

(51) International Patent Classification:

F02M 25/035 (2006.01) *F02M 25/06* (2016.01)
F02M 35/10 (2006.01) *F02M 25/028* (2006.01)
F02B 37/00 (2006.01) *F02M 26/09* (2016.01)

(21) International Application Number:

PCT/EP2016/060302

(22) International Filing Date:

09 May 2016 (09.05.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **VOLVO TRUCK CORPORATION**
[SE/SE]; 405 08 Göteborg (SE).

(72) Inventor: **YUDANOV, Sergi**; Skratmåsgången 7, 426 69
Västra Frölunda (SE).

(74) Agent: **VOLVO TECHNOLOGY CORPORATION**;
Volvo Group Intellectual Property, BF14100, M1.7, 405 08
Göteborg (SE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: AN INLET SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

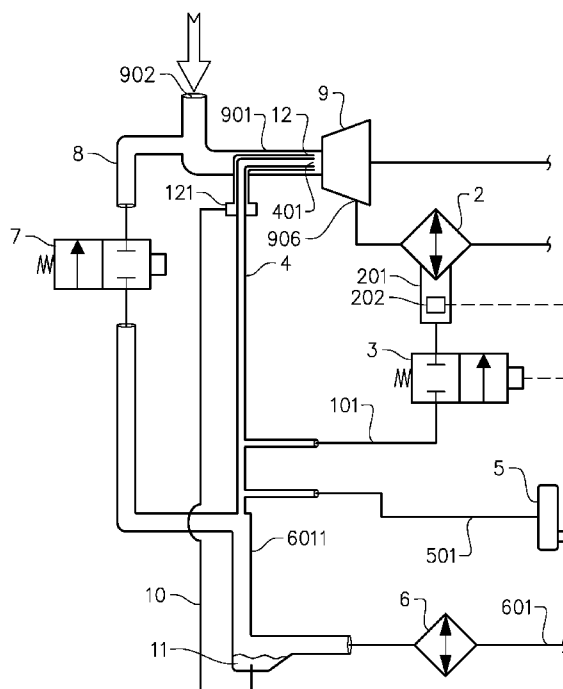


FIG. 5

(57) Abstract: The invention provides an internal combustion engine system comprising - a compressor (9), and - an air guide (901) arranged to guide an air flow from an air inlet (902) to at least one cylinder (301) of the engine via the compressor (9), - characterized in that the inlet system comprises at least two fluid sources (2, 5, 502, 6, 11), and at least two fluid guiding elements (4, 12, 101, 501, 601, 10) each arranged to guide a fluid from a respective of the fluid sources (2, 5, 502, 6, 11) to the air guide (901), between the air inlet (902) and an outlet (906) of the compressor (9).

Published:

— *with international search report (Art. 21(3))*

AN INLET SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

TECHNICAL FIELD

- 5 The invention relates to an inlet system for an internal combustion engine, and internal combustion engine system and a vehicle.

The invention can be applied in heavy-duty vehicles, such as trucks, buses and construction equipment. Although the invention will be described with respect to a heavy-duty vehicle, the invention is not restricted to this particular vehicle, but may also be used
10 in other vehicles such as a car.

BACKGROUND

- 15 In internal combustion engine systems, e.g. for heavy duty vehicles, water may form due to condensation, which water may accumulate and cause problems to the operation of the system. EP1391677 describes a charge air cooler with a condensate outlet opening which is connected to an upstream side of an air charger. However, there is a desire to further reduce possibilities of liquid formation causing problems in an internal combustion engine
20 system.

SUMMARY

- An object of the invention is to reduce risks of problems in internal combustion engine
25 systems due to liquid formation.

The objects are achieved by an inlet system according to claim 1. Thus the invention provides an inlet system for an internal combustion engine, comprising

- a compressor, and
- 30 - an air guide arranged to guide an air flow from an air inlet to at least one cylinder of the engine via the compressor,
- characterized in that the inlet system comprises at least two fluid sources, and at least two fluid guiding elements each arranged to guide a fluid from a respective of the fluid sources to the air guide, between the air inlet and an outlet of the
35 compressor.

By providing at least two fluid guiding elements arranged to guide fluid from a respective of at least two fluid sources, the possibilities of reducing risks of liquid formation, e.g. due to condensation, causing operational problems is greatly reduced. By the fluid guiding
5 elements being arranged to guide the fluid into the air guide, the water may be used for suppression of NO_x formation during the engine operation. Where the engine system comprises a multi cylinder engine, the distribution of the fluid upstream of the compressor, or at least upstream of the outlet of the compressor, may provide an advantageous atomization of condensation liquid from various fluid sources for a better distribution
10 between the engine cylinders.

At least one of the fluid guiding elements may be arranged to guide a fluid from the respective of the fluid sources to the air guide, between the air inlet and the compressor, i.e. upstream of the compressor. Alternatively or in addition, as exemplified below, at least
15 one of the fluid guiding elements and the compressor may be partly integrated, e.g. by a portion of the compressor extending into the at least one of the fluid guiding elements.

Preferably, one of the fluid sources is a charge air cooler, the air guide being arranged to guide the air flow to the at least one cylinder via the charge air cooler, the charge air
20 cooler being located downstream of the compressor. Thereby a condensed water delivery system may advantageously be provided, transporting water condensing in the charge air cooler up to the engine intake for suppression of NO_x formation. The embodiment provides simple means of water delivery to engine intake by utilising the available air pressure difference to drive the water from the charge air cooler to the air guide upstream
25 of the outlet of the compressor.

In some embodiments, one of the fluid sources is a crankcase of the engine or is adapted to communicate with a crankcase of the engine. One of the fluid guiding elements may be a crankcase ventilation conduit for ventilating a crankcase of the engine. In further
30 embodiments, one of the fluid sources may be an oil separator adapted to clean crankcase gas of the engine. The crankcase gas may include blow-by gases which during engine operation enter the crankcase from the combustion chambers of the engine. Where the engine has a relatively high amount of water in the combustion process, the blow-by gases may present a relatively high humidity. Thereby the gases transported to
35 the air duct by the crankcase ventilation conduit will contain water which will be

transported to the air duct. Thus, an effective removal of water from the crankcase is provided, while said water may be due to the transportation to the air guide advantageously used for reduction of NO_x formation in the cylinders.

- 5 As understood from the discussion above, the fluid sources may be liquid sources, and the fluid guiding elements may each be arranged to guide a liquid from a respective of the liquid sources to the air guide, between the air inlet and the outlet of the compressor. The inlet system may comprise a valve arranged to control the communication between one of the liquid sources and the air guide via one of the fluid guiding elements based on an
10 amount of liquid upstream of the valve. In some embodiments, said valve may be a float valve, or an electrically actuated, electronically controlled valve as exemplified below.

Such a valve provides means for reliably emptying liquid from the fluid source in a controlled manner. For example, where the fluid source is a charge air cooler, the valve
15 provides means for disallowing compressed gas, rather than water, out of the charge air cooler, and this will prevent a loss of compressor power due to the fluid guiding element providing the communication between the charge air cooler and the air guide upstream of the outlet of the compressor. Also, the pressure differential over the compressor may vary and become insufficient in some operating conditions for driving water out of the cooler to
20 the air guide upstream of the compressor. When this happens, a relatively large amount of water may accumulate in the cooler and then, upon a sudden change of operating conditions of engine, in systems without a communication between the cooler and the air guide via a fluid guiding element and without a valve for controlling the communication, the accumulated water could rush into the engine and cause undesirable effects. With the
25 fluid guiding element and the valve it will be possible to avoid such large water accumulations.

Preferably, at least two of the fluid guiding elements form a conduit outlet arrangement for injecting fluid into the air guide, upstream of the outlet of the compressor. In particularly
30 advantageous embodiments, the conduit outlet arrangement is, as seen in a transverse cross-section of the air guide, centrally arranged in the air guide. Where the compressor comprises a rotor, the conduit outlet arrangement is preferably arranged to inject the fluid guided by said at least two of the fluid guiding elements towards the centre of the rotor. It is understood that the rotational axis of the rotor may be parallel to the local air flow
35 upstream of the compressor; e.g. as in a centrifugal compressor.

