(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 328 430 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.02.2024 Bulletin 2024/09

(21) Application number: **23192419.2**

(22) Date of filing: **21.08.2023**

(51) International Patent Classification (IPC):
F02B 29/04 *(2006.01)* ***F02B 37/007*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F02B 29/0412; F02B 29/0425; F02B 37/007;
F02B 2275/30

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **25.08.2022 IT 202200017595**

(71) Applicant: **FERRARI S.p.A.**
41100 Modena (IT)

(72) Inventor: **FAVARETTO, Fabrizio**
41100 MODENA (IT)

(74) Representative: **Studio Torta S.p.A.**
Viale Antonio Silvani, 6
40122 Bologna (IT)

(54) **CAR PROVIDER WITH A SUPERCHARGED INTERNAL COMBUSTION ENGINE PROVIDED WITH INTERCOOLER**

(57) A car (1) comprising: two front wheels (2) ; two rear drive wheels (4); a supercharged internal combustion engine (5) that is provided with a plurality of cylinders (18), where respective pistons (19) slide on the inside, and a drive shaft (20) connected to the pistons (19), and is longitudinally arranged in a central or rear position; at least one compressor (49) that is arranged along an intake duct (34, 38) and is configured to compress air to be sucked up by the supercharged internal combustion engine (5); a first intercooler (39) that is arranged along the intake duct (34, 38) downstream of the compressor (49); and a second intercooler (40) that is arranged along the intake duct (34, 38) downstream of the first intercooler (39) and, hence, is connected in series to the first intercooler (39).

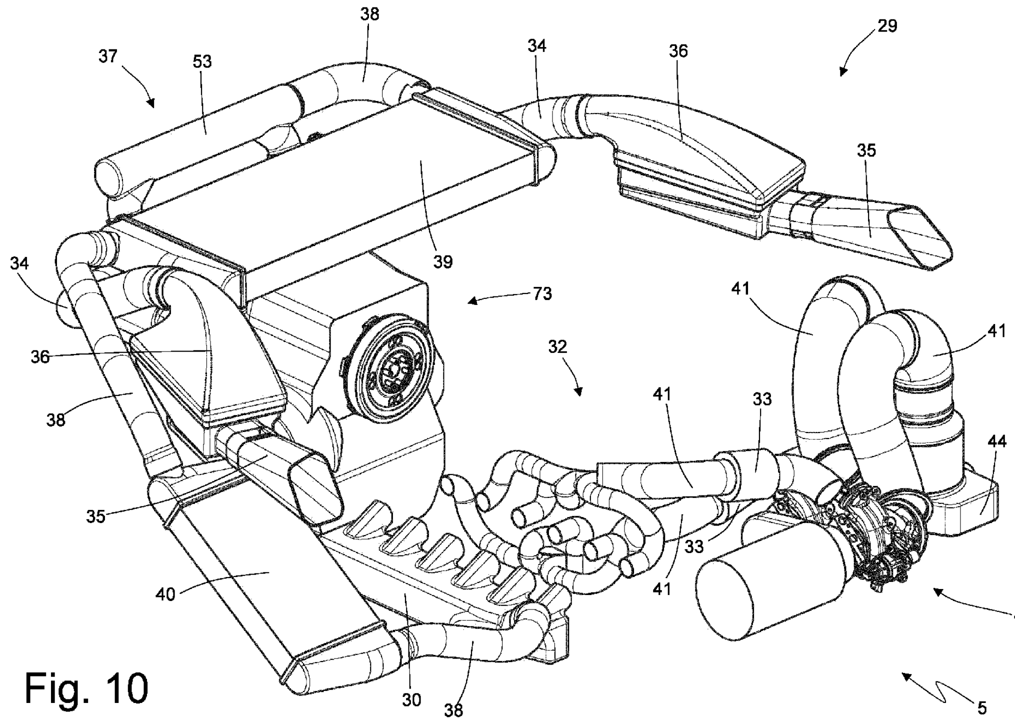


Fig. 10

EP 4 328 430 A1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from Italian patent application no. 102022000017595 filed on August 25, 2022, the entire disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] This invention relates to a car provided with a supercharged internal combustion engine.

PRIOR ART

[0003] For many years, it has been known to use supercharging (i.e., the forced introduction of air in the cylinders at a pressure above atmospheric pressure) in internal combustion engines to increase the volumetric yield of the cylinders and, thus, ensure the internal combustion engines greater power and torque with the same capacity. In other words, along the intake duct a compressor is arranged that compresses the intake air to increase the pressure (and, thus, the capacity) of the intake air and is driven by a turbine that is rotated by exhaust gases (in the case of a turbocompressor), by the drive shaft, or (in more recent applications) by an electric motor.

[0004] The compression of the intake air operated by the compressor inevitably increases the temperature of the air itself; as a result, to increase the volumetric yield of the internal combustion engine and to eliminate pre-combustion caused by an excessive temperature of the air, a heat exchanger (called an "intercooler") is installed in series with the compressor (i.e., downstream of the compressor) having the function of cooling the air directed towards the cylinders. In other words, the intercooler is an air-to-air or air-to-water heat exchanger that cools the air coming out of the compressor before the air enters the cylinders.

[0005] The positioning of the intercooler in the engine compartment may be problematic both because the intercooler has large dimensions and because the intercooler must be connected to a radiator (in the case of an air-to-water intercooler) or to an air duct (in the case of an air-to-air intercooler). Thus, often the placement of the intercooler is a compromise between the space actually available and the operational needs that inevitably penalises the efficacy and efficiency of the intercooler.

