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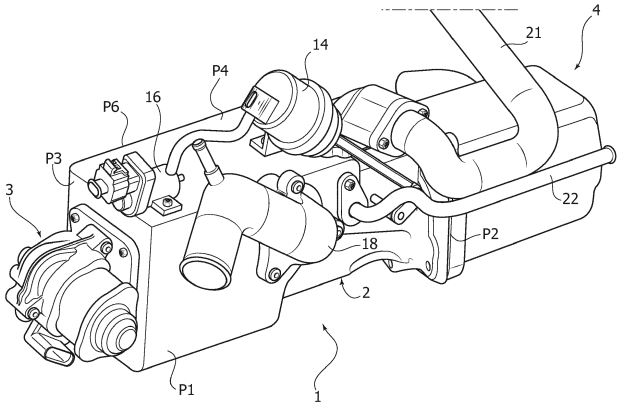
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(54) **MULTI-FUNCTIONAL MODULE FOR AN INTERNAL COMBUSTION ENGINE OF A MOTOR-VEHICLE**

(57) A multi-functional module (1) for an internal combustion engine (E) of a motor-vehicle incorporates a part of an exhaust gas recirculation system and a part of an engine cooling circuit. The multi-functional module comprises a central structural element, with a metal body having a face (P6) for attachment to an end face of the cylinder head (T) of the engine (E). The body has a configuration elongated along a direction which is perpendicular to the longitudinal direction of the cylinder head (T). A conduit (6) for circulation of the exhaust gases and a conduit (7) for circulation of the engine coolant are formed within said metal body. The module also comprises an EGR valve unit (3), which is mounted on a first end face (P3) of said body and a heat exchanger (4) for cooling the exhaust gases, said heat exchanger (4) being mounted on a second end face (P2) opposite to said first end face (P3). The EGR valve unit (3) is operatively positioned along the conduit (6) for the exhaust gases in a position which is upstream of said heat exchanger (4), in such a way that the exhaust gases pass through said EGR valve unit (3) when this is in an opened condition, before being cooled in the heat exchanger (4). The exhaust gases can leave the module without passing through the heat exchanger (4), flowing in a by-pass conduit (65) controlled by a by-pass valve (13). The by-pass valve (13) is controlled by a vacuum actuator (14). Such actuator is operated by means of a vacuum source external to the module (1). So the module (1) is deprived of a vacuum tank, with the resulting advantage of a lower bulk.

FIG. 3



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Description

Field of the invention

[0001] The present invention relates to a multi-functional module for an internal combustion engine of a motor-vehicle, incorporating a part of an exhaust gas recirculation system of the engine and a part of a cooling circuit of the engine, in particular said module comprising an EGR valve unit for regulating the recirculated exhaust gas flow and a heat exchanger for cooling the recirculated exhaust gases, by means of the engine coolant.

Prior art

[0002] Multi-functional modules of the type indicated above are yet known (see for example documents EP 2 037 116 B1 and EP 1 793 115 B1), wherein the multi-functional module comprises a central structural element, with a metal body having a face for attachment to an end face of the engine cylinder head. Such a body having an elongated shape according to a direction which is perpendicular to the longitudinal direction of the cylinder head in the mounted condition of said module on the engine.

[0003] A conduit for circulation of the exhaust gases and a conduit for circulation of the engine coolant are formed within said metal body of the central structural element. Such conduits extend starting form an inlet opening of the exhaust gases and an inlet opening of the coolant, said inlet openings are positioned on said attachment face and are intended to communicate respectively with the engine exhaust manifold and with a coolant jacket of the cylinder head.

[0004] The exhaust gases conduit ends into an exhaust gases outlet opening intended to communicate with the engine intake manifold, whereas said coolant conduit flows into at least one coolant outlet opening to which a thermostatic valve is associated for controlling a connection with a radiator of the engine cooling system.

[0005] In such multi-functional modules, said EGR valve unit for regulating the recirculated exhaust gas flow is mounted on a first end face of said central structural element elongated body, and is operatively interposed along said exhaust gases conduit. Furthermore, said heat exchanger for cooling exhaust gases with the coolant is mounted on a second end face of said elongated body of the central structural element, which is opposite to said first end face on which said EGR valve unit is mounted. The heat exchanger has internal conduits in heat exchange relationship to each other, which are respectively operatively interposed along said exhaust gases conduit and said coolant conduit. A by-pass conduit for exhaust gas is formed within said elongated body of the central structural element, through which exhaust gases can flow towards said exhaust gases outlet opening without passing through said heat exchanger, in said by-pass conduit being interposed a by-pass valve operated by means of a vacuum actuator carried by said multi-functional module.

[0006] Multi-functional modules of the type indicated above which has been produced since now have several drawbacks. Firstly, the EGR valve unit is subjected to carbon deposits (so called "EGR soot") due to the exhaust gas flow which passes through thereof, with consequent efficiency reduction of such component with the passing of time. Furthermore, all the aforementioned known solutions provide a vacuum tank integrated to the central structural element of the module, such a vacuum tank results necessary for controlling the vacuum actuator which controls the aforementioned by-pass valve. Such a vacuum tank is mounted at a module end, adjacent to the heat exchanger, causing a reduction of the available space of the heat exchanger. Therefore it is mandatory to use a relatively small heat exchanger, with consequent less efficiency of the exhaust gases cooling. Another drawback that occurs in the known solutions consists in slowing down the exhaust gas flow that passes through the heat exchanger, due to gas density reduction that is determined while gas are cooled in the heat exchanger.

Object of the invention

[0007] The object that is on the basis of the present invention is to overcome above mentioned drawbacks which occur in the known solutions.

[0008] A further object of the invention is to provide a multi-functional module with limited dimensions, reduced weight, inexpensive to be manufactured.

[0009] Again a further object of the present invention is to provide a multi-functional module which remains efficient in all its functions during the entire life of the engine to which the module is associated.

Summary of the invention

[0010] In view of achieving the above objects, the invention relates to a multi-functional module for an internal combustion engine having all the features that have been indicated above and characterized in that said EGR valve unit is operatively positioned along the exhaust gases conduit upstream of said heat exchanger, in such a way that when said EGR valve unit is in an opened condition, the exhaust gases pass through said EGR valve unit, before being cooled in the heat exchanger.

[0011] Thanks to this feature, the exhaust gases pass through the EGR valve at a temperature which is considerably higher than what occurs in the known solutions, so causing reduction or entire cancellation of risk of carbon deposits within the EGR valve and ensuring that such valve maintains constant efficiency for the entire operative life of the engine.

[0012] The module according to the invention is also characterized in that said vacuum actuator which controls the by-pass valve is arranged for being operated by a

vacuum source external to the module, whereby said module is without of any vacuum source or tank.

[0013] Thanks to this feature, the weight and the overall dimensions of the module are considerably reduced. In particular, compared to the known solutions in which next to the heat exchanger is provided said vacuum tank, the multifunctional module according to the invention has the advantage that the entire second end face of the body of the central structural element can be entirely occupied by the heat exchanger. This allows to obtain a more efficient cooling of the exhaust gases, using a larger heat exchanger without increasing the overall size of the module. Or it is thus possible to use a heat exchanger with similar dimensions to the known solutions, but considerably decreasing the overall size of the module.

[0014] According to a further preferred feature, said heat exchanger is configured in such a way as the exhaust gases which pass through thereof follow a U-shaped path.

[0015] Thanks to this feature, considering an equal cooling efficiency of the exhaust gases, the overall dimensions of the heat exchanger in the longitudinal direction of the module can be considerably reduced.