The conduit outlet arrangement may comprise one or more nozzles, ejectors or dispersion device. By the injection towards the centre of the rotor, the risk that water from said fluid sources will damage the rotor is minimized. More specifically, since the linear velocity of the inner rotor part is, due to a smaller radial distance from the centre of rotation, smaller than the velocity of the outer rotor part, the impact velocity of water droplets will be smaller closer to the centre of the rotor.

In some embodiments, where the system comprises a conduit outlet arrangement for injecting fluid guided by at least one of the fluid guiding elements into the air guide, and the compressor comprises a rotor, a restriction of a flow of the injected fluid is provided by the conduit outlet arrangement and the rotor, or a portion of the rotor. The restriction may be created between the end of the fluid guiding element and the rotor. The restriction may provide for the flow cross-sectional area to decrease at the end of the fluid guiding element or as the fluid leaves the fluid guiding element. This will increase the local fluid speed and decrease the pressure at the end of the fluid guiding element. Thereby, fluid transported by the fluid guiding element may be driven by a pressure difference between the fluid source from which the fluid is transported and the end of the fluid guiding element, serving to drive the fluid towards the end of the fluid guiding element, i.e. towards the conduit outlet arrangement.

In some embodiments, the conduit outlet arrangement and the rotor are partly integrated. Thereby, a portion of the rotor may extend into the conduit outlet arrangement. Preferably, the conduit outlet arrangement is located upstream of a high pressure part of the compressor. Preferably, the conduit outlet arrangement is located upstream of a part of the compressor in which part the fluid(s) is/are fully compressed. The compressor may be a centrifugal compressor comprising the rotor onto which blades are mounted. Preferably, the conduit outlet arrangement is located upstream of the blades. By means of the integration, e.g. by a portion of the rotor extending into the conduit outlet arrangement, the restriction may be created between the end of the fluid guiding element and the rotor.

In alternative embodiments, the fluid guiding element may terminate upstream of the compressor rotor. Thereby, a portion of the rotor may present a diameter that is close to the inner diameter of the fluid guiding element. The end of the fluid guiding element may be relatively close to the rotor portion. Thereby, a restriction is created between the end of

the fluid guiding element and the rotor. Similarly to the embodiment described above, this will increase the local fluid speed and decrease the pressure at the end of the fluid guiding element, whereby fluids transported by the fluid guiding element may be driven by a pressure difference between one or more fluid sources from which the fluids are transported and the end of the fluid guiding element, serving to drive the fluids towards the end of the fluid guiding element.

Preferably, at least a part of one of the fluid guiding elements is integrated with at least a part of another of the fluid guiding elements so as to form an integrated fluid guiding element. The integrated fluid guiding element may terminate at the air guide. The integrated fluid guiding element may present a conduit for guiding a fluid from one of the fluid sources as well as a fluid from another of the fluid sources. Thereby, fluids from a plurality of sources may advantageously be injected towards the centre of the rotor of the compressor.

In some embodiments, the integrated fluid guiding element presents a first conduit for guiding a fluid from one of the fluid sources, and a second conduit for guiding a fluid from another of the fluid sources. The first and second conduits are preferably concentrically arranged. Advantageously, said at least two fluid guiding elements are concentrically arranged at the conduit outlet arrangement. Thereby, fluid from two or more fluid sources may be guided separately up to the conduit outlet arrangement, but nevertheless both injected towards the centre of the rotor of the compressor.

In some embodiments, compared to the first conduit, the second conduit extends further downstream in the air guide. This is particularly advantageous where, as exemplified above, the system comprises a conduit outlet arrangement for injecting fluid guided by the fluid guiding elements into the air guide, the compressor comprises a rotor, and the conduit outlet arrangement and the rotor are partly integrated, e.g. by a portion of the rotor extending into the conduit outlet arrangement. Thereby, the conduit outlet arrangement may be formed by downstream ends of the first and second conduits. Since compared to the first conduit, the second conduit extends further downstream in the air guide, the low pressure given as a result of the restriction provided by the first conduit and the rotor, may serve also to drive fluid through the second conduit towards the conduit outlet arrangement.

In some embodiments, one of the fluid sources is a condensation water trap which may trap condensation water in an exhaust gas recirculation conduit for the engine. One of the fluid guiding elements may form a part of an exhaust gas recirculation conduit for the engine. The fluid source, from which said one of the fluid guiding elements is arranged to
5 guide a fluid, may be an exhaust gas cooler arranged to cool exhaust gases in the exhaust gas recirculation conduit. By including such a water trap and/or an exhaust gas cooler in the inlet system in said manner, condensation water in the exhaust gas recirculation conduit may be effectively trapped and removed and used in the engine operation for reduction of NO_x formation. The condensation water trap may be arranged
10 to trap condensation water in the exhaust gas recirculation conduit. E.g., the trap may be provided as a pocket in the conduit, adapted to collect or trap condensation water. Alternatively the condensation water trap may be an area of the exhaust gas recirculation conduit where condensed water tends to collect without said area having been particularly designed for it. E.g. the condensation water trap may be a conduit turn or bend in which
15 condensation water accumulates due to gravity.

Preferably, the condensation water trap is located downstream of the exhaust gas cooler. The fluid guiding element arranged to guide fluid from the condensation water trap may be arranged to guide the fluid to a conduit outlet arrangement as described above. Thereby a
20 pressure differential may be provided to effectuate such a transport of fluid.

The inlet system may comprise in addition to said one of the fluid guiding elements an exhaust gas recirculation bypass conduit arranged to guide exhaust gases from the exhaust gas recirculation conduit to the air guide while bypassing a part of said one of the
25 fluid guiding elements and terminating at the air guide. The exhaust gas recirculation bypass conduit is preferably less restrictive than the bypassed part of said one of the fluid guiding elements. The inlet system preferably comprises a valve for controlling the flow through the exhaust gas recirculation bypass conduit.

30 In operational circumstances where there is little or no water condensation in the exhaust recirculation conduit, and any water therein is provided in a vaporized form, said valve may be open so as to allow recirculated exhaust gases to pass through the bypass conduit. However, when there is a risk of substantial water condensation, e.g. during cold engine operations, the valve may be closed to force recirculated exhaust gases to the
35 conduit outlet arrangement so as to direct the condensate water into the centre of the

compressor rotor. In systems where portions of the exhaust gas recirculation conduit, including the exhaust gas cooler, are located below the compressor, e.g. due to space restrictions, a particularly large amount of water may accumulate in the cooler and in various conduit pockets and turns, and thereby guiding the water in said manner

5 according to embodiments of the invention to the compressor rotor centre will be especially advantageous. As suggested, the bypassed part of said one of the fluid guiding elements may be more restrictive than the exhaust gas recirculation bypass conduit. This will facilitate allowing the conduit outlet arrangement to inject fluid towards the centre of the rotor. More specifically, a relatively restrictive conduit outlet arrangement will provide
10 for concentrating the injected fluid towards the rotor centre.

It is understood that various combinations of fluid sources are possible within the scope of the invention. In particularly advantageous embodiments, one of the fluid sources is a charge air cooler, the air guide being arranged to guide the air flow to the at least one
15 cylinder via the charge air cooler, the charge air cooler being located downstream of the compressor, and one of the fluid sources is a crankcase of the engine, is adapted to communicate with a crankcase of the engine, or is an oil separator adapted to clean crankcase gas of the engine. In further advantageous embodiments one of the fluid sources is a charge air cooler, and one of the fluid sources forms a part of an exhaust gas
20 recirculation conduit for the engine. In some embodiments, one of the fluid sources is a charge air cooler, and one of the fluid sources is a condensation water trap which may trap condensation water in an exhaust gas recirculation conduit for the engine.

The object is also reached with an inlet system for an internal combustion engine,
25 comprising

- a compressor, and
- an air guide arranged to guide an air flow from an air inlet to at least one cylinder of the engine via the compressor,
- characterized in that the inlet system comprises a fluid source, and a fluid guiding
30 element arranged to guide a fluid from the fluid source to the air guide, that the compressor comprises a rotor, that the inlet system comprises a conduit outlet arrangement for injecting fluid guided by the fluid guiding element into the air guide and towards the centre of the rotor, and that a restriction of a flow of the injected fluid is provided by the conduit outlet arrangement and the rotor.