[0006] The patent application US2015184580A1 describes an internal combustion engine provided with four compressors that, two by two, feed air to the inlets of two twin intercoolers; the outlets of the two twin intercoolers converge towards a single diverter valve that has several inlets and a single outlet connected to an intake manifold common to all the cylinders of the internal combustion engine.

[0007] The patent US7490462B2 describes an internal combustion engine provided with an intake system comprising two turbocompressors connected in series, one after the other, and two intercoolers connected in series, one after the other.

DESCRIPTION OF THE INVENTION

[0008] The purpose of this invention is to provide a car provided with a supercharged internal combustion engine that is free of the drawbacks described above and, in particular, makes it possible to maximise the efficacy and efficiency of the intercooler without requiring too onerous constraints on the placement of all the other components of the internal combustion engine.

[0009] According to this invention a car is provided that has a supercharged internal combustion engine, in accordance with what is claimed in the attached claims.

[0010] The claims describe preferred embodiments of this invention forming an integral part of this description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] This invention will now be described with reference to the attached drawings that illustrate some non-limiting embodiments thereof, in which:

- Figure 1 is a perspective view of a car provided with an internal combustion engine;
- Figures 2 and 3 are, respectively, a view from above and a view from below of the car in Figure 1;
- Figure 4 is a schematic plan view of the car in Figure 1;
- Figure 5 is a schematic view of the internal combustion engine of the car in Figure 1;
- Figure 6 is a perspective view with parts removed for clarity of a chassis of the car in Figure 1;
- Figures 7 and 8 are, respectively, a perspective view and a side view of an aerodynamic extractor of the car in Figure 1;
- Figures 9-12 are, respectively, two different perspective views, one view from above, and one rear view of the internal combustion engine;
- Figures 13 and 14 are, respectively, a perspective view and a side view of a transmission system of the car in Figure 1;
- Figure 15 is a schematic view of the transmission system in Figures 13 and 14;
- Figure 16 is a perspective of a compressor assembly of the internal combustion engine of the car in Figure 1;
- Figure 17 is a perspective of a turbine assembly of the internal combustion engine of the car in Figure 1;
- Figures 18-21 are, respectively, two different perspective views, one view from above, and one view from below of an embodiment of the internal combustion engine;
- Figures 22 and 23 are, respectively, a perspective

view and a rear view of a transmission system and a compressor assembly coupled to the internal combustion engine in Figures 18-21;

- Figures 24 and 25 are two different perspective views of the compressor assembly in Figures 22 and 23 and of a corresponding actuation system;
- Figure 26 is a schematic view of part of the actuation system in Figures 24 and 25; and
- Figures 27 and 28 are, respectively, a perspective view and a schematic view of two cam shafts of the internal combustion engine highlighting the arrangement of lubricating pumps and of a cooling pump.

PREFERRED EMBODIMENTS OF THE INVENTION

[0012] In Figure 1, the reference number 1 denotes, as a whole, a hybrid car (i.e., with hybrid propulsion) provided with two front drive wheels 2 that receive the drive torque from (at least) one electric machine 3 (schematically illustrated in Figure 4) and two rear drive wheels 4 that receive the torque from an internal combustion engine 5 (schematically illustrated in Figure 4).

[0013] Two directions are identified in the car 1: the longitudinal direction that is horizontal and parallel to the direction of the car 1 and the transverse direction that is horizontal and perpendicular to the direction of the car 1 (i.e., perpendicular to the longitudinal direction).

[0014] According to what is illustrated in Figure 4, the electric machine 3 is connected to the two front drive wheels 2 via a transmission system (of a known type not illustrated) provided with a front differential; similarly, the internal combustion engine 5 is also connected to the two rear drive wheels 4 via a transmission system 6 provided with a transmission 7 and a rear differential 8 (schematically illustrated in Figure 15).

[0015] The electric machine 3 is, preferably, reversible (i.e., it can function both as an electric motor absorbing electricity and generating mechanical torque and as an electric generator absorbing mechanical energy and generating electricity); according to other embodiments not illustrated, the electric machine 3 is not included.

[0016] According to what is illustrated in Figures 1 and 2, the car 1 comprises a passenger compartment 9 that is arranged between the two front wheels 2 and the two rear wheels 4 and contains a driving position 10 inside (schematically illustrated in Figure 4) that is arranged on the left side (alternatively, it could also be arranged on the right side). According to what is illustrated in Figure 4, the driving position 10 comprises a steering wheel 11, a driver's seat (not illustrated), and a series of other controls (known and not illustrated) that the driver can activate (including, for example, an accelerator, a brake, and at least one lever for choosing the gears).

[0017] According to what is illustrated in Figures 1 and 2, the car 1 comprises a body 12 that delimits (among other things) the passenger compartment 9 and has two sides wherein at least two doors 13 are formed. The left door 13 allows direct access to the driving position 10.

[0018] According to what is illustrated in Figure 3, the car 1 comprises a bottom 14 that constitutes the lower part of the car 1 and, in use, faces a road surface on which the car 1 moves.

[0019] According to a possible embodiment, the internal combustion engine 5 is powered by hydrogen (or another gaseous fuel). According to a different embodiment, the internal combustion engine 5 is powered by petrol (or another liquid fuel).

[0020] According to what is illustrated in Figure 4, the internal combustion engine 5 is powered by hydrogen that is stored under high pressure (for example, with a maximum pressure of approx. 700 bar) in four different tanks 15 and 16: the two tanks 15 have a spherical form and have the same dimensions, while the two tanks 16 have a cylindrical shape and have different dimensions (i.e., one tank 16 is larger than the other tank 16).