[0016] According to a further preferred feature, the U-shaped passage for the exhaust gases through the heat exchanger is defined by a first row of tubes or flat channels for the exhaust gas flow in a first direction, by a second row of tubes or flat channels for the exhaust gas flow in a second direction opposite to the first direction, and by an intermediate chamber which connects the tubes or flat channels of the first row to the tubes or flat channels of the second row.

[0017] Thanks to this feature, it is possible to provide, with a simple and low cost structure, a variation of the overall section for the passage of the exhaust gases while they proceed to the heat exchanger. In particular it is possible to provide that tubes or flat channels of said second row define an overall passage section lower than the overall passage section defined by tubes or flat channels of the first row, so as to counteract a reduction of the exhaust gases speed resulting from the reduction of density due to the cooling.

Detailed description of the preferred embodiment

[0018] Further features and advantages of the invention will become apparent from the following description with reference to the annexed figures, given purely by way of non limiting example, in which:

- figure 1 is a diagram of a preferred embodiment of the multi-functional module according to the present invention, where has been shown only the exhaust gas circuit,
- figure 2 is a diagram similar to figure 1, wherein has been shown only the engine coolant circuit,
- figure 3 shows a perspective view of the aforesaid preferred embodiment of the multi-functional module according to the present invention,
- figures 4 and 5 show two exploded views of the module illustrated in figure 3, where have been shown respectively the exhaust gases circuit and the engine coolant circuit,
- figures 6, 7 are two further perspective views in enlarged scale, where some internal conduits of the module according to the invention have been illustrated as solid parts, for major clarity, and
- figure 8 shows a diagrammatic sectional view of the heat exchanger forming part of the multi-functional module according to the invention.

[0019] With reference to the annexed drawings, the reference number 1 indicates a preferred embodiment of the multi-functional module for an internal combustion engine of a motor-vehicle according to the present invention.

[0020] Figures 1, 2 diagrammatically shown the cylinder head T of a multi-cylinder engine E, having an intake manifold CA for the air supply, coming from a suction duct 5 to the engine cylinders, and an exhaust manifold CS for discharging in an exhaust conduit 17 the outgoing gas from the engine cylinders. Figure 2 also diagrammatically illustrates the cooling jacket J of the cylinders head T.

[0021] The module 1 incorporates a part of the exhaust gas recirculation system of the engine and a part of the cooling circuit of the engine. In particular said module comprises an EGR valve unit 3 for regulating the recirculated exhaust gas flow and a heat exchanger 4 for cooling the recirculated exhaust gases by means of the engine coolant.

[0022] The EGR valve unit 3 and the heat exchanger 4 are mounted at two opposite ends of a central structural element 2. In particular with reference to figures 1-5, the central structural element 2 comprises a metal body (such as aluminium) having a face (indicated with P6 in figures 3-5) for attachment to an end face of the cylinder head T of the engine E (see figures 1, 2). Such a connection can be realized for example by means of screws, providing also a seal between faces in contact of the structural element body 2 and of the cylinder head T. Such constructive details have not been illustrated so getting more simple the drawings.

[0023] As shown in figures 1, 2, the body of the structural element 2 has an elongated shape according to a direction which is perpendicular to the longitudinal direction of the cylinder head. A conduit 6 for circulation of the exhaust gases (in particular see figures 1, 4, 7) and a conduit 7 for circulation of the engine coolant (in particular see figures 2, 5, 6) are formed within said central structural element metal body 2.

[0024] The exhaust gases conduit 6 extends starting from an inlet opening 9 of the exhaust gas positioned on said face P6 of the body 2 provided for attachment with the cylinder head (see figures 4 and 6, 7). The coolant conduit 7 extends starting from an inlet opening 8 posi-

tioned also in this case on said attachment face P6.

[0025] As seen in figure 1, the opening 9 for inlet in the module 1 of the exhaust gases communicates with the intake manifold CS by means of a conduit 24 formed in the cylinder head T. Otherwise as seen in figure 2, the opening 8 for inlet of the coolant in the module 1 communicates with the coolant jacket J of the cylinder head T.

[0026] Again with reference to figure 1, the exhaust gases conduit 6 follows a path, which will be described in detail below, through the body 2, up to ends into an outlet opening 10 connected to the suction duct 5, so as to enable recirculation of exhaust gases in the engine intake manifold.

[0027] With reference to figure 2, the coolant conduit 7 communicates with an outlet opening 11 to which a thermostatic valve 19 is associated for controlling a connection with the radiator of the engine cooling system.

[0028] The EGR valve unit 3 and the heat exchanger 2 are mounted at opposite ends of the central structural element 2.

[0029] As will be better illustrated in the following, the EGR valve unit 3 is operatively interposed in the exhaust gases conduit 6, for regulating the recirculated exhaust gas flow. The heat exchanger 4 has internal conduits, which also will be better illustrated in the following, which are in heat exchange relationship to each other, and which are respectively operatively interposed along said exhaust gases conduit 6 and said coolant conduit 7.

[0030] A by-pass conduit 65 for exhaust gases is formed within said elongated body of the central structural element 2 (see figure 1), through which exhaust gases can flow towards said exhaust gases outlet opening 10 without passing through said heat exchanger 4. A by-pass valve 13 (only diagrammatically shown in figure 1) is interposed inside said by-pass conduit 65 which is operated by means of a vacuum actuator 14 carried by said multi-functional module 1. The actuator 14 is shown in figures 3-5 and only in a diagrammatic way in figure 1. Using a vacuum actuator is necessary in order to efficiently develop the force that must be applied to the movable member of the by-pass valve. In the illustrated example in figures 4,5, the actuator body is rigidly fixed on the upper face P4 (with reference to drawings) of the body 2 and controls a stem which controls the movable member of the by-pass valve by means of a lever.

[0031] A first important feature of the present invention is that the EGR valve unit 3 is operatively positioned along the exhaust gases conduit 6 upstream the heat exchanger 4, in such a way that when said EGR valve unit is in an opened condition, the exhaust gases pass through said EGR valve unit 3, before being cooled in the heat exchanger 4.

[0032] Thanks to this feature, the exhaust gases pass through the EGR valve with a temperature which is considerably higher than what occurs in the known solution, so decreasing or entirely cancelling the risk of carbon deposits within the EGR valve 3 and ensuring that this valve maintains a constant efficiency for the entire life of the engine.

[0033] A further feature of the module according to the invention is that the vacuum actuator 14 which controls the by pass valve 13 is arranged for being operative by a vacuum pump 15 (figure 1) external to the module. The communication of the actuator 14 with the vacuum pump 15 is controlled by an electrovalve 16 of the type on-off. The electrovalve 16 is illustrated in figures 3-5 and only diagrammatically in figure 1. The actuator 14 is controlled by the vacuum pump 15 in order to open the by-pass conduit 65 during a warm-up phase of the engine, so when cooling of the exhaust gases is not required. In the module according to the invention, otherwise of the known solutions, it is not provided any vacuum tank in order to operate the actuator 14. Thanks to this feature, weight and overall size of the module are considerably reduced. In particular, compared to the known solutions in which next to the heat exchanger is provided said vacuum tank, the multifunctional module according to the invention has the advantage that the end face of the body 2 in which is mounted the heat exchanger can be entirely occupied by the heat exchanger. This fact permits to obtain a more efficient cooling of the exhaust gases, using a heat exchanger bigger, but without increasing the overall size of the module. Or it is also possible to use a heat exchanger with overall size similar to what is provided in the known solutions, so considerably decreasing the overall size of the module.

