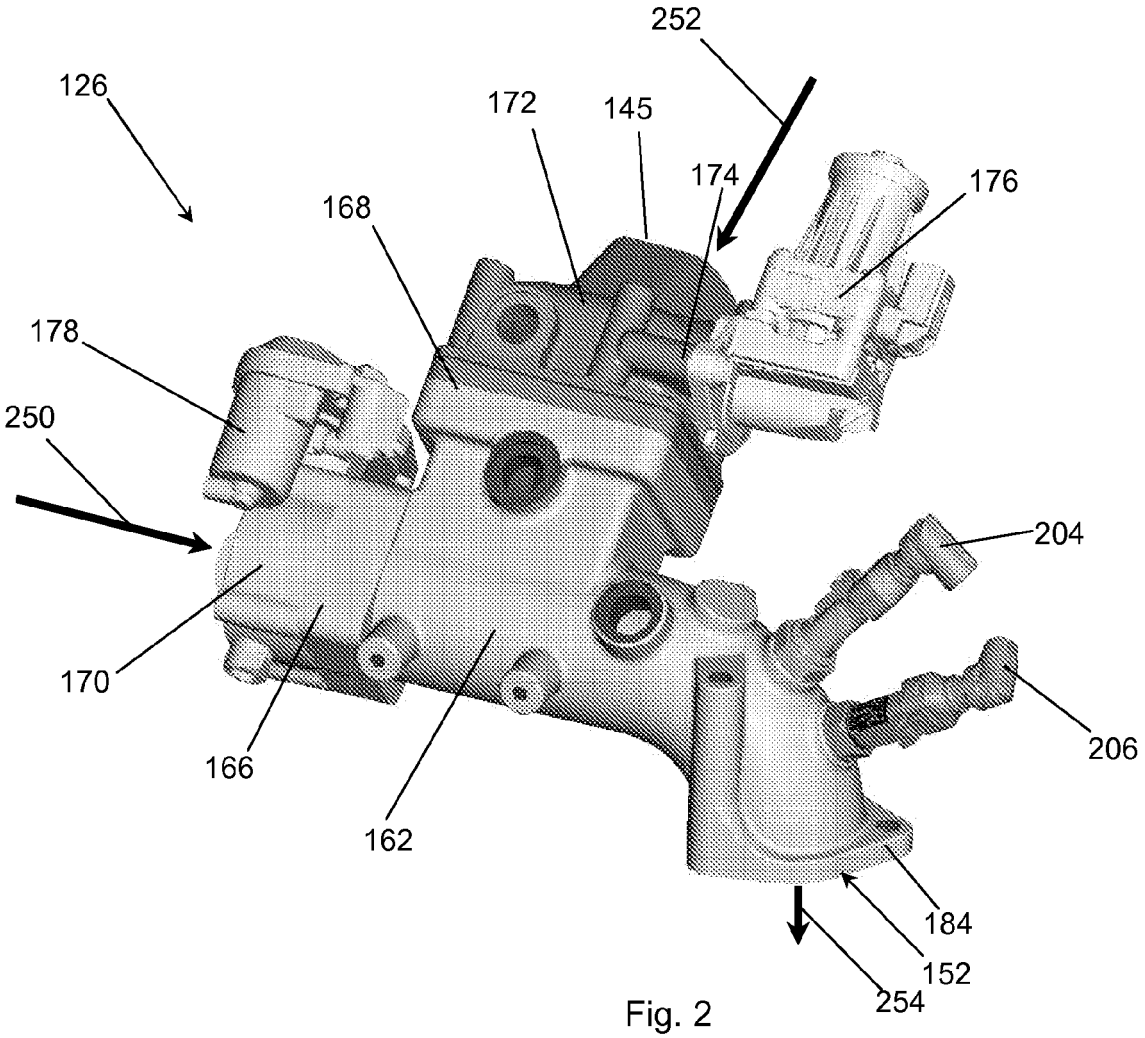
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Fig. 2