[0021] The two tanks 15 (spherical in shape) are arranged beside an engine block of the internal combustion engine 5 on two opposite sides of the internal combustion engine 5 itself; i.e., one tank 15 is arranged to the right of the engine block of the internal combustion engine 5 while the other tank 15 is arranged to the left of the engine block of the internal combustion engine 5. In other words, the two tanks 15 (spherical in shape) are arranged at the same vertical level, are arranged at the same longitudinal level, and are separated from each other transversely (with the interposition of the engine block of the internal combustion engine 5), i.e., they are only spaced apart from each other transversely.

[0022] The two tanks 16 (cylindrical in shape) are arranged above the internal combustion engine 5, one in front of the other. In other words, the two tanks 16 (cylindrical in shape) are arranged (approximately) at the same vertical level, are arranged at the same transverse level, and are separated from each other longitudinally, i.e., they are only spaced apart from each other longitudinally (i.e., one is arranged in front of the other). In particular, both the tanks 16 (cylindrical in shape) are oriented transversely, i.e., their central, symmetry axes are oriented transversely. In the embodiment illustrated in Figure 4, the tank 16 arranged in front (i.e., closer to the front) is larger than the tank 16 arranged behind (i.e., closer to the rear).

[0023] According to what is illustrated in Figure 5, the internal combustion engine 5 comprises a base 17 inside of which multiple cylinders 18 are formed (only one of which is illustrated in Figure 5). Preferably (but not necessarily), the cylinders 18 are arranged in line since this solution makes it possible to reduce the transverse dimensions of the internal combustion engine 5 and, thus, among other things, makes it possible to leave more space to the tanks 15. In the embodiment illustrated in the attached figures, six cylinders 18 are provided in line, but, obviously, the number and arrangement of the cylinders 18 could be different.

[0024] Each cylinder 18 has a corresponding combustion chamber and a respective piston 19 mechanically connected to a drive shaft 20 (via a corresponding connecting rod) to transmit the force generated by the combustion to the drive shaft 20. A cylinder head 21 is coupled (connected) to the base 17; the cylinder head constitutes the crown of the cylinders 18 (i.e., the closure above the cylinders 18 with the so-called *"flame plate"*). In the case of an in-line arrangement of the cylinders 18, there is a single cylinder head 21 while in the case of a "V"-shaped arrangement of the cylinders 18, there are two twin cylinder heads 21 for the two banks of cylinders 18.

[0025] The group of the base 17 and the cylinder head 21 constitutes the engine block of the internal combustion engine 5.

[0026] In the embodiment illustrated in the attached figures, the internal combustion engine 5 is arranged (oriented) longitudinally, i.e., the drive shaft 20 is arranged (oriented) longitudinally since this solution makes it possible to reduce the transverse dimensions of the internal combustion engine 5 and, thus, among other things, leave more space for the tanks 15. According to other embodiments not illustrated, the internal combustion engine 5 is arranged (oriented) transversely.

[0027] In the embodiment illustrated in the attached figures, the internal combustion engine 5 is arranged in the central or rear position, i.e., the internal combustion engine 5 is arranged behind the passenger compartment 9 and is located between the front wheels 2 and the rear wheels 4 (central arrangement as illustrated in the attached figures) or is located beyond the rear wheels 4 (rear arrangement not illustrated).

[0028] Each cylinder 18 comprises two intake valves 22 controlled by a cam shaft 23 that receives the motion from the drive shaft 20 via a belt transmission 24 (illustrated in Figure 26); alternatively, to the belt transmission 24, a chain transmission or a gear transmission could be used. In addition, each cylinder 18 comprises two exhaust valves 25 controlled by a cam shaft 26 that receives the motion from the drive shaft 20 via the belt transmission 24 (illustrated in Figure 26). The intake valves 22, the exhaust valves 25, and the corresponding control means (i.e., the return springs and cam shafts 23 and 26) are housed in the cylinder head 21.

[0029] Each cylinder 18 also comprises (at least) one fuel injector 27 that cyclically injects the fuel into the cylinder 18; in Figure 5, a direct injection of fuel into the cylinder 18 is illustrated, but the fuel injection into the cylinder 18 could also be (partially or completely) indirect. Each cylinder 18 comprises (at least) one spark plug 28 that is cyclically activated to trigger the ignition of the mix of air (comburent) and fuel present in the combustion chamber at the end of the compression step.

[0030] According to what is illustrated in the attached figures, the internal combustion engine 5 is oriented vertically with the drive shaft 20 arranged higher than the cylinders 18. In other words, the internal combustion engine 5 is arranged *"upside down"* compared to the conventional arrangement that has the cylinders 18 high up and the drive shaft 20 down low. As a result, the cylinder head 21 that constitutes the crown of the cylinders 18 is arranged below the base 17 and represents the lowest part of the internal combustion engine 5.

[0031] The internal combustion engine 5 comprises an intake system 29 that withdraws air from the external environment to convey the air into the cylinders 18 (the inlet of the air into the cylinders 18 is adjusted by the intake valves 22). Among other things, the intake system 29 comprises an intake manifold 30 that is directly connected to all the cylinders 18; the inlet of the air into the intake manifold 30 is adjusted by a throttle valve 31.

[0032] The internal combustion engine 5 comprises an exhaust system 32 that ejects the exhaust gases coming from the cylinders 18 into the external environment. Among other things, the intake system 29 comprises (at least) one treatment device 33 for exhaust gases (typically a catalyser).