[0034] In the following, it will be described in detail the path of the exhaust gas in the preferred embodiment of the module according to the invention.

[0035] In particular with reference to figures 4 and 7, the exhaust gases conduit 6 comprises a blind conduit portion 60 which extends through the central structural element body 2 from said inlet opening 9 positioned on the attachment face of the central structural element 2. From the conduit portion 60 branches a further conduit portion 61 which extends in a parallel direction to the longitudinal direction of the body 2, up to ends into an opening 23 on the end face P3 on which is mounted the EGR valve unit 3. Adjacent to the opening 23 is provided a conduit portion 62 in which the conduit portion 61 communicates with a further conduit portion 63 which runs in parallel to the conduit portion 61 and extends from the end face P3 of the body 2 up to the opposite end face P2 on which is mounted the heat exchanger 4, which flows into an opening 12 which communicates with an exhaust gases inlet in the heat exchanger 4.

[0036] The communication of the conduit portion 61 with the conduit portion 62 (figure 4) is controlled by the EGR valve unit which comprises a body which is rigidly connected by screws (not shown) to the body of the element 2 and including an electric actuator for the position control of a shutter O which cooperates with a valve seat (not shown in the drawings) formed on the wall of the conduit portion 61. The shutter O is axially movable between a rest position on the valve seat, in which the communication between the conduit portions 61, 62 is inter-

rupted, and a position which is spaced from the valve seat, in which the aforesaid communication is open.

[0037] Again with reference to figures 4 and 8, the end face of the central structural element body 2 is entirely occupied by the heat exchanger 4. Such heat exchanger 4 is configured in such a way as the exhaust gas which pass through thereof follow a U-shaped path. Thanks to this feature, with equal efficiency of exhaust gas cooling, the overall size of the heat exchanger in the longitudinal direction of the module can be considerably reduced.

[0038] The U-shaped path for the exhaust gases through the heat exchanger 4 is defined by a first row of tubes 41 (in the case illustrated in the drawings) or alternatively by flat channels, for exhaust gas flow in a first direction, by a second row of tubes 41 or alternatively by flat channels for the exhaust gas flow in a second direction which is opposite to the first direction, and by an intermediate chamber 44 which connects the tubes or the flat channels of the first row to the tubes or the plates channel of the second row.

[0039] In the preferred embodiment of the heat exchanger 4 which is here illustrated, the tubes or flat channels of the second row (positioned downstream of the first row) define a total section of passage smaller than the total section of passage defined by the tubes or flat channels of the first row in such a way as counteracting a reduction of exhaust gases speed caused by the reduction of density due to the cooling. In the illustrated example that is obtained providing tubes 41 all of the same section, but providing a number of tubes of the upstream first row bigger than the number of tubes of the downstream second row.

[0040] The tubes 41 of the heat exchanger are all surrounded by a chamber 43 filled of the coolant.

[0041] The exhaust gases which leave the heat exchanger, enter again in the body of the element 2 merging in the by-pass conduit 65 (figures 1 and 7) and in the outlet opening 10 connected to the suction duct 5, which flows on the upper face P4 of the metal body of the element 2. A fitting element for the connection of a pipe 21 is mounted at the outlet opening 10, in which said pipe 21 let flows the recirculated exhaust gas in the suction duct 5.

[0042] In the following, it will be described more in detail the path of the coolant in the preferred embodiment of the module according to the invention.

[0043] With reference to figures 2, 5 and 6, the coolant conduit 7 comprises a conduit portion 71 which extends through the body of the central structural element 2 from said inlet opening 8 positioned on said attachment face P6 up to the opposite face P1 of the central structural element 2, wherein said conduit portion 71 ends into an outlet opening 11. A fitting element 18 is mounted at the opening 11 and said fitting element 18 incorporates the thermostatic valve 19 diagrammatically shown in figure 2 (not illustrated in figure 5), which controls the feeding of the coolant to the radiator of the cooling system.

[0044] A further conduit portion 72 branches from the conduit portion 71 in direction of the end face P3 of the central structural element 2 to which the EGR valve unit 3 is associated and which flows in a chamber 73 which is adjacent to said end face P3, for the cooling of the EGR valve unit 3. A further conduit portion 74 extends longitudinally along said central structural element 2 starting from a chamber 73 up to an inlet 22 of the coolant in the heat exchanger 4. Through the inlet 22, the coolant enters in the chamber 43 (figure 8) of the heat exchanger 4, where cools the exhaust gases which circulate in the tubes 41. The coolant leaves the heat exchanger through an outlet fitting 42 (figure 6), connected with the cooler of the engine oil, which is part of the engine cooling system. From the conduit portion 74 (figure 5) branches a further conduit (not illustrated) which ends in the face P1 of the body 2, where is fixed a fitting element 22 connected with the cabin heater of the motor-vehicle.

[0045] In the following it will be described the operation of the module 1 according to the present invention.

[0046] In figures of the annexed drawings, arrows F1 and F2 indicates respectively the exhaust gas flow and the coolant flow.

[0047] During the operation of the engine E, a part of the exhaust gas flow is recirculated to the engine intake by means of the module 1. In particular, a part of the exhaust gas flow passes through the intake manifold in the conduit 24 (figure 1) of the cylinders head T in order to enter in the inlet opening 9 in the module 1. If the EGR valve is opened, the exhaust gases entered in the opening 9 flow through the successive conduit portion 60-63 (figures 4 and 6) up to enter in the inlet of the heat exchanger 4. Subsequently, the gas flow in a direction and than in the opposite direction through the two rows of tubes (or flat channels) 41 of the heat exchanger 4 up to flow out from the module 1 through the opening 10 and so flow into the suction duct 5 (figure 1).

[0048] The electric actuator of the EGR valve unit 3 controls the stem O for regulating the recirculated exhaust gas flow. The actuator of the EGR valve is controlled by the engine control unit, on the basis of one or more engine operation parameters, according to a known technique.

[0049] Because the exhaust gas flow through the stem seat O of the EGR valve before being cooled in the heat exchanger 4 (there is only a reduced cooling caused by the coolant in the chamber 73) the gas are still relatively hot at the stem O, so consequently the risk of carbon deposit is reduced or completely eliminated, which could prejudice the efficiency of the EGR valve in the time.

[0050] During the warm-up phase of the engine, when the cooling of the exhaust gases in the exchanger 4 is not required, the actuator 14 controls the opening of the by-pass valve 13, so that the gases flow out from the module 1 without passing through the heat exchanger 4. The actuator 14 becomes operative by means of the opening of the electrovalve 16 and activating the vacuum pump 15 (which is not part of the module 1, being integrated in the engine E). Therefore, a like prior art, the

module 1 doesn't include a vacuum tank for supplying the actuator 14, with consequent possibility of adopt a heat exchanger bigger and more efficient, which occupies the entire end face P2 of the metal body 2, without increasing the overall size of the module 1. The configuration with U-shape of the path of the exhaust gases in the heat exchanger 4 enables a reduction of the dimensions of the heat exchanger 4 in the longitudinal direction of the body 2. The predisposition of the two different rows of tubes 41 or flat channels communicating with an intermediate chamber 44 enables also to provide an overall passage section for the exhaust gases which is reduced along the path of the exhaust gases, so as to counteract the reduction of speed due to the reduction of density caused by the cooling.