35

Preferably, a portion of the rotor extends into the conduit outlet arrangement. Preferably, the conduit outlet arrangement is, as seen in a transverse cross-section of the air guide, centrally arranged in the air guide. It is understood that the inlet system in which a restriction of a flow of the injected fluid is provided as stated by the conduit outlet
5 arrangement and the rotor may be combined with any suitable aspect or embodiment described herein.

The object is also reached with an internal combustion engine system according to claim 33 and a vehicle according to claim 34.
10 Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

15 With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

20 Fig. 1 is a side view of a vehicle in the form of a truck.

Fig. 2 is a schematic view of an inlet system for an internal combustion engine.

25 Fig. 3 is a schematic drawing of an internal combustion engine system in the vehicle in fig. 1.

Fig. 4 shows a cross-sectional view of a detail in fig. 3.

30 Fig. 5 shows an inlet system for an internal combustion engine, according to an alternative embodiment of the invention.

Fig. 6 shows a cross-sectional view of a detail in fig. 5.

35 DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

Fig. 1 shows a vehicle in the form of a truck, or a tractor for a semitrailer. It should be noted that the vehicle can be of a variety of alternative types, e.g. it may be a car, a bus, or a working machine such as a wheel loader. The vehicle comprises an internal
5 combustion engine system with an internal combustion engine 1 with a plurality of cylinders. It should be noted that the invention is applicable to engines with any number of cylinders, even with a single cylinder. Also, the invention is applicable to engines with any cylinder configuration, e.g. an in-line configuration or a V-configuration.

10 Fig. 2 depicts schematically an inlet system for an internal combustion system, according to an embodiment of the invention. The inlet system comprises a compressor 9, and an air guide 901 arranged to guide an air flow from an air inlet 902 to at least one cylinder 301 of the engine via the compressor 9. The inlet system further comprises two fluid
15 sources 2, 5, and two fluid guiding elements 4, 12 each arranged to guide a fluid from a respective of the fluid sources 2, 5 to the air guide 901, between the air inlet 902 and an outlet 906 of the compressor 9.

The internal combustion engine system in the vehicle in fig. 3 is schematically depicted in fig. 3. In fig. 3 only one of the cylinders 301 of the engine is depicted. Each cylinder
20 presents a piston connected to a crankshaft, which is located in a crankcase 502 of the engine.

The internal combustion engine system comprises for the engine an inlet system. The inlet system comprises a compressor 9, and an air guide 901 arranged to guide an air
25 flow from an air inlet 902 to the cylinders 301 of the engine 1 via the compressor 9.

The compressor 9 is a part of a turbocharger, also comprising a turbine 911 which is fixedly connected to the compressor and arranged to be driven by exhaust gases from the cylinder 301, guided by an exhaust guide 912, as is known per se. Thereby, the
30 compressor 9 is arranged to compress air in the air guide 901. Alternatively, the compressor 9 may be driven in some other suitable manner, for example by the engine camshaft, e.g. via a belt, or by an electric motor.

The inlet system also comprises a first fluid source 2 in the form of a charge air cooler
35 located in the air guide 901, downstream of the compressor 9. The charge air cooler

comprises a bottom part 201 arranged to collect a fluid in the form of condensed water formed in the charge air cooler 2. A first fluid guiding element 4, 101, in the form of a water conduit, is arranged to guide the water from the bottom part 201 to a conduit outlet arrangement 401, closer described below, in the air guide 901, between the air inlet 902 and an outlet 906 of the compressor 9, more specifically, between the air inlet 902 and a rotor of the compressor.

The inlet system further comprises a valve 3 arranged to control the communication between the charge air cooler 2 and the air guide 901 based on an amount of water in the bottom part 201. In this embodiment, the valve is a float valve 3, with a float in the bottom part 201, fixed to shutter arranged to block the water conduit 101. Thereby, gas escape from the charge air cooler is minimized. Alternatively, a simpler arrangement may be utilized, where the connection between the bottom part 201 of the charge air cooler 2 and the first fluid guiding element 4, 101 is effected via a relatively small restrictor orifice, big enough to allow water removal but small enough to limit the energy loss due to pumping the gas in and out of the compressor.

The inlet system further comprises a second fluid source 5 in the form of an oil separator 5 arranged to communicate with the crankcase 502 of the engine. The separator 5 is adapted to clean crankcase gas of the engine from oil as is known per se. A second fluid guiding element 4, 501, in the form of a crankcase ventilation conduit, is arranged to guide a fluid in the form of the cleaned crankcase gases from the oil separator 5 to the air guide 901, between the air inlet 902 and the outlet 906 of the compressor 9, more specifically, between the air inlet 902 and the rotor of the compressor 9.

A part of the second fluid guiding element 501 is integrated with a part of the first fluid guiding element 101 so as to form an integrated fluid guiding element 4. The integrated fluid guiding element presents a conduit 4 for guiding fluid from the charge air cooler 2 as well as fluid from the oil separator 5. The integrated fluid guiding element 4 terminates at the air guide 901, more specifically at the conduit outlet arrangement 401 described closer below.

The crankcase ventilation conduit 501, 4 is arranged to ventilate the crankcase 502. The crankcase gas may include blow-by gases which during engine operation enter the crankcase from the combustion chambers in the cylinders 301. Where the engine has a

relatively high amount of water in the combustion process, the blow-by gases may present a relatively high humidity. Thereby the gases transported to the air duct by the crankcase ventilation conduit 501, 4 will contain water which will be transported to the air duct 901.

5 The engine system comprises an exhaust gas recirculation conduit 601 arranged to guide exhaust gases from a location in the exhaust guide 912 downstream of the turbine 911, to the air duct 901, between the air inlet 902 and the compressor 9. An exhaust gas cooler 6 is arranged to cool exhaust gases in the exhaust gas recirculation conduit 601. Thereby, a part of the exhaust gas recirculation conduit 601 extending between the exhaust gas
10 cooler 6 and the air duct forms what is herein referred to as a third fluid guiding element 6011. Thus, the engine system comprises a so called long-route EGR system. However the invention is also applicable to engine systems with so called short-route EGR systems in which the EGR circuit is fed from upstream of the turbine.

15 A part of the third fluid guiding element 6011 forms a part of the integrated fluid guiding element 4. Thus, said part of the third fluid guiding element 6011 is integrated with the parts of the first and second fluid guiding elements 101, 501. The integrated fluid guiding element is thus arranged to guide fluid from the exhaust gas cooler 6 as well as fluid from the charge air cooler 2 and fluid from the oil separator 5.

20

During engine operation, a relatively large amount of condensation water may form in the exhaust gas cooler 6. By means of the third fluid guiding element 6011, this water may be transported to the conduit outlet arrangement 401 described below.

25 The conduit outlet arrangement 401 is provided for injecting the water containing fluid from the charge air cooler 2, the oil separator 5 and the exhaust gas cooler 6, into the air guide 901, upstream of the compressor 9. The conduit outlet arrangement 401 is, as seen in a transverse cross-section of the air guide 901, centrally arranged in the air guide 901. More specifically, a nozzle of the conduit outlet arrangement 401 is, as seen in a
30 transverse cross-section of the air guide 901, centrally arranged in the air guide 901.

The compressor 9 is a centrifugal compressor comprising as suggested a rotor. The conduit outlet arrangement 401 is arranged to deliver the fluid from the charge air cooler 2, the oil separator 5 and the exhaust gas cooler 6, towards the centre of the rotor.

35 Thereby, the risk that water from said fluid sources 2, 5, 6 will damage the rotor is

minimized. More specifically, since the linear velocity of the inner rotor part is, due to a smaller radial distance from the centre of rotation, smaller than the velocity of the outer rotor part, the impact velocity of water droplets will be smaller at the centre of the rotor.

- 5 As suggested in fig. 4, the rotor 907 of the compressor 9 comprises a rotor body 903 with blades 908 for compressing the air, and also a rotor shaft 904. Downstream of the blades 908 and upstream of the compressor outlet 906, the compressor 9 presents a high pressure part in which the fluids entering the compressor are fully compressed, i.e. compressed according to the capacity of the compressor in the operational
- 10 circumstances. At the centre of the rotor 907 the rotor body 903 is mounted on the rotor shaft by means of a bolt 904 with a head 905. The integrated fluid guiding element 4 terminates upstream of the rotor 907.