[0033] According to what is illustrated in Figures 9-12, the intake system 29 comprises two twin, separate intake ducts 34 that are arranged on the two sides of the car 1 (i.e., one intake duct 34 is arranged on the right side and the other intake duct 34 is arranged on the left side) and derives from respective air intakes 35 formed through the body 12. Along each intake duct 34 and near the respective air intake 35 an air filter 36 is arranged. Each intake duct 34 ends in a compressor assembly 37 that increases the pressure of the air to increase the volumetric yield of the cylinders 18. A single intake duct 38 originates from the compressor assembly 37 and ends in the intake manifold 30 after having crossed two intercoolers 39 and 40 arranged in series. In other words, an initial section of the intake duct 38 connects the compressor assembly 37 to the intercooler 39, then an intermediate section of the intake duct 38 connects the intercooler 39 to the intercooler 40 and, finally, a final section of the intake duct 38 connects the intercooler 40 to the intake manifold 30.

[0034] According to a preferred embodiment, the intercooler 39 is an air-to-air one and the intercooler 40 is also an air-to-air one. According to a preferred embodiment, the intercooler 39 has a greater volume than a volume of the intercooler 40; to this end, it is important to observe that the intercooler 39 is disadvantaged compared to the intercooler 40, since it is arranged further from the corresponding air intake and compensates for this drawback both with greater volume and by having to cool the air having a higher inlet temperature (since the intercooler 39 receives the air directly from the compressor assembly 37 while the intercooler 40, being arranged in series with the intercooler 39, receives the air already partially cooled by the intercooler 39).

[0035] According to what is illustrated in Figures 9-12, the exhaust system 32 comprises two twin, separate exhaust pipes 41 that receive exhaust gases from respective cylinders 18 to which they are connected individually; in particular, each exhaust pipe 41 is connected to three cylinders 18 via respective channels that originates from the three cylinders 18 and end in an exhaust pipe 41 inlet (from another point of view, each exhaust pipe 41 is initially divided into three parts to connect with the respective three cylinders 18). Along each exhaust pipe 41, a corresponding treatment device 33 for treating exhaust gases (typically a catalyser) is arranged; thus, overall, the exhaust system 32 comprises two twin, separate treatment devices 33 for exhaust gases.

[0036] Along the exhaust pipes 41, a turbine assembly 42 provided with two twin turbines 43 (better illustrated in Figure 17) is arranged, each of which is coupled to a corresponding exhaust pipe 41. In other words, each exhaust pipe 41 crosses a respective turbine 43 and the two turbines 43 are arranged side by side to constitute the turbine assembly 42. In other words, a turbine 43 that is connected along each exhaust pipe 41 and is arranged beside the engine block (consisting of the base 17 and the cylinder head 21) of the internal combustion engine 5 is provided.

[0037] The two exhaust pipes 41 end in a single, shared muffler 44 that receives the exhaust gases from both exhaust pipes 41. According to other embodiments not illustrated, two twin, separate mufflers 44 are provided, each of which receives the exhaust gases only from one respective exhaust pipe 41.

[0038] In the preferred embodiment illustrated in the attached figures, the muffler 44 has an individual end pipe 45 for the exhaust gases that leads to an outlet opening 46; according to other embodiments not illustrated, the muffler 44 has two or more end pipes 45, each of which leads into a corresponding outlet opening 46.

[0039] According to what is illustrated in Figure 16, the compressor assembly 37 (intended to be used in the supercharged internal combustion engine 5) comprises a single shaft 47 mounted so that it can rotate around a rotation axis 48. In the embodiment illustrated in the attached figures, the shaft 47 (thus, the rotation axis 48) is oriented transversely; according to a different embodiment not illustrated, the shaft 47 (thus, the rotation axis 48) is oriented longitudinally or is inclined (not parallel) both in relation to the longitudinal direction and to the transverse direction.

[0040] The compressor assembly 37 comprises two twin compressors 49 (identical), each of which is integral with the shaft 47 to rotate together with the shaft 47 and is configured to compress air to be sucked in by the supercharged internal combustion engine 5; in particular, each compressor 49 receives air from a corresponding intake duct 34 (i.e., each intake duct 34 ends in a corresponding compressor 49).

[0041] The compressor assembly 37 comprises a single, common electric motor 50 that is integral with the shaft 47 to rotate the shaft 47 (and, thus, to rotate both the compressors 49 mounted on the shaft 47). In the embodiment illustrated in the attached figures, the electric motor 50 is arranged between the two compressors 49 and is perfectly spaced apart by the two compressors 49; according to a different embodiment not illustrated, the electric motor 50 is arranged on one side in relation to both the compressors 49 (i.e., it is closer to one compressor 49 and further from the other compressor 49).

[0042] As mentioned earlier, the two compressors 49 are identical and are centrifugal ones. In particular, each compressor 49 comprises an axial inlet 51 arranged on the opposite side of the shaft 47 and connected to a corresponding intake duct 34 and a radial outlet 52. According to a preferred embodiment, the compressor assembly 37 comprises a joining duct 53 (illustrated in Figures 9-12) that is connected to both outlets 52 of the two compressors 49 to receive and join the air compressed by both the compressors 49; the joining duct 53 ends in the intake duct 38, i.e., the intake duct 38 starts from the joining duct 53 to receive and join the air compressed by both compressors 49.

[0043] In the embodiment illustrated in the attached figures, the joining duct 53 is oriented transversely; according to a different embodiment not illustrated, the joining duct 53 is oriented longitudinally or is inclined (not parallel) both in relation to the longitudinal direction and to the transverse direction.

[0044] In the embodiment illustrated in the attached figures, the joining duct 53 is oriented parallel to the shaft 47 (thus, to the rotation axis 48); according to a different embodiment not illustrated, the joining duct 53 is not oriented parallel to the shaft 47, thus to the rotation axis 48) .