[0051] With reference to figures 1 and 5, 6, the coolant coming from the cooling jacket J of the cylinders head flows into the inlet opening 8 of the module 1. Part of the flow pass through the conduit portion 71 and cause out the module 1 through the fitting element 18 when the thermostatic valve 19 (figure 1) is open, so as to flow towards the radiator of the motor-vehicle. Part of the flow of the coolant subsequently flows through the conduit portion 71, 72, the chamber 73 (which cools the EGR valve) and a conduit portion 74 up to flows in to the chamber 43 of the heat exchanger, where the exhaust gas are cooled. The coolant leaving the heat exchanger 44 goes out from the module 1 through the fitting element 42 (figure 6) from which it has been directed to the cooler of the engine oil of the motor-vehicle cooling system. Part of the coolant goes out instead from the module 1 through the fitting element 22, from which it is directed to the cabin heater.

[0052] As result evident from the above description, the multi-functional module according to the invention combines a simple configuration and economical process for manufacturing with limited overall size features, low weight and constant efficiency in the time.

[0053] Naturally, while the principle of the invention remains the same, the details of construction and the embodiments may widely wary with respect to what has been described and illustrated purely by way of example, without departing from the scope of the present invention.

Claims

1. Multi-functional module (1) for an internal combustion engine (E) of a motor-vehicle, incorporating a part of an exhaust gas recirculation system of the engine and a part of a cooling circuit of the engine, in particular said module comprising an EGR valve unit (3) for regulating the recirculated exhaust gas flow and a heat exchanger (4) for cooling the recirculated exhaust gases, by means of the engine coolant, further wherein:

   - said multi-functional module comprises a central structural element (2), with a metal body having a face (P6) for attachment to an end face of the cylinder head (T) of the engine (E), such a body having an elongated shape according to a direction which is perpendicular to the longitudinal direction of the cylinder head, in the mounted condition of said module on the engine,
   - a conduit (6) for circulation of the exhaust gases and a conduit (7) for circulation of the engine coolant are formed within said metal body of the central structural element (2), said conduits (6, 7) extending starting from an inlet opening (9) of the exhaust gases and an inlet opening (8) of the coolant, said inlet openings (8,9) being positioned on said attachment face (P6) and being respectively for communication with the engine exhaust manifold and with a coolant jacket of the cylinder head,
   - said exhaust gas conduit (6) ends into an exhaust gas outlet opening (10) intended to communicate with the engine intake manifold, whereas said coolant conduit (7) ends into at least one coolant outlet opening (11) to which is associated a thermostatic valve (19) for controlling a connection to the radiator of the engine cooling system,
   - said EGR valve unit (3) for regulating the recirculated exhaust gas flow is mounted on a first end face (P3) of said elongated body of the central structural element (2), and is operatively interposed along said exhaust gas conduit (6),
   - said heat exchanger (4) for cooling the exhaust gases by the coolant is mounted on a second end face (P2) of said elongated body of the central structural element (2), which is opposite to said first end face (P3) on which said EGR valve unit is mounted (3), said heat exchanger (4) having internal conduits (41, 43) in heat exchange relationship to each other, which are respectively operatively interposed along said exhaust gas conduit (6) and said coolant conduit (7),
   - a by-pass conduit (65) for the exhaust gases is formed within said elongated body of central structural element (2), through which the exhaust gases can flow towards said exhaust gas outlet opening (10) without passing through said heat exchanger (4),
   - a by-pass valve (13) is interposed inside said by-pass conduit (65) which is operated by means of a vacuum actuator (14) carried by said multi-functional module (1),
   - said multi-functional module (1) being **characterized in that** said EGR valve unit (3) is operatively positioned along the exhaust gas conduit (6) upstream of said heat exchanger (4), in such a way that when said EGR valve unit (3) is in an opened condition, the exhaust gases pass through said EGR valve unit (3), before being

cooled in the heat exchanger (4), and
- **in that** said vacuum actuator (14) which controls the by-pass valve (13) is arranged for being operated by a vacuum source external to the module (1), whereby said module is deprived of any vacuum source or tank.

2. Multi-functional module (1) according to claim 1, **characterized in that** said second end face (P2) of the body of the central structural element (2) is entirely occupied by said heat exchanger (4).

3. Multi-functional module (1) according to claim 1, **characterized in that** said heat exchanger is configured in such a way that the exhaust gases which pass through the heat exchanger follow a U-shaped path.

4. Multi-functional module (1) according to claim 3, **characterized in that** the U-shaped path for the exhaust gases trough the heat exchanger (4) is defined by a first row of tubes or flat channels (41) for the flow of the exhaust gases in a first direction, by a second row of tubes or flat channels (41) for the flow of the exhaust gases in a second direction opposite to the first direction and by an intermediate chamber (44) which connects the tubes or flat channels of the first row to the tubes or flat channels of the second row.

5. Multi-functional module (1) according to claim 4, **characterized in that** the tubes or flat channels (41) of said second row define an overall passage cross-sectional area smaller than the overall passage cross-sectional area defined by the tubes or flat channels (41) of the first row, in such a way as to counteract a reduction of the speed of the exhaust gases caused by the reduction of density due to cooling.

6. Multi-functional module (1) according to claim 1, **characterized in that** said cooling conduit (7) comprises:

- a first conduit portion (71) which extends through the central structural element body (2) from said inlet opening (8) positioned at said attachment face (P6) up to an opposite face (P1) of the central structural element (2), where said outlet opening (11) is located, to which the thermostatic valve (19) is associated;
- a second conduit portion (71) which branches from the first conduit portion (71) in direction of said first end face (P3) of the central structural element (2) to which the EGR valve unit (3) is associated and which terminates in a chamber (73) adjacent to said first end face (P3) of the central structural element (2) for cooling the EGR valve unit (3), and
- a third conduit portion (74) which extends longitudinally along said central structural element (2) starting from said chamber (73) up to an inlet (22) of the coolant in the heat exchanger (4),
- said heat exchanger (4) having an outlet (42) for the coolant intended to be connected with an external element of the engine cooling circuit, such as a cooler for the engine oil.

7. Multi-functional module according to claim 1, **characterized in that** said exhaust gas conduit (6) comprises:

- a conduit portion (60, 61) for the exhaust gases, operatively positioned upstream of the EGR valve unit (3) and which is extended through the body of the central structural element (2) from said inlet opening (9) for the exhaust gases positioned on said attachment face (P6) of the central structural element (2) up to said first end face (P3) of the central structural element (2),
- a conduit portion (62, 63) for the exhaust gases which is operatively positioned downstream the EGR valve unit (3), and which is extended through the body of the central structural element (2) up to said second end face (P2) of the central structural element (2) where it merges into an inlet for the exhaust gases in the heat exchanger (4), the communication between said upstream portion and said downstream portion of the exhaust gas conduit (6) being controlled by said EGR valve unit (3),
- a terminal conduit portion for the exhaust gases formed in said body of the central structural element (2), which connects an outlet of the exhaust gases from the heat exchanger (4) with said outlet opening (10) of the exhaust gases of the multi-functional module (1),
- said by-pass conduit (65) being defined by a conduit formed in the body of the central structural element (2) which directly connects said conduit portion (62, 63) for the exhaust gases downstream of the EGR valve unit (3) with said terminal conduit portion for the exhaust gases.

8. Multi-functional module (1) according to claim 7, **characterized in that** said conduit portion (60, 61) for the exhaust gases which is operatively positioned upstream of the EGR valve unit (3) ends into an opening (23) on said first end face (P3) of the body of the central structural element (2) and **in that** said EGR valve unit (3) comprises a valve shutter (8) which is provided movable within said opening (23) of said first end face (P3) and which cooperates with a valve seat formed within said central structural element for controlling the communication between the upstream and downstream portions of the con-

duit (6) for the exhaust gases.