- The bolt head 905 presents a diameter that is close to the inner diameter of the second
- 15 conduit 12, and the end of the integrated fluid guiding element 4 is relatively close to the bolt head 905. Thereby, a restriction is created between the end of the first conduit 4 and the rotor 907. This will increase the local fluid speed and decrease the pressure at the end of the integrated fluid guiding element 4. Thereby, fluids transported by the integrated fluid guiding element 4 may be driven by a pressure difference between the fluid sources 2, 5,
- 20 6 from which the fluids are transported and the end of the integrated fluid guiding element 4, serving to drive the fluids towards the conduit outlet arrangement 401.

- Reference is made again to fig. 3. The inlet system further comprises an exhaust gas recirculation bypass conduit 8 arranged to guide exhaust gases from the part of the
- 25 exhaust gas recirculation conduit 601 forming the third fluid guiding element 6011, to the air guide 901 while bypassing a part of the third fluid guiding element 6011. In this embodiment, the exhaust gas recirculation bypass conduit 8 bypasses the integrated fluid guiding element 4, and terminates in the air guide 901, between the air inlet 902 and the conduit outlet arrangement 401.

30

- The exhaust gas recirculation bypass conduit 8 is less restrictive than the integrated fluid guiding element 401. The inlet system further comprises a valve 7 for controlling the flow through the exhaust gas recirculation bypass conduit 8. The valve 7 may be opened, e.g. by control of an electronic control unit (not shown), in operational conditions where the
- 35 temperature downstream of the exhaust gas cooler 6 is high enough to preclude formation

of any condensed water. The control of the valve 7 may be based on signals from a temperature sensor downstream of the exhaust gas cooler 6.

Reference is made to fig. 5 depicting an inlet system according to an alternative
5 embodiment. The embodiment shares features with the embodiment described above with reference to fig. 3, but presents the following differences:

In addition to the first, second and third fluid sources 2, 5, 6, the inlet system in fig. 5
comprises a fourth fluid source 11 in the form of a condensation water trap 11 arranged to
10 trap condensation water in the exhaust gas recirculation conduit 601. The condensation water trap 11 is provided as a pocket in the conduit 601, and is located downstream of the exhaust gas cooler 6. A fourth fluid guiding element 10 is arranged to guide a fluid from the fourth fluid source 11 to the conduit outlet arrangement 401.

15 A part of the fourth fluid guiding element 10 is integrated with parts of the first, second and third fluid guiding elements 101, 501, 6011 so that the first, second, third and fourth fluid guiding elements 101, 501, 6011, 10 form an integrated fluid guiding element 4, 12. The integrated fluid guiding element presents a first conduit 4 arranged to guide fluids from the first, second and third fluid sources 2, 5, 6. The integrated fluid guiding element further
20 presents a second conduit 12 arranged to guide fluid from the fourth fluid source 11. A separated part of the fourth fluid guiding element 10 extends from the fourth fluid source to an upstream end 121 of the second conduit. The upstream end 121 of the second conduit 12 has an increased radial extension to provide for a beneficial distribution of the fluid delivered by the separated part of the fourth fluid guiding element 10.

25

The first and second conduits are coaxially arranged whereby the second conduit 12 is arranged externally of the first conduit 4. This coaxial arrangement continues all the way to the conduit outlet arrangement 401 where fluids from both conduits are injected towards the centre of the rotor of the compressor 9, similarly as described above. For this
30 the conduit outlet arrangement 401 presents two coaxial nozzles, each arranged to receive fluid guided by a respective of the first and second conduits 4, 12. The coaxial arrangement is thus provided as a double-walled pipe.

As suggested in fig. 6, the rotor 907 of the compressor 9 comprises a rotor body 903 with
35 blades 908 for compressing the air, and also a rotor shaft 904. Downstream of the blades

908 and upstream of the compressor outlet 906, the compressor 9 presents a high pressure part in which the fluids entering the compressor are fully compressed, i.e. compressed according to the capacity of the compressor in the operational circumstances. At the centre of the rotor 907 the rotor body 903 is mounted on the rotor shaft 904 by means of a retaining nut 905. At the conduit outlet arrangement 401 the shaft 904 extends somewhat into the first conduit 4. Further, compared to the first conduit 4, the second conduit 12 extends further towards the rotor body 903, i.e. further downstream in the air guide 901. Thereby, the rotor shaft 904 and the retaining nut 905 extends into the second conduit 12. The conduits 4, 12 terminate upstream of blades 908 of rotor 907.

10

Thus, the conduit outlet arrangement 401 and the rotor 907 are partly integrated by a portion of the rotor 907 extending into the conduit outlet arrangement 401. By a portion of the rotor 907 extending into the conduit outlet arrangement, a restriction is created between the end of the first conduit 4 and the rotor 907. This will increase the local fluid speed and decrease the pressure at the end of the first conduit 4. Thereby, fluids transported by the first conduit may be driven by a pressure difference between the fluid sources 2, 5, 6 from which the fluids are transported and the end of the first conduit, serving to drive the fluids towards the conduit outlet arrangement 401.

20 In addition, since compared to the first conduit 4, the second conduit 12 extends further downstream in the air guide 901, the low pressure given as a result of the restriction provided by the first conduit 4 and the rotor 907, may serve also to drive fluid through the second conduit towards the conduit outlet arrangement 401. In addition, the retaining nut 905 extending into the second conduit 12 provides a further restriction also serving to drive fluid through the second conduit 12 towards the conduit outlet arrangement 401. In alterative embodiments, the retaining nut 905 may present a diameter that is close to the inner diameter of the second conduit 12, and a restriction may be achieved by positioning the opening of the second conduit 12 close to the retaining nut 905 without the latter extending into the second conduit 12.

30

In the embodiment in fig. 5, the valve 3 for controlling the communication between the charge air cooler 2 and the conduit outlet arrangement 401 is provided in the form of an electronically controlled, electrically actuated valve 3. The valve 3 is controlled based on a sensor 202 in the bottom part 201 of the charge air cooler 2, which sensor is arranged to provide signals indicative of the water level in the bottom part 201.

35

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended
5 claims.

CLAIMS

1. An inlet system for an internal combustion engine, comprising
 - a compressor (9), and
 - 5 - an air guide (901) arranged to guide an air flow from an air inlet (902) to at least one cylinder (301) of the engine via the compressor (9),
 - characterized in that the inlet system comprises at least two fluid sources (2, 5, 502, 6, 11), and at least two fluid guiding elements (4, 12, 101, 501, 6011, 10) each arranged to guide a fluid from a respective of the fluid sources (2, 5, 502, 6,
 - 10 11) to the air guide (901), between the air inlet (902) and an outlet (906) of the compressor (9).
2. An inlet system according to claim 1, characterized in that one of the fluid sources (2) is a charge air cooler (2), the air guide (901) being arranged to guide the air
- 15 flow to the at least one cylinder (301) via the charge air cooler, the charge air cooler being located downstream of the compressor (9).
3. An inlet system according to any one of the preceding claims, characterized in that one of the fluid sources is a crankcase (502) of the engine or is adapted to
- 20 communicate with a crankcase (502) of the engine.
4. An inlet system according to any one of the preceding claims, characterized in that one of the fluid guiding elements is a crankcase ventilation conduit (501) for ventilating a crankcase (502) of the engine.
- 25 5. An inlet system according to any one of the preceding claims, characterized in that one of the fluid sources is an oil separator (5) adapted to clean crankcase gas of the engine.
- 30 6. An inlet system according to any one of the preceding claims, characterized in that the fluid sources are liquid sources, and the fluid guiding elements (4, 12, 101, 501, 6011, 10) are each arranged to guide a liquid from a respective of the liquid sources (2, 5, 502, 6, 11) to the air guide (901), between the air inlet (902) and the outlet (906) of the compressor.