[0045] According to what is illustrated in Figure 17, the turbine assembly 42 comprises two twin (identical) turbines 43 that together drive the same electric generator 54. In particular, the two turbines 43 are arranged side by side and have two corresponding rotation axes 55 that are parallel and spaced apart. The turbine assembly 42 comprises a transmission device 56 that connects both the turbines 43 to the same electric generator 54. The transmission device 56 comprises two gears, each of which is integral with the shaft of a corresponding turbine 43 to receive the rotary motion from the turbine 43 itself, and a connection element (a toothed belt, a chain, a cascade gear set) that connects the two gears so as to make both the gears rotate together and at the same rotation speed. According to one possible embodiment, one gear of the two gears of the transmission device 56 is directly fastened to a shaft of the electric generator 54 so that the electric generator 54 rotates at the same rotation speed as the two turbines 43; alternatively, a gear of the two gears of the transmission device 56 is connected to the shaft of the electric generator 54 via the interposition of a speed reducer (typically with gears) so that the electric generator 54 rotates at a lower rotation speed than the rotation speed of the two turbines 43.

[0046] According to a preferred embodiment illustrated in the attached figures, the electric generator 54 is coaxial to a turbine 43; i.e., a turbine 43 and the electric generator 54 rotate around the same first rotation axis 55 while the other turbine 43 rotates around a second rotation axis 55 parallel to, and spaced apart from, the first rotation axis 55.

[0047] The two turbines 43 are identical and are centrifugal ones. In particular, each turbine 43 comprises a radial inlet 57 connected to one side of the corresponding exhaust pipe 41 and an axial outlet 52 arranged on the opposite side of the transmission device 56 and connected to another side (which leads into the muffler 44) of the corresponding exhaust pipe 41.

[0048] According to a preferred embodiment better illustrated in Figures 11 and 12, the muffler 41 is arranged beside an engine block (consisting of the base 17 and cylinder head 21) of the internal combustion engine 5 (on the side of the exhaust valves 25). The outlet opening 46 of the muffler 41 is formed through one side of the car 1 (as shown in Figure 1) or, according to an alternative embodiment, through the bottom 14 of the car 1 (as illustrated in Figure 3).

[0049] In other words, the outlet opening 46 of the muffler 44 is arranged asymmetrically on just one side of the car 1 and is located between a rear wheel 4 and a door 13. According to a preferred embodiment, the outlet opening 46 of the muffler 44 is arranged on the side where the driver's position 16 is located; in this way, the driver's position 16 is close to the outlet opening 46 of the muffler 44 and, thus, in the best position for optimally noticing the noise spread through the outlet opening 46 of the muffler 44.

[0050] In the embodiment illustrated in Figure 1, the outlet opening 46 of the muffler 44 is formed through a side of the body 12, while in the alternative embodiment illustrated in Figure 3, the outlet opening 46 of the muffler 44 is formed through the bottom 14.

[0051] In the embodiment illustrated in the attached figures, the muffler 44 comprises a single outlet opening 46; according to other embodiments not illustrated, the muffler 44 comprises several outlet openings 46 that may be more or less aligned (potentially, it is also possible that an outlet opening 46 of the muffler 44 is formed through a side of the body 12 while the other outlet opening 46 of the muffler 44 is formed through the bottom 14).

[0052] According to a preferred embodiment better illustrated in Figures 11 and 12, the muffler 44 is arranged on one side of the car 1 beside an engine block (consisting of the base 17 and cylinder head 21) of the internal combustion engine 5 and in front of a rear drive wheel 4.

[0053] According to a preferred embodiment better illustrated in Figures 11 and 12, the turbine assembly 42 is arranged beside an engine block (consisting of the base 17 and cylinder head 21) of the internal combustion engine 5 (on the side of the exhaust valves 25). In particular, the turbine assembly 42 is arranged between the internal combustion engine 5 (i.e., between the engine block consisting of the base 17 and the cylinder head 21) and the muffler 44; in this way, the exhaust pipes 41 are particularly short and relatively straight.

[0054] In the embodiment illustrated in Figures 9-12, the compressor assembly 37 (comprising the two twin compressors 49) is connected between the two intake ducts 34 and 38, is arranged behind the engine block (consisting of the base 17 and the cylinder head 21) of the internal combustion engine 5, is arranged higher than the engine block of the internal combustion engine 5, and is driven by the electric motor 50.

[0055] According to what is better illustrated in Figures 9-12, the compressor assembly 37 (comprising the two twin compressors 49) is arranged at the rear behind the intercooler 39 (i.e., the two compressors 49 of the compressor assembly 37 are arranged at the rear behind the intercooler 39). The intercooler 39 is oriented horizontally and is arranged behind (to the rear of) the engine block (consisting of the base 17 and the cylinder head 21) of the internal combustion engine 5; in particular, the intercooler 39 is arranged higher than the engine block of the internal combustion engine 5 and is located behind the engine block of the internal combustion engine 5. In other words, the intercooler 39 has a parallelepiped shape having the two bigger walls (the two larger walls, or the two more extended walls) oriented horizontally, is arranged above the transmission 7 and, thus, is arranged longitudinally further behind the engine block of the internal combustion engine 5, and is arranged higher than the engine block of the internal combustion engine 5.

[0056] In contrast, the intercooler 40 (connected in series with the intercooler 39 along the intake duct 38) is arranged on one side of the car 1 beside the engine block (consisting of the base 17 and cylinder head 21) of the internal combustion engine 5 and in front of a rear drive wheel 4. In particular, the intercooler 40 is arranged on one side of the car 1 opposite the muffler 44; i.e., the intercooler 40 and the muffler 44 are arranged on opposite sides of the car 1 separated from each other by the engine block (consisting of the base 17 and the cylinder head 21) of the internal combustion engine 5. In other words, the intercooler 40 and the muffler 44 are arranged on the opposite sides of the engine block of the internal combustion engine 5.