FIG. 1

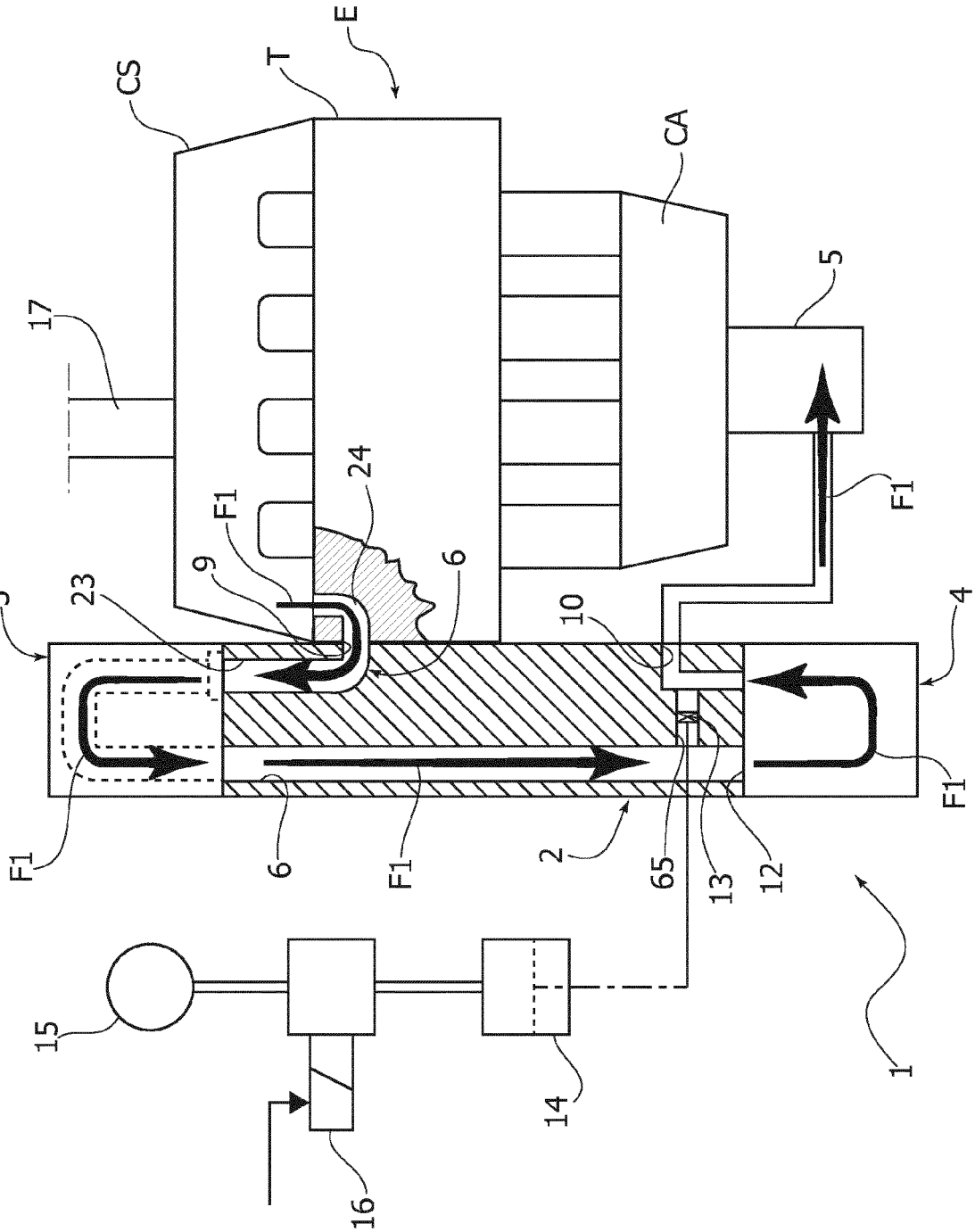


FIG. 2

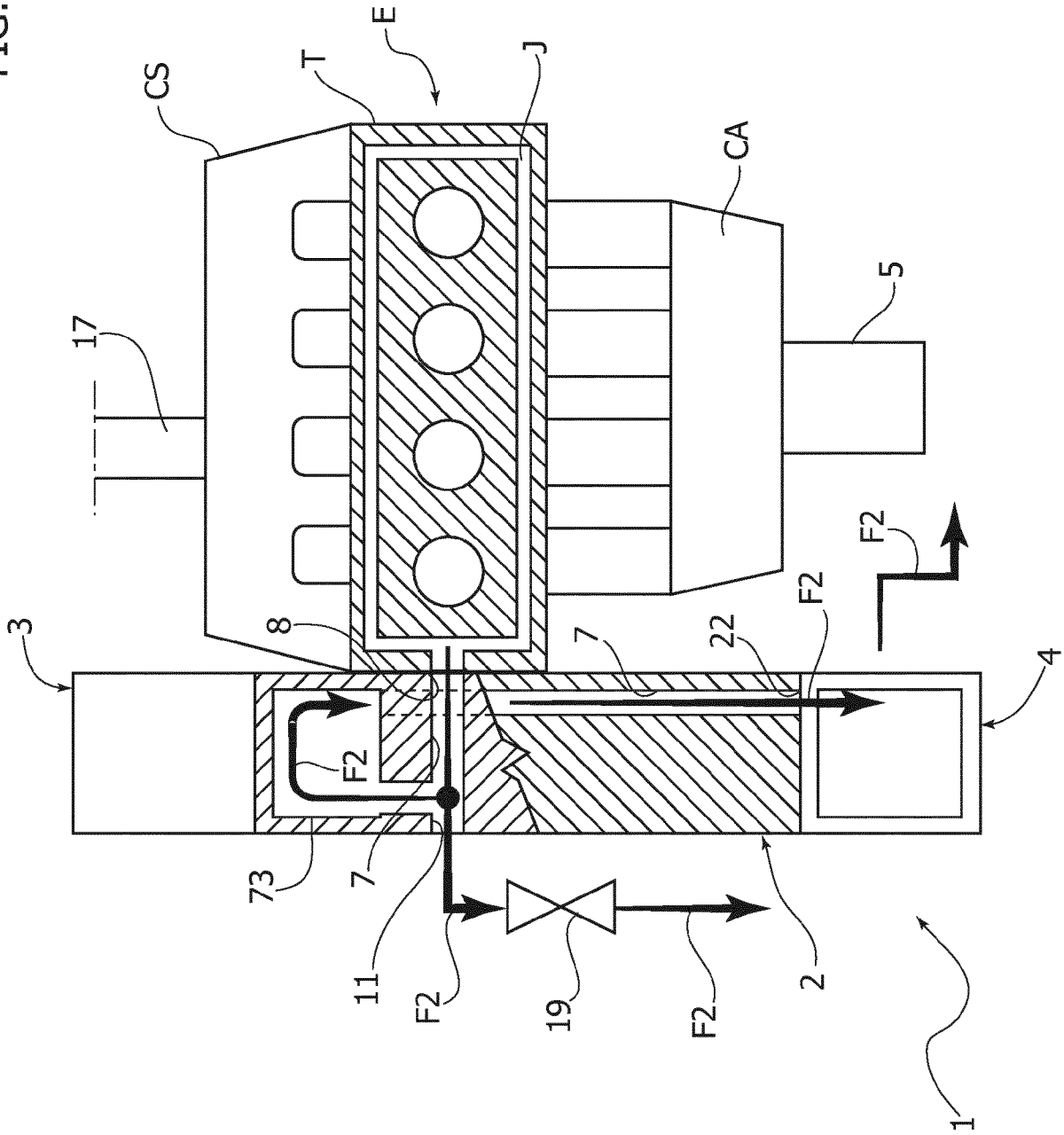
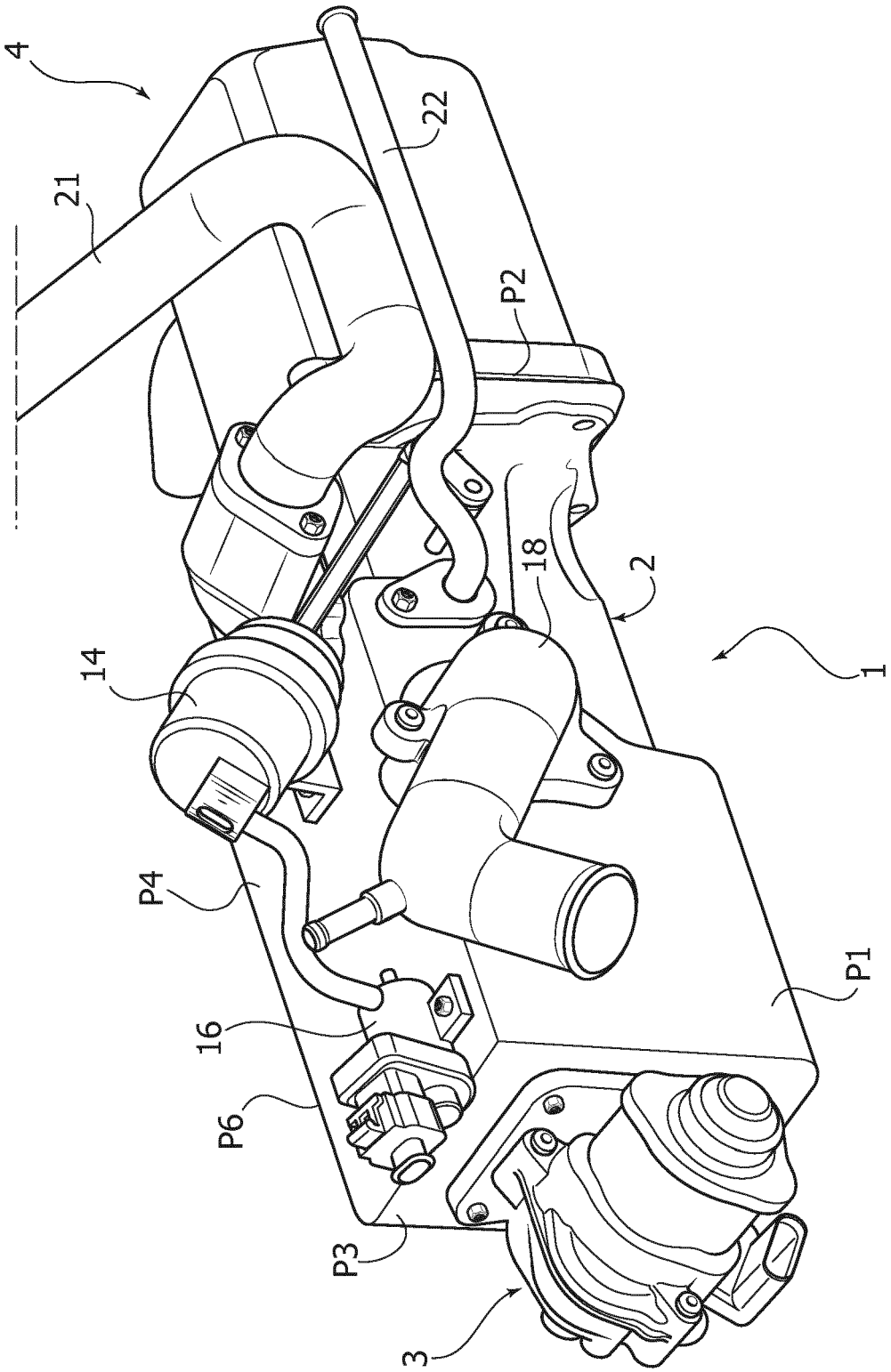


FIG. 3



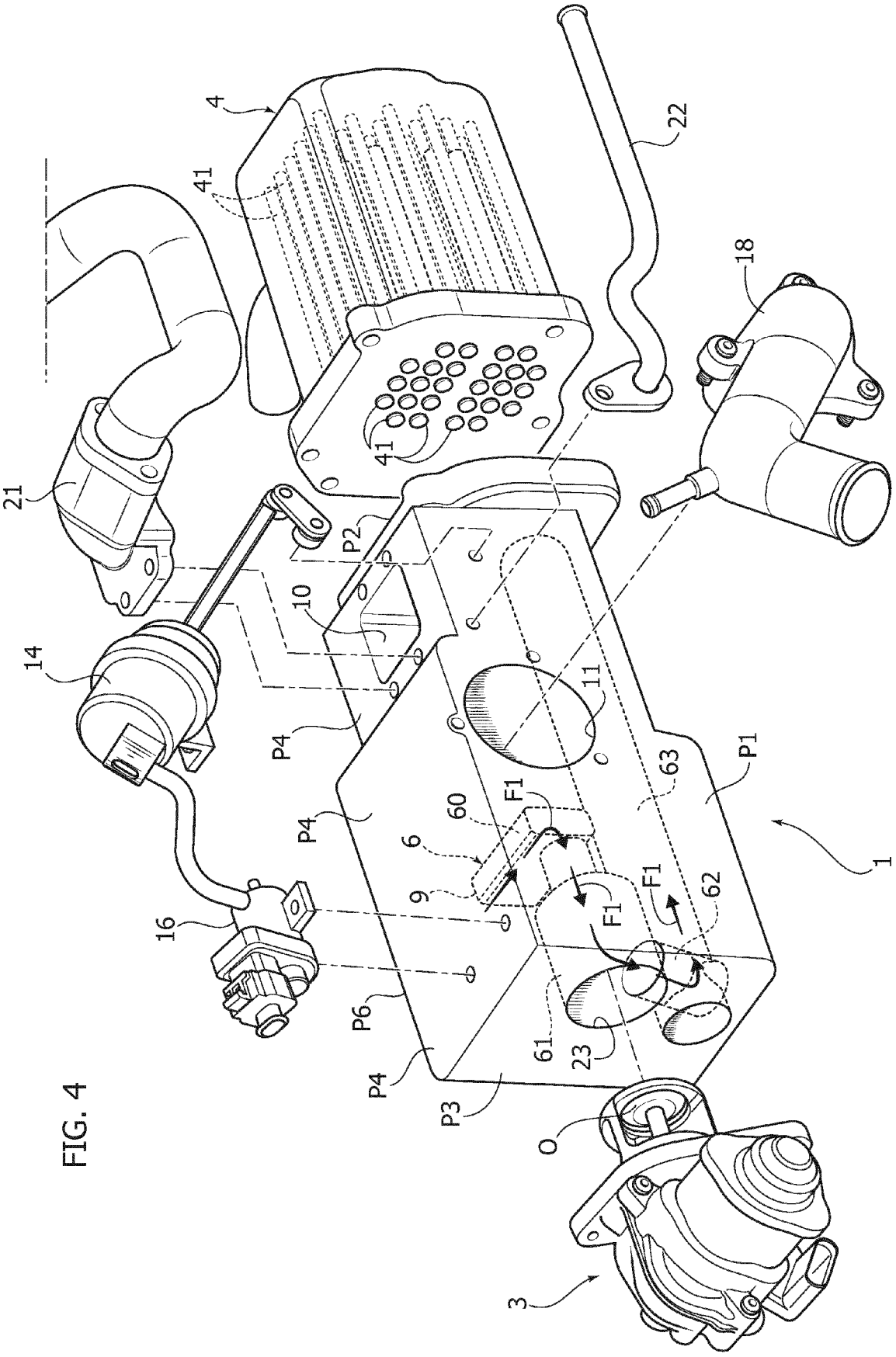

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P2
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P4
63
P1
60
F1
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62
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P6
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23
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FIG. 4