7. An inlet system according to claim 6, characterized in that the inlet system comprises a valve (3) arranged to control the communication between one of the liquid sources and the air guide via one of the fluid guiding elements (101) based on an amount of liquid upstream of the valve.
- 5
8. An inlet system according to claim 7, characterized in that said valve is a float valve (3).
9. An inlet system according to any one of the preceding claims, characterized in that at least two of the fluid guiding elements (4, 12, 101, 501, 6011, 10) form a conduit outlet arrangement (401) for injecting fluid into the air guide (901), upstream of the outlet (906) of the compressor (9).
- 10
10. An inlet system according to claim 9, characterized in that the conduit outlet arrangement (401) is, as seen in a transverse cross-section of the air guide (901), centrally arranged in the air guide (901).
- 15
11. An inlet system according to any one of claims 9-10, characterized in that the compressor (9) comprises a rotor (907), wherein the conduit outlet arrangement (401) is arranged to inject the fluid guided by said at least two of the fluid guiding elements (4, 12, 101, 501, 6011, 10) towards the centre of the rotor (907).
- 20
12. An inlet system according to any one of claims 9-11, characterized in that said at least two of the fluid guiding elements (4, 12, 101, 501, 6011, 10) are concentrically arranged at the conduit outlet arrangement.
- 25
13. An inlet system according to any one of the preceding claims, characterized in that the system comprises a conduit outlet arrangement (401) for injecting fluid guided by at least one of the fluid guiding elements (4, 12, 101, 501, 6011, 10) into the air guide (901), that the compressor (9) comprises a rotor (907) and that a restriction of a flow of the injected fluid is provided by the conduit outlet arrangement and the rotor.
- 30

14. An inlet system according to claim 13, characterized in that a portion of the rotor (907) extends into the conduit outlet arrangement (401).
15. An inlet system according to any one of the preceding claims, characterized in that
5 at least a part of one of the fluid guiding elements (501, 6011, 10) is integrated with at least a part of another of the fluid guiding elements (101) so as to form an integrated fluid guiding element (4, 12).
16. An inlet system according to claim 15, characterized in that the integrated fluid
10 guiding element terminates at the air guide (901).
17. An inlet system according to any one of claims 15-16, characterized in that the integrated fluid guiding element (4, 12) presents a conduit (4) for guiding a fluid from one of the fluid sources as well as a fluid from another of the fluid sources.
15
18. An inlet system according to any one of claims 15-16, characterized in that the integrated fluid guiding element (4, 12) presents a first conduit (4) for guiding a fluid from one of the fluid sources, and a second conduit (10) for guiding a fluid from another of the fluid sources.
20
19. An inlet system according to claim 18, characterized in that the first and second conduits (4, 12) are concentrically arranged.
20. An inlet system according to any one of claims 18-19, characterized in that
25 compared to the first conduit (4), the second conduit (12) extends further downstream in the air guide (901).
21. An inlet system according to any one of the preceding claims, characterized in that one of the fluid sources is a condensation water trap (11) which may trap
30 condensation water in an exhaust gas recirculation conduit (601) for the engine.
22. An inlet system according to any one of the preceding claims, characterized in that one of the fluid guiding elements (6011) forms a part of an exhaust gas recirculation conduit (601) for the engine.
35

23. An inlet system according to claim 22, characterized in that the fluid source, from which said one (6011) of the fluid guiding elements is arranged to guide a fluid, is an exhaust gas cooler (6) arranged to cool exhaust gases in the exhaust gas recirculation conduit (601).

5

24. An inlet system according to any one of claims 22-23, characterized in that the inlet system comprises in addition to said one (6011) of the fluid guiding elements an exhaust gas recirculation bypass conduit (8) arranged to guide exhaust gases from the exhaust gas recirculation conduit (601) to the air guide (901) while bypassing a part of said one (6011) of the fluid guiding elements and terminating at the air guide.

10

25. An inlet system according to claim 24, characterized in that the exhaust gas recirculation bypass conduit (8) is less restrictive than the bypassed part of said one (6011) of the fluid guiding elements.

15

26. An inlet system according to any one of claims 24-25, characterized in that the inlet system comprises a valve (7) for controlling the flow through the exhaust gas recirculation bypass conduit (8).

20

27. An inlet system according to any one of the preceding claims, characterized in that one of the fluid sources is a charge air cooler (2), the air guide (901) being arranged to guide the air flow to the at least one cylinder (301) via the charge air cooler, the charge air cooler being located downstream of the compressor (9), and in that one of the fluid sources is a crankcase (502) of the engine, is adapted to communicate with a crankcase (502) of the engine, or is an oil separator (5) adapted to clean crankcase gas of the engine.

25

28. An inlet system according to any one of the preceding claims, characterized in that one of the fluid sources is a charge air cooler (2), the air guide (901) being arranged to guide the air flow to the at least one cylinder (301) via the charge air cooler, the charge air cooler being located downstream of the compressor (9), and in that one (6011) of the fluid sources forms a part of an exhaust gas recirculation conduit (601) for the engine.

30

35

29. An inlet system according to any one of the preceding claims, characterized in that one of the fluid sources is a charge air cooler (2), the air guide (901) being arranged to guide the air flow to the at least one cylinder (301) via the charge air cooler, the charge air cooler being located downstream of the compressor (9), and
5 in that one of the fluid sources is a condensation water trap (11) which may trap condensation water in an exhaust gas recirculation conduit (601) for the engine.

30. An inlet system for an internal combustion engine, comprising

- a compressor (9), and
- 10 - an air guide (901) arranged to guide an air flow from an air inlet (902) to at least one cylinder (301) of the engine via the compressor (9),
- characterized in that the inlet system comprises a fluid source (2, 5, 502, 6, 11), and a fluid guiding element (4, 12, 101, 501, 6011, 10) arranged to guide a fluid from the fluid source (2, 5, 502, 6, 11) to the air guide (901), that the compressor
15 (9) comprises a rotor (907), that the inlet system comprises a conduit outlet arrangement (401) for injecting fluid guided by the fluid guiding element (4, 12, 101, 501, 6011, 10) into the air guide (901) and towards the centre of the rotor (907), and that a restriction of a flow of the injected fluid is provided by the conduit outlet arrangement and the rotor.

20

31. An inlet system according to claim 30, characterized in that a portion of the rotor (907) extends into the conduit outlet arrangement (401).

32. An inlet system according to any one of claims 30-31, characterized in that the
25 conduit outlet arrangement (401) is, as seen in a transverse cross-section of the air guide (901), centrally arranged in the air guide (901).