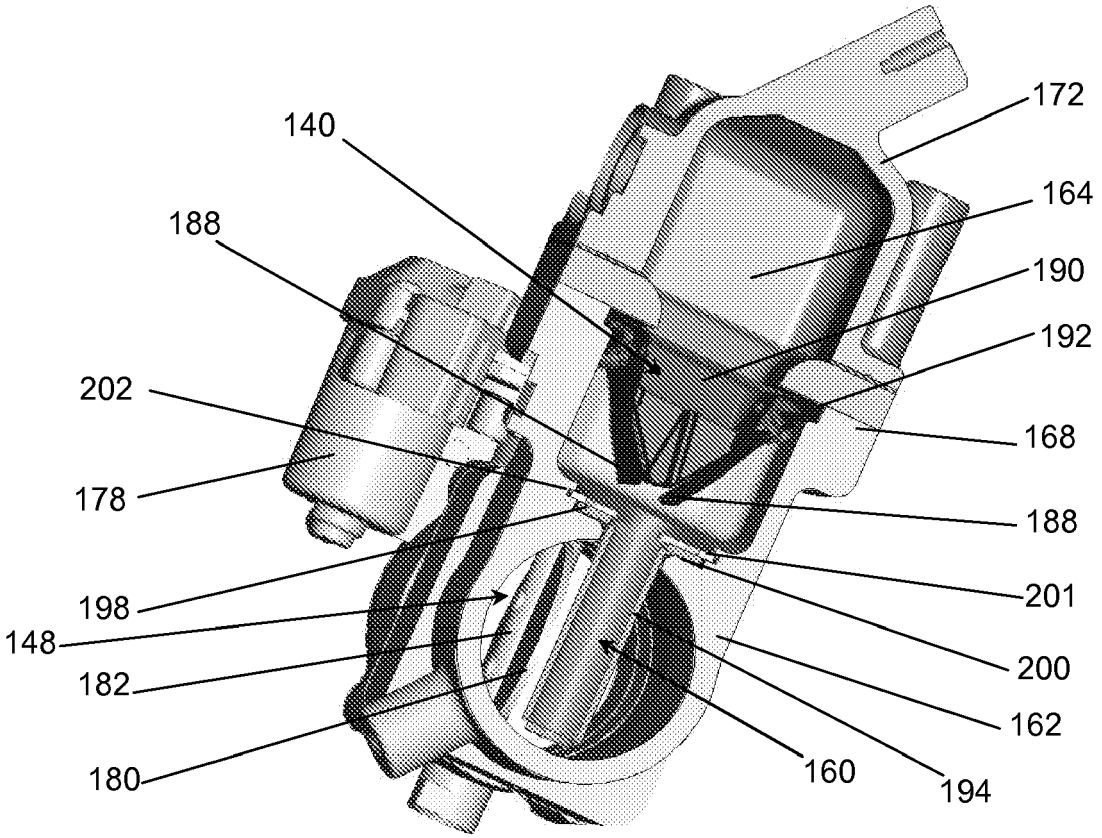
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Fig. 3

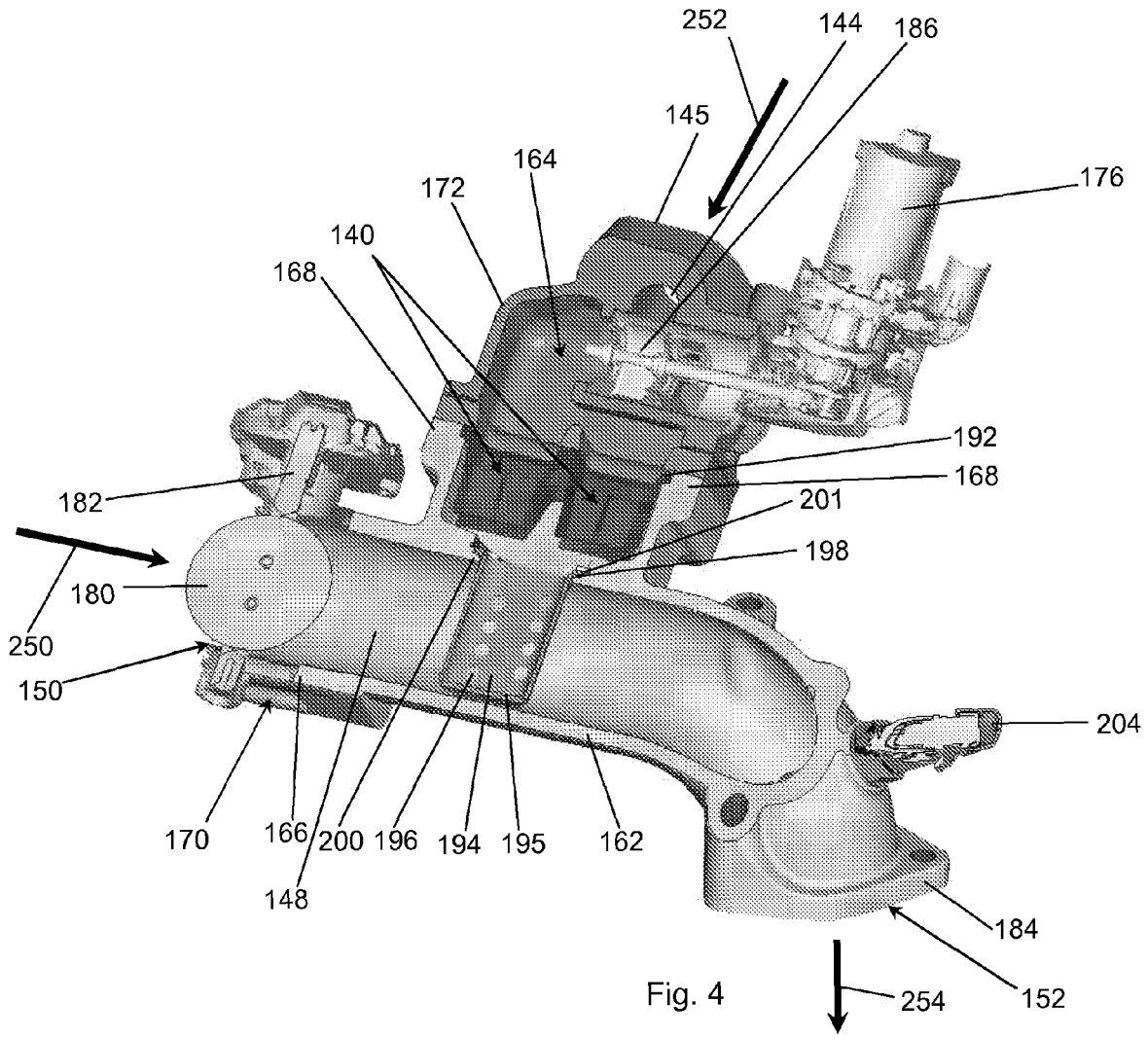
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Fig. 4