[0057] According to what is illustrated in Figure 28, the internal combustion engine 5 comprises a dry-sump lubricating circuit 59 that makes a lubricating oil circulate throughout the moving parts of the internal combustion engine 5. The lubricating circuit 59 comprises a lubricating delivery pump 60 configured to circulate the lubricating oil; in other words, the lubricating delivery pump 60 withdraws the lubricating oil from an oil tank to send the lubricating oil inside the engine block (consisting of the base 17 and the cylinder head 21). The lubricating circuit 59 comprises two lubricating scavenge pumps 61 configured to circulate the lubricating oil; i.e., each scavenge pump 61 withdraws the oil from the engine block (consisting of the base 17 and the cylinder head 21) and, in particular, from the lowest part of the engine block and, thus, from the cylinder head 21 to send the lubricating oil into the tank (arranged higher than the cylinder head 21).

[0058] According to a preferred embodiment, the two lubricating scavenge pumps 61 are arranged on opposite sides of the cylinder head 21, so as to scavenge the lubricating oil in opposite areas of the cylinder head 21.

[0059] According to what is illustrated in Figure 28, the internal combustion engine 5 comprises a cooling circuit 62 that circulates a cooling liquid (for example, a mix of water and glycol) in the engine block (consisting of the base 17 and the cylinder head 21) of the internal combustion engine 5. The cooling circuit 62 comprises a cooling pump 63 configured to circulate the cooling liquid.

[0060] According to what is illustrated in Figures 27 and 28, the cam shaft 23 axially comes out from the cylinder head 21 on both sides: a lubricating pump 61 is arranged coaxial to the cam shaft 23 and is directly connected to the cam shaft 23 to be rotated by the cam shaft 23 itself and, similarly, the cooling pump 63 is arranged coaxial to the cam shaft 23 on the opposite side of the lubricating pump 61 and is directly connected to the cam shaft 23 to be rotated by the cam shaft 23 itself.

[0061] According to what is illustrated in Figures 27 and 28, the cam shaft 26 axially comes out from the cylinder head 21 on both sides: the other lubricating pump 61 (different to the lubricating pump 61 connected to the cam shaft 23) is arranged coaxial to the cam shaft 26 and is directly connected to the cam shaft 26 to be rotated by the cam shaft 26 itself and, similarly, the lubricating pump 60 is arranged coaxial to the cam shaft 26 on the opposite side of the lubricating pump 61 and is directly connected to the cam shaft 26 to be rotated by the cam shaft 26 itself.

[0062] In this way, all four pumps 60, 61, and 63 are coaxial to the corresponding cam shafts 23 and 26 and are directly rotated by the corresponding cam shafts 23 and 26.

[0063] According to other embodiments not illustrated, the number of pumps 60, 61, and 63 is different (smaller) since, for example, just one lubricating delivery pump 61 could be included; in this case (at least) one cam shaft 23 or 26 comes axially out of the cylinder head 21 on just one side.

[0064] According to other embodiments not illustrated, the arrangement of the pumps 60, 61, and 63 could be different, or could vary: for example, the cooling pump 63 could be connected to the cam shaft 26 or the lubricating pump 60 could be connected to the cam shaft 23.

[0065] According to what is illustrated in Figure 15, the transmission 7 is directly connected to the drive shaft 20 of the internal combustion engine 5, is aligned with the internal combustion engine 5, and is arranged behind the internal combustion engine 5. In particular, the transmission 7 is vertically aligned with an upper part of the engine block of the internal combustion engine 5; i.e., the transmission 7 is vertically aligned with the upper part of the base 17.

[0066] The transmission 7 is a dual-clutch one and is placed between the drive shaft 20 of the internal combustion engine 5 and the rear drive wheels 4. The transmission 7 comprises a basket 64 that is rotated by the drive shaft 20 and two clutches 65 contained one beside the other in the basket 64 to take the motion from the basket 64. In addition, the transmission 7 comprises two primary shafts 66 that are coaxial to each other, are inserted one inside the other, and are each connected to a corresponding clutch 65 to receive the motion from the corresponding clutch 65. Each clutch 65 comprises conductive discs that are integral with the basket 64 (thus always rotate together with the drive shaft 20 to which the basket 64 is fastened) and conducted discs that are alternated with the conductive discs and are integral with the corresponding primary shafts 66 (thus always rotate together with the corresponding primary shafts 66) .

[0067] The basket 64 of the dual-clutch 65 transmission 7 is arranged on the opposite side to the internal combustion engine 5 (i.e., to the drive shaft 20) compared to the two primary shafts 66; in addition, the dual-clutch 65 transmission 7 comprises a transmission shaft 67 that connects the drive shaft 20 to the basket 64, is coaxial to the two primary shafts 66, and is inserted in the two primary shafts 66. In other words, the transmission shaft 67 ends at one end wall of the basket 64 and is fastened to the end wall of the basket 64. In particular, a first primary shaft 66 is arranged outside, the transmission shaft 67 is arranged inside, and the other (second) primary shaft 66 is arranged between the transmission shaft 67 and the primary shaft 66. In other words, from inside towards the outside, you find the transmission shaft 67 (that is at the centre) and, in succession, the two primary shafts 66 (that are inserted one inside the other and both surround the transmission shaft 67) .

[0068] According to a preferred embodiment illustrated in the attached figures, the primary shafts 66 and the transmission shaft 67 of the transmission 7 are coaxial to the drive shaft 20 of the internal combustion engine 5; i.e., the internal combustion engine 5 is aligned with the transmission 7.