33. An internal combustion engine system comprising an inlet system according to any one of the preceding claims.

30

34. A vehicle comprising an internal combustion engine system according to claim 33.

1/6

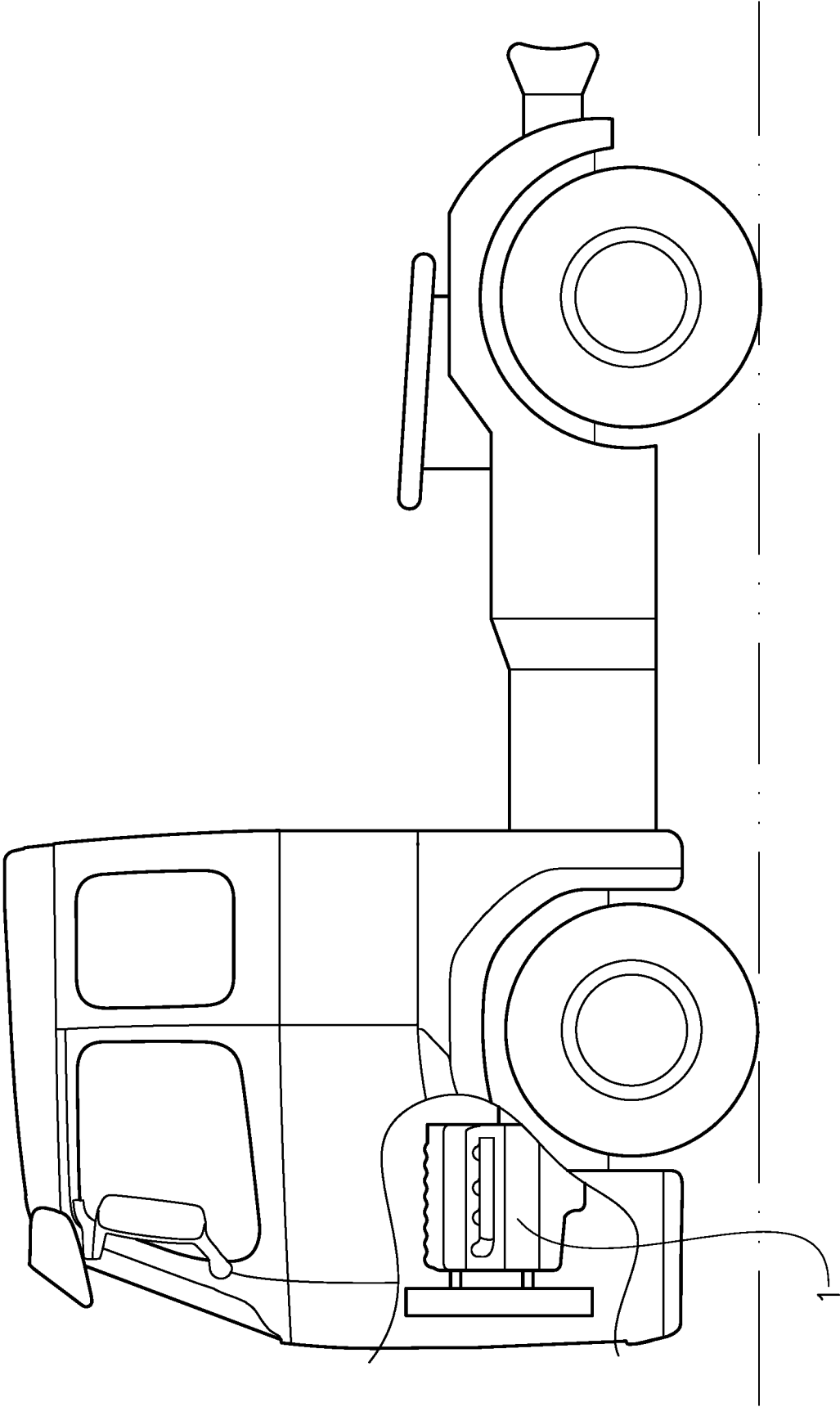


FIG. 1

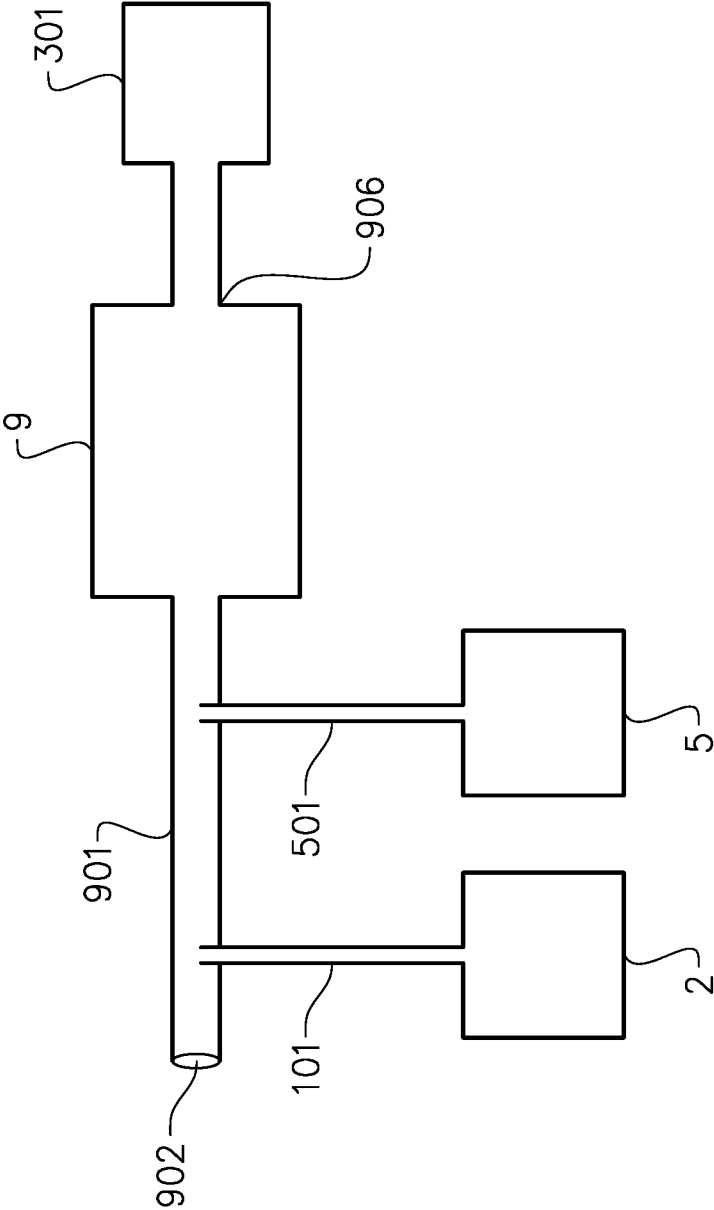


FIG. 2

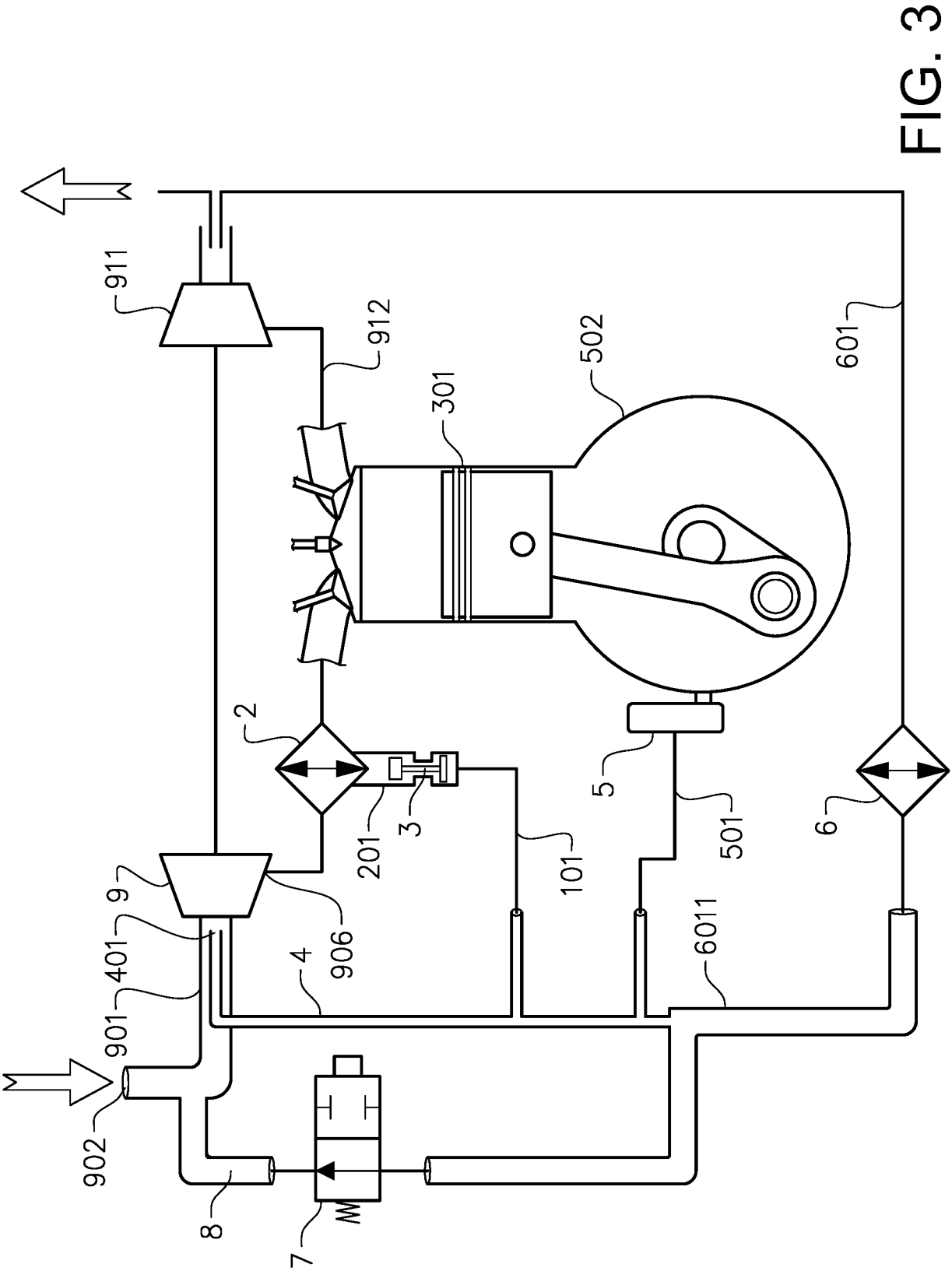


FIG. 3

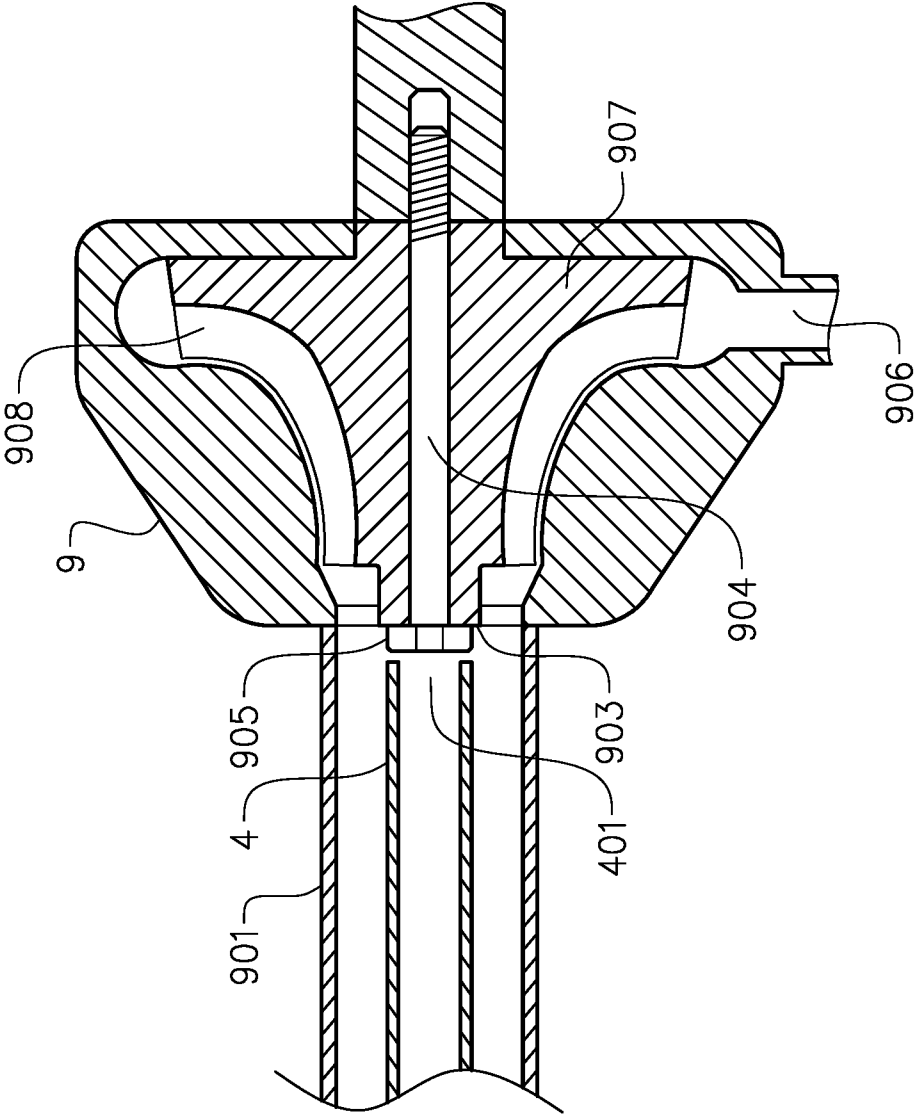


FIG. 4

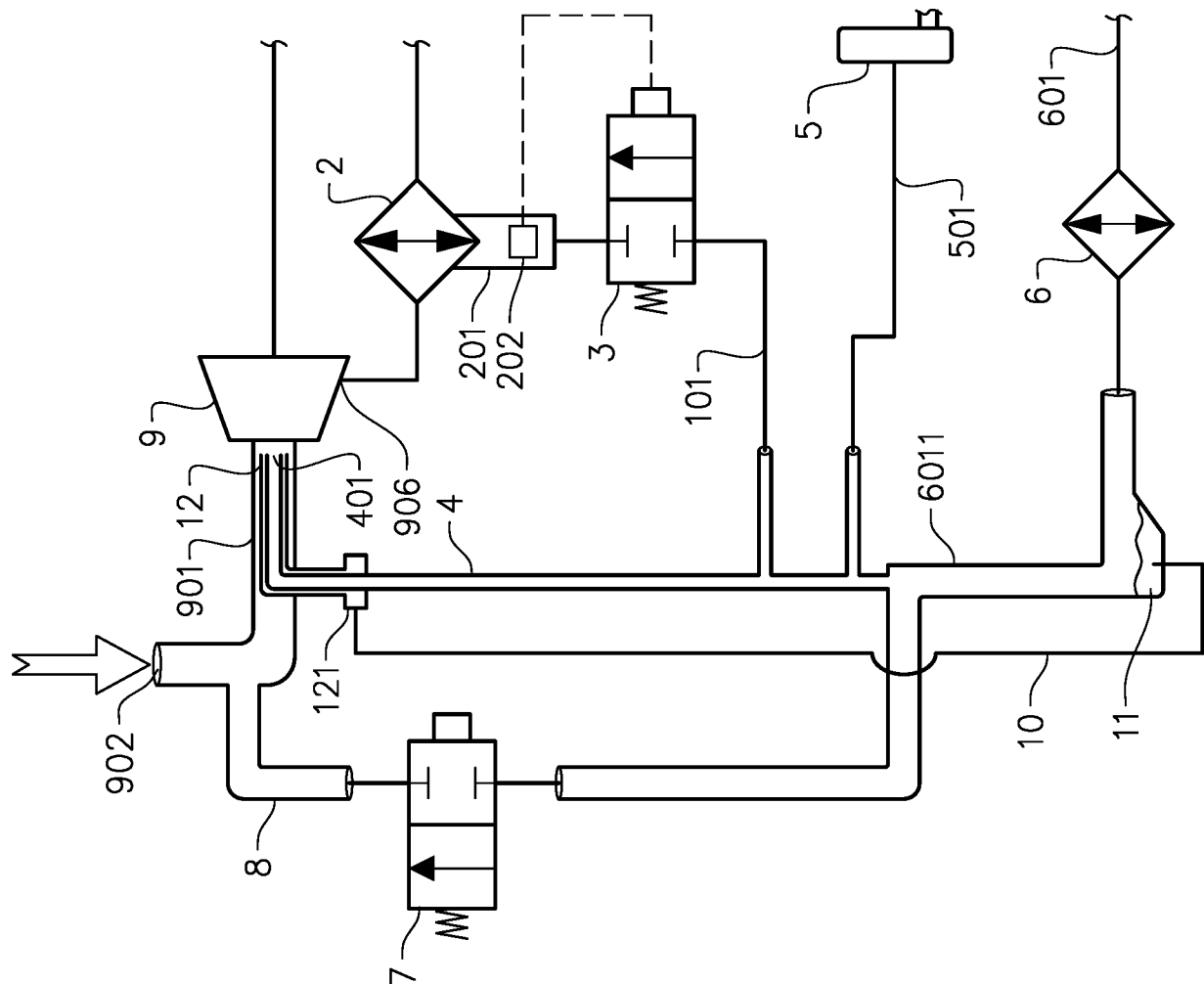


FIG. 5

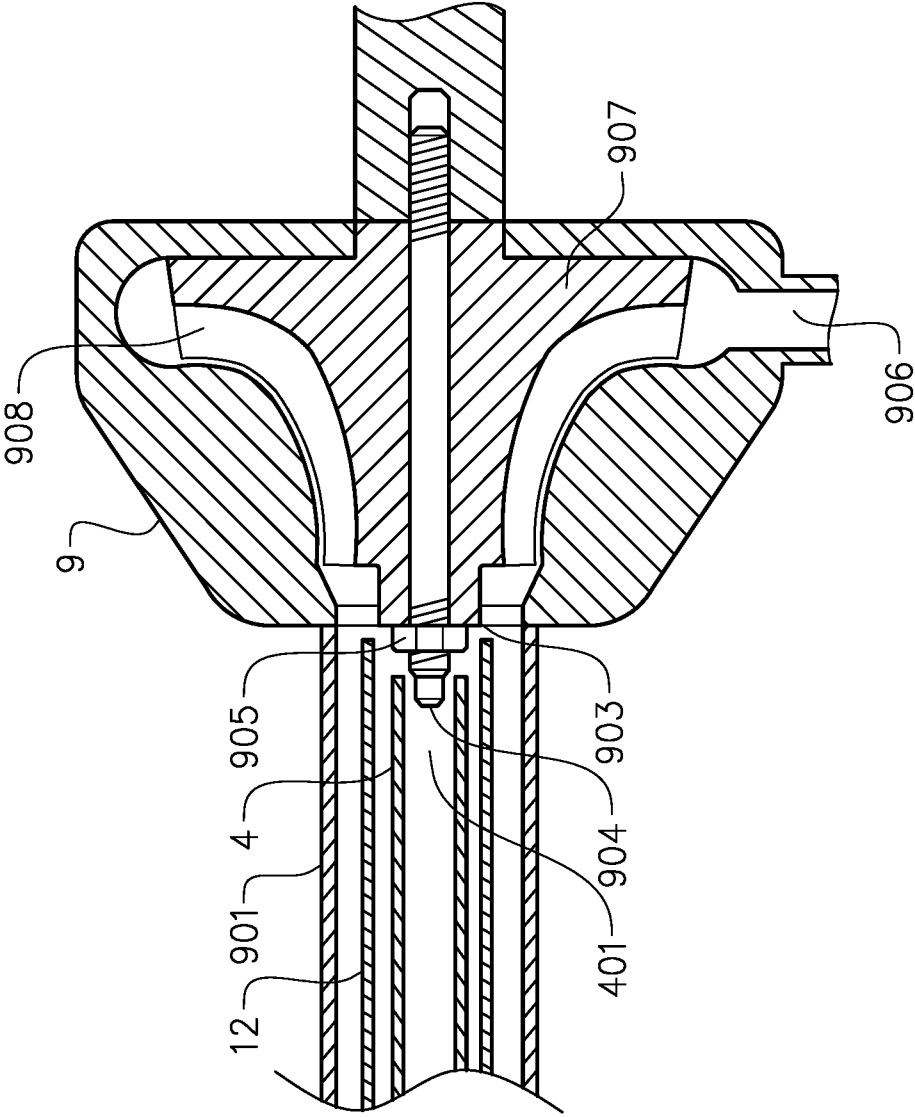


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/060302

A. CLASSIFICATION OF SUBJECT MATTER INV. F02M25/035 F02M35/10 F02B37/00 F02M25/06 F02M25/028 F02M26/09 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) F02B F02M F02C 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 <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>EP 2 570 629 A1 (MITSUBISHI HEAVY IND LTD [JP]) 20 March 2013 (2013-03-20)</td> <td>1-9,11,13,14,21-29,33,34</td> </tr> <tr> <td>Y</td> <td>paragraph [0020] - paragraph [0025]; figures 1-8</td> <td>10,12,15-20</td> </tr> <tr> <td>Y</td> <td>----- WO 2015/098391 A1 (TOYOTA MOTOR CO LTD [JP]) 2 July 2015 (2015-07-02) paragraph [0018] - paragraph [0023]; figures 1-3</td> <td>10,12,15-20</td> </tr> <tr> <td>X</td> <td>----- FR 2 922 961 A1 (VALEO SYSTEMES THERMIQUES [FR]) 1 May 2009 (2009-05-01) page 6, line 19 - page 6, line 24; figures 1,2 ----- -/--</td> <td>1</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	EP 2 570 629 A1 (MITSUBISHI HEAVY IND LTD [JP]) 20 March 2013 (2013-03-20)	1-9,11,13,14,21-29,33,34	Y	paragraph [0020] - paragraph [0025]; figures 1-8	10,12,15-20	Y	----- WO 2015/098391 A1 (TOYOTA MOTOR CO LTD [JP]) 2 July 2015 (2015-07-02) paragraph [0018] - paragraph [0023]; figures 1-3	10,12,15-20	X	----- FR 2 922 961 A1 (VALEO SYSTEMES THERMIQUES [FR]) 1 May 2009 (2009-05-01) page 6, line 19 - page 6, line 24; figures 1,2 ----- -/--	1