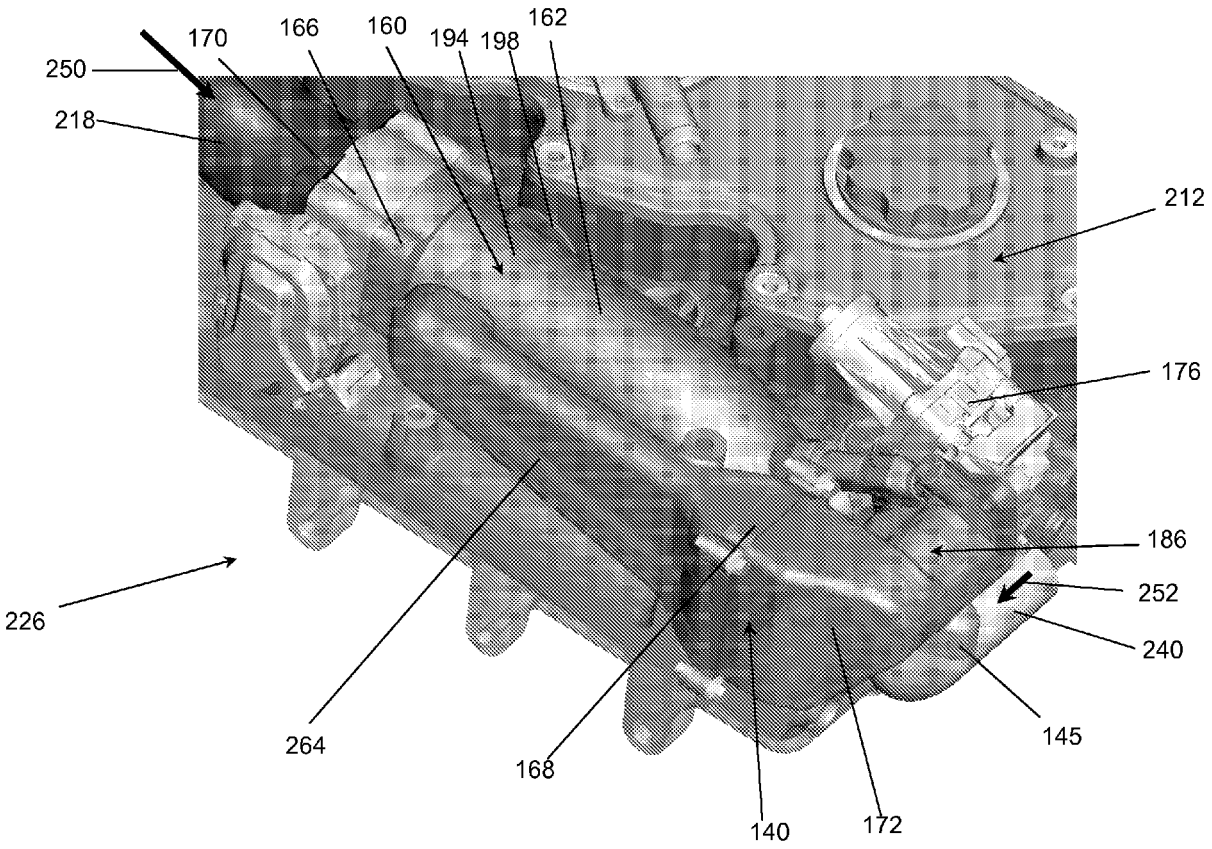
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Fig. 5

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 08 15 8166

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 Y	WO 2006/129371 A (HITACHI LTD [JP]; SUKEGAWA YOSHIHIRO [JP]; MUNAKATA AKIHIRO [JP]; KOWA) 7 December 2006 (2006-12-07) * abstract; figures 1,2,11,12,15 *	1-3,8-15 7	INV. F02M25/07 ADD. F02D9/10
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Place of search	Date of completion of the search	Examiner
The Hague	5 December 2008	Martinez Cebollada

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