[0069] The dual-clutch 65 transmission 7 comprises a single secondary shaft 68 connected to the differential 8 that transmits the motion to the rear drive wheels 4; according to an alternative and equivalent embodiment, the dual-clutch transmission 7 comprises two secondary shafts 68 both connected to the differential 8. A pair of axle shafts 69 originate from the differential 8, each of which is integral with a rear drive wheel 4.

[0070] The transmission 7 has seven forward gears indicated by Roman numerals (first gear I, second gear II, third gear III, fourth gear IV, fifth gear V, sixth gear VI, and seventh gear VII) and one reverse gear (indicated by the letter R). Each primary shaft 66 and the secondary shaft 68 are mechanically coupled together via multiple gears, each of which defines a respective gear and comprises a primary gear 70 mounted on the primary shaft 66 and a secondary gear 71 mounted on the secondary shaft 68. In order to enable the proper operation of the transmission 7, all odd gears (first gear I, third gear III, fifth gear V, seventh gear VII) are coupled to the same primary shaft 66, while all even gears (second gear II, fourth gear IV, and sixth gear VI) are coupled to the other primary shaft 66.

[0071] Each primary gear 70 is keyed to a corresponding primary shaft 66 so as to always rotate integrally with the primary shaft 66 and permanently meshes with the corresponding secondary gear 71; in contrast, each secondary gear 71 is idly mounted on the secondary shaft 68. In addition, the transmission 7 comprises four double synchronizers 72, each of which is mounted coaxial to the secondary shaft 68, is arranged between two secondary gears 19, and is designed to be actuated to alternatively engage the two respective secondary gears 19 with the secondary shaft 68 (i.e., to alternatively make the two respective secondary gears 19 angularly integral with the secondary shaft 68). In other words, each synchronizer 72 may be moved in one direction to engage a secondary gear 71 with the secondary shaft 68, or it may be moved in the other direction to engage the other secondary gear 71 with the secondary shaft 68.

[0072] According to what is illustrated in Figures 13 and 14, the car 1 comprises a containment body 73 that contains, inside, the dual-friction transmission 7 too and has a tapered shape towards the rear so that the height of the containment body 73 gradually reduces from the front to the rear. In other words, one front wall of the containment body 73 is more extended in height than a rear wall of the containment body 73. In particular, the containment body 73 has, below, a bottom wall 74 that is inclined in relation to the horizontal due to the tapered form of the containment body 73.

[0073] The differential 8 (that receives the motion from the secondary shaft 68 of the transmission 7 and transmits the motion to the two rear drive wheels 4 via the two corresponding axle shafts 69) is arranged inside the containment body 73 in a front position below the transmission 7. The two axle shafts 69 come out at the side from the containment body 73.

[0074] From the above, we can summarise that the transmission 7 is directly connected to the drive shaft 20 of the internal combustion engine 5, is aligned with the internal combustion engine 5 (i.e. the primary shafts 66 and the transmission shaft 67 of the transmission 7 are coaxial to the drive shaft 20 of the internal combustion engine 5), and is arranged behind the internal combustion engine 5; in addition, the intercooler 39 is arranged horizontally above the transmission 7 (i.e. above the containment body 37 wherein the transmission 7 is located).

[0075] According to what is illustrated in Figures 3, 7, and 8, the car 1 comprises a rear aerodynamic extractor 75 that faces the road surface 14, starts at one rear wall of the engine block (consisting of the base 17 and the cylinder head 21) of the internal combustion engine 5, and is arranged below the transmission 7 (i.e., below the containment body 73 wherein the transmission 7 is located).

[0076] According to a preferred embodiment, the bottom wall 74 of the containment body 73 (inside of which the transmission 7 is located) has the same inclination as the rear aerodynamic extractor 75; i.e., the bottom wall 74 of the containment body 73 reproduces the shape of the rear aerodynamic extractor 75 having the same inclination thereof. In this way, the rear aerodynamic extractor 75 exploits the whole space available below the transmission 7 (i.e., below the containment body 73 wherein the transmission 7 is located).

[0077] According to what is illustrated in Figure 6, the car 1 comprises a chassis 76 (partially illustrated in Figure 6). The rear part of the chassis 76 comprises side bars 77 that are arranged at the spherical tanks 15 to protect the spherical tanks 15 from side collisions; the side bars 77 form tetrahedrons to have greater resistance to collisions.

[0078] According to what is illustrated in Figure 6, inside the chassis 76 there is an engine compartment 78 wherein the internal combustion engine 5 is arranged. According to what is illustrated in Figure 3, the bottom 14 of the car 1 comprises an opening 79 that is arranged in the engine compartment 78 and a removable panel 80 that is removably fixed and closes the opening 79. The opening 79 has a similar dimension to one dimension of the engine compartment 78; i.e., the dimension of the opening 79 is approximately (as far as possible) equal to the dimension of the engine compartment 78 so that there can be complete access to the engine compartment 78 through the opening 79.

[0079] According to a preferred embodiment, the removable panel 80 is at least partially transparent; in particular, the removable panel 80 has a central, transparent window 81 (for example made of glass). The function of the transparent window 81 is basically technical since it makes it possible to visually inspect the internal combustion engine 5 without having to remove the removable panel 80.

[0080] According to a preferred embodiment, the body 12 does not have a bonnet that can be opened (arranged above the engine compartment 78) that allows access to the engine compartment 78; i.e., access to the engine compartment 78 occurs only from below through the opening 79 since the upper part of the engine compartment 78 is permanently closed by fixed, non-removable panels of the body 12.