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.															
X	EP 2 570 629 A1 (MITSUBISHI HEAVY IND LTD [JP]) 20 March 2013 (2013-03-20)	1-9,11,13,14,21-29,33,34															
Y	paragraph [0020] - paragraph [0025]; figures 1-8	10,12,15-20															
Y	----- WO 2015/098391 A1 (TOYOTA MOTOR CO LTD [JP]) 2 July 2015 (2015-07-02) paragraph [0018] - paragraph [0023]; figures 1-3	10,12,15-20															
X	----- FR 2 922 961 A1 (VALEO SYSTEMES THERMIQUES [FR]) 1 May 2009 (2009-05-01) page 6, line 19 - page 6, line 24; figures 1,2 ----- -/--	1															
☒ 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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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 30 November 2016		Date of mailing of the international search report 03/02/2017															
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 Marsano, Flavio															

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/060302

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2010 054478 A1 (BRUSS DICHTUNGSTECHNIK [DE]) 14 June 2012 (2012-06-14) paragraph [0011] - paragraph [0015]; figure 1 -----	1
A	DE 10 2008 005308 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 23 July 2009 (2009-07-23) paragraph [0012] - paragraph [0014]; figure 1 -----	1
A	FR 2 936 023 A1 (VALEO SYSTEMES THERMIQUES [FR]) 19 March 2010 (2010-03-19) page 6, line 11 - page 8, line 7; figures 1,2 -----	1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2016/060302

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-29, 33, 34

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-29, 33, 34