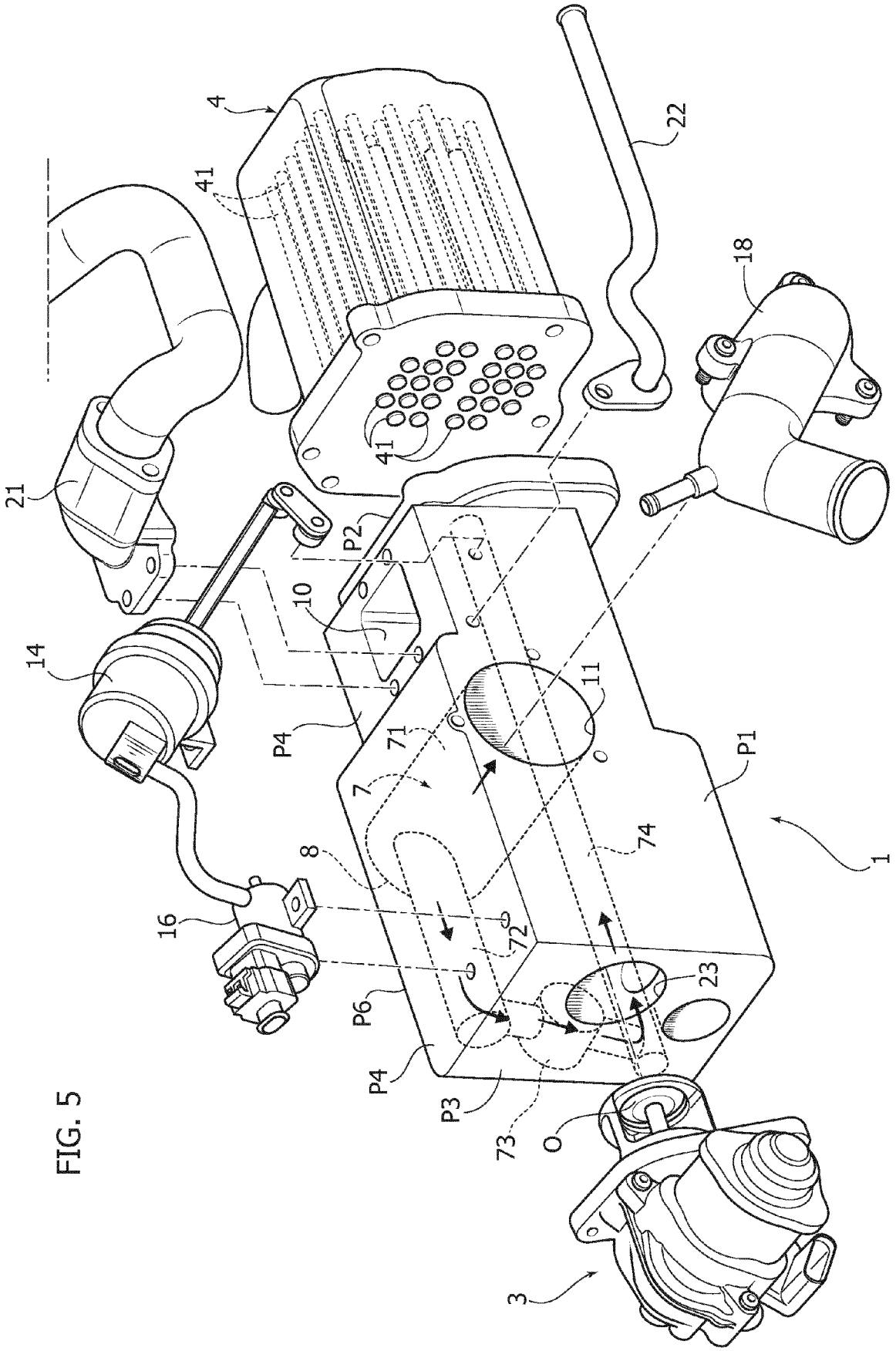


FIG. 5

FIG. 6

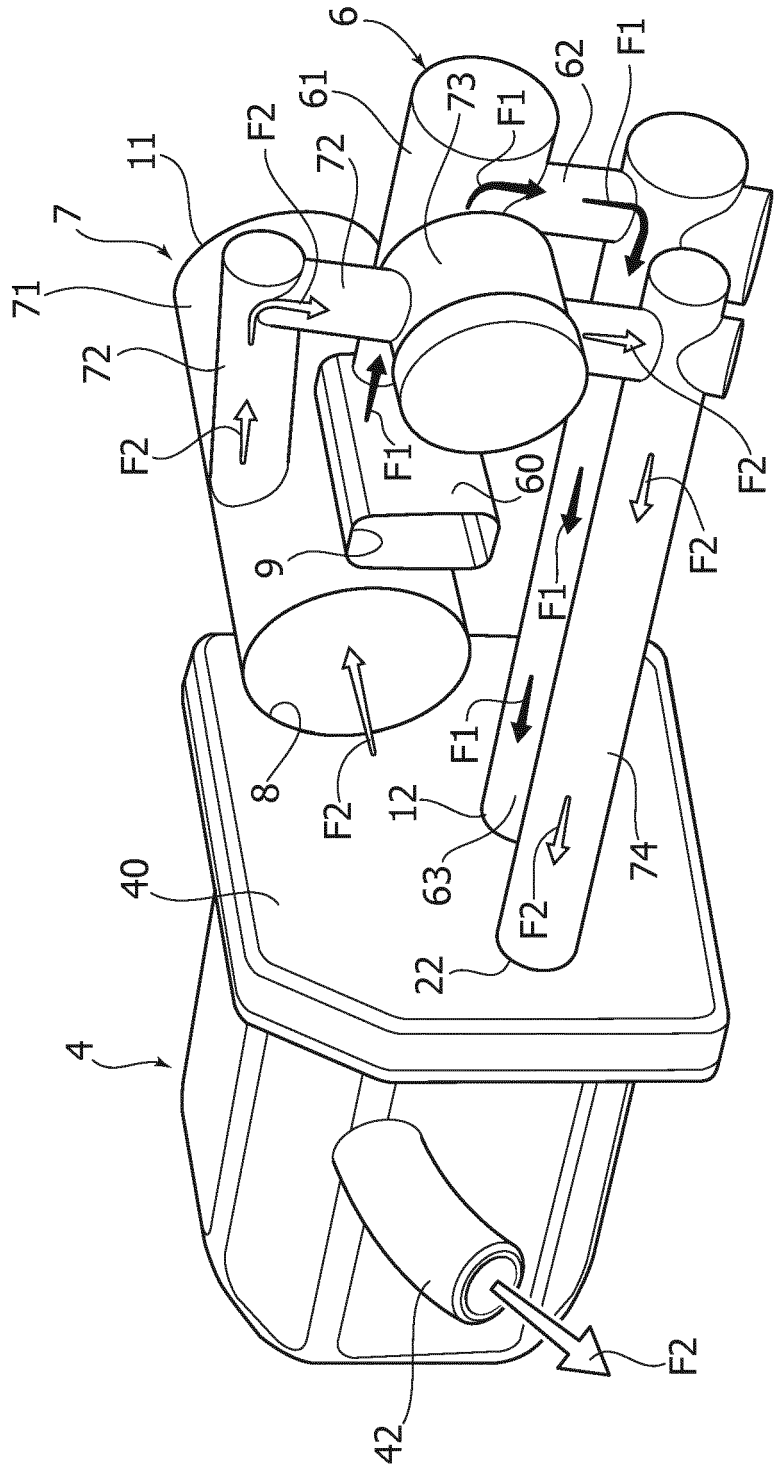

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FIG. 7

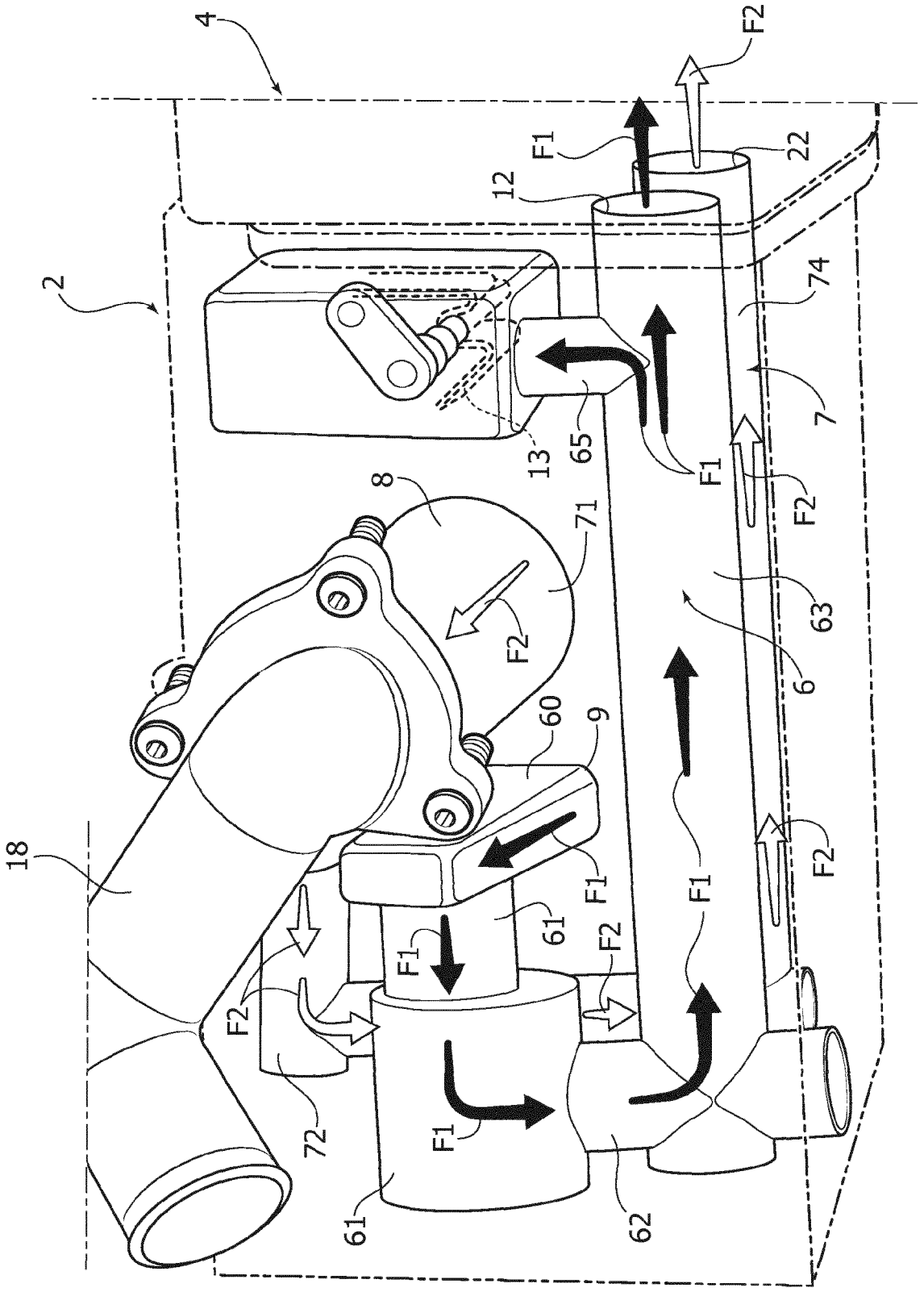
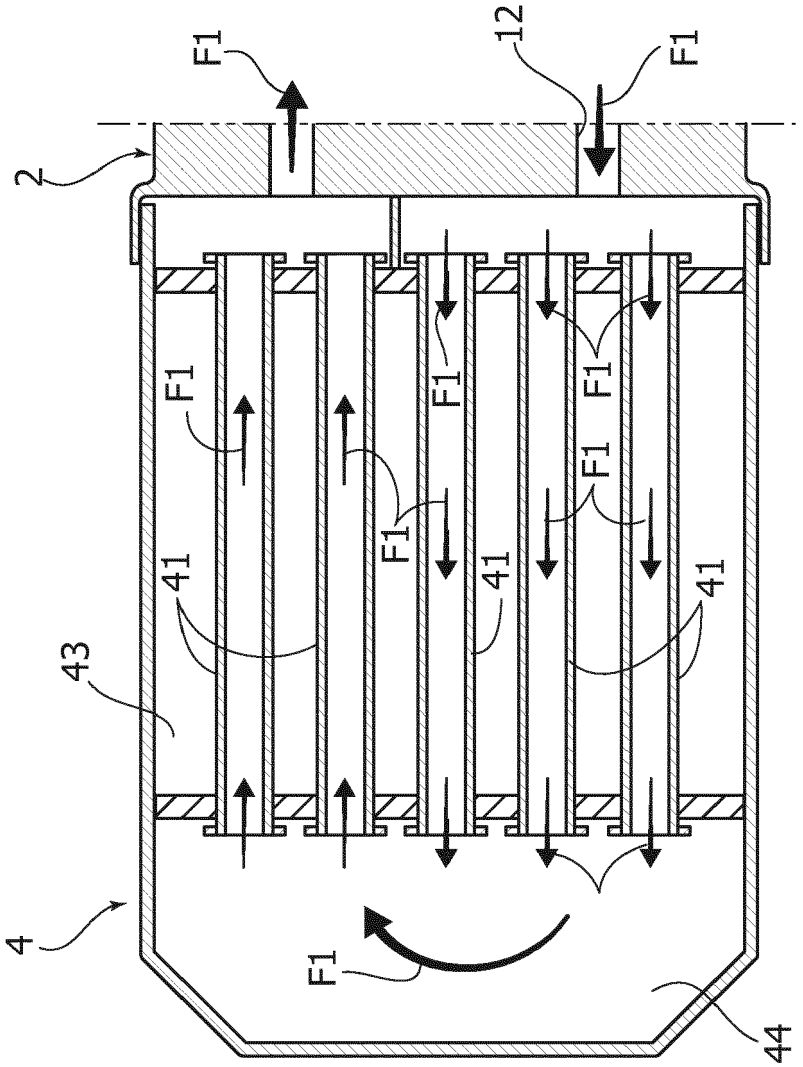

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F1
61
62

FIG. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 5369

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Place of search	Date of completion of the search	Examiner
Munich	29 September 2016	Marsano, Flavio

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