An inlet system for an internal combustion engine, comprising a compressor (9), and an air guide (901) arranged to guide an air flow from an air inlet (902) to at least one cylinder (301) of the engine via the compressor (9), characterized in that the inlet system comprises at least two fluid sources (2, 5, 502, 6, 11), and at least two fluid guiding elements (4, 12, 101, 501, 6011, 10) each arranged to guide a fluid from a respective of the fluid sources (2, 5, 502, 6, 11) to the air guide (901), between the air inlet (902) and an outlet (906) of the compressor (9).

2. claims: 30-32

An inlet system for an internal combustion engine, comprising a compressor (9), and an air guide (901) arranged to guide an air flow from an air inlet (902) to at least one cylinder (301) of the engine via the compressor (9), characterized in that the inlet system comprises a fluid source (2, 5, 502, 6, 11), and a fluid guiding element (4, 12, 101, 501, 6011, 10) arranged to guide a fluid from the fluid source (2, 5, 502, 6, 11) to the air guide (901), that the compressor (9) comprises a rotor (907), that the inlet system comprises a conduit outlet arrangement (401) for injecting fluid guided by the fluid guiding element (4, 12, 101, 501, 6011, 10) into the air guide (901) and towards the centre of the rotor (907), and that a restriction of a flow of the injected fluid is provided by the conduit outlet arrangement and the rotor.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/060302

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2570629	A1	20-03-2013	CN 103270272 A 28-08-2013
			EP 2570629 A1 20-03-2013
			JP 5047352 B2 10-10-2012
			JP 2012140876 A 26-07-2012
			US 2013266436 A1 10-10-2013
			WO 2012090723 A1 05-07-2012
WO 2015098391	A1	02-07-2015	JP 2015124661 A 06-07-2015
			WO 2015098391 A1 02-07-2015
FR 2922961	A1	01-05-2009	NONE
DE 102010054478	A1	14-06-2012	NONE
DE 102008005308	A1	23-07-2009	NONE
FR 2936023	A1	19-03-2010	NONE