[0081] According to a preferred embodiment, the removable panel 80 is directly fixed to the chassis 76 using multiple screws 82 (preferably quarter turn screws 82).

[0082] The rear aerodynamic extractor 75 faces the road surface 14, is arranged at the rear of the removable panel 80, and borders the removable panel 80. In other words, the rear aerodynamic extractor 75 starts where the removable panel 80 finishes. The aerodynamic extractor 75 is also removable to allow simpler access to the containment body 73 of the transmission 7.

[0083] In the embodiment illustrated in Figures 9-12, the turbine assembly 42 that generates electricity using the electric generator 54 is included and the compressor assembly 37 drives the two compressors 49 using the electric motor 50 that uses (at least in part) the electricity generated by the electric generator 54 of the turbine assembly 42.

[0084] In the embodiment illustrated in Figures 18-21, the turbine assembly 42 is not included and the compressor assembly 37 does not have the electric motor 50 since the two compressors 49 are driven by the transmission 7 withdrawing the motion from the basket 64 of the clutches 65 of the transmission 7 (as will be better explained below). In other words, the two compressors 49 are driven by the transmission shaft 67 of the transmission 7 (which directly rotates the clutch 65 basket 64 and is directly connected to the drive shaft 20). This embodiment is, in terms of power, a little less efficient (not recovering part of the energy of the exhaust gases through the turbine assembly 42) but it is lighter, more compact, and simpler, entirely eliminating the electrical part (in fact, neither the electric generator 54 of the turbine assembly 42, nor the electric motor 50 of the compressor assembly 37 are present).

[0085] According to what is illustrated in Figures 22-26, there is an actuation system 83 that connects the basket 64 of the transmission 7 to the compressor assembly 37 (i.e., to the two compressors 49 of the compressor assembly 37) so as to take the motion from the basket 64 of the transmission 7 to be able to rotate the two compressors 49 of the compressor assembly 37. By way of example, the actuation system 83 increases the rotation speed so that the two compressors 49 of the compressor assembly 37 always rotate faster than the basket 64 of the transmission 7; for example, the two compressors 49 of the compressor assembly 37 could rotate 7-8 times faster than the basket 64 of the transmission 7.

[0086] According to what is illustrated in Figure 15, the actuation system 83 is connected to an end wall of the basket 64 of the transmission 7 on the opposite side of the transmission shaft 67; i.e., the basket 64 of the transmission 7 has an end wall that, on one side, is connected to the transmission shaft 67 and, on the other side, is connected to the actuation system 83.

[0087] According to one possible embodiment schematically illustrated in Figure 24, the actuation system 83 comprises a variator device 84 that is interposed between the basket 64 of the transmission 7 and the compressors 49 and has a variable transmission ratio. The variator device 84 preferably has a centrifugal activation so as to autonomously change the transmission ratio as a function of the rotation speed of the basket 64 of the transmission 7; in particular, the variator device 84 is configured to reduce the transmission as the rotation speed of the basket 64 of the transmission 7 increases. In other words, when the rotation speed of the basket 64 of the transmission 7 is lower, the transmission ratio is greater and, thus (with the same rotation speed of the basket 64), the compressors 49 rotate more strongly, while when the rotation speed of the basket 64 of the transmission 7 is higher, the transmission ratio is smaller and, thus (with the same rotation speed of the basket 64), the compressors 49 rotate more slowly; in this way, the compressors 49 manage to generate an effective compression even when the basket 64 of the transmission rotates slowly without *"over revving"* when the basket 64 of the transmission quickly rotates.

[0088] According to a preferred embodiment, the variator device 84 just has two different transmission ratios; by way of example, the two transmission ratios that can be obtained using the variator device 84 could differ from each other by 30-40%.

[0089] According to one preferred embodiment, the variator device 84 comprises a direct drive engaged by a centrifugal clutch and an epicyclic gearing that creates a lower transmission ratio by the direct drive: the centrifugal clutch is driven by the centrifugal force that compresses the discs of the clutch engaging the direct drive when the rotation speed of the basket 64 of the transmission 7 exceeds a threshold value (thus, they determine a reduction in the transmission ratio when the rotation speed of the basket 64 of the transmission 7 exceeds the threshold value) . According to a preferred embodiment, a transmission ratio of the variator device 84 could correspond to a direct drive (i.e., a 1:1 transmission ratio) while the other transmission ratio could range between 1:1.3 and 1:1.4.

[0090] According to a preferred embodiment, the variator device 84 is connected to the basket 64 of the transmission 7 on the opposite side to the primary shafts 66 and to the transmission shaft 67.

[0091] In the embodiment illustrated in Figures 22-26, the two compressors 49 are arranged parallel to each other and spaced apart so as to rotate around two rotation axes 85 that are parallel to each other and spaced apart and are parallel to a rotation axis 86 of the basket 64 of the transmission 7 (that is coaxial to the primary shafts 66, to the transmission shaft 67, and to the drive shaft 20). In particular, the rotation axis 86 of the basket 64 of the transmission 7 is arranged between the rotation axes 85 of the two compressors 49; i.e., the two compressors 49 are arranged on the two opposite sides of the rotation axis 86 of the basket 64 of the transmission 7.

[0092] According to a preferred embodiment illustrated in Figure 26, the actuation system 83 comprises an intermediate shaft 87 that receives the motion from the basket 64 of the transmission 7 and rotates around a rotation axis 88 that is parallel and spaced apart from the rotation axis 86 of the basket 64 of the transmission 7. In particular, between the basket 64 of the transmission 7 and the intermediate shaft 87 there is the variator device 84. The actuation system 83 comprises a central gear 89 that receives the motion from the intermediate shaft 87 (i.e., is bound to the intermediate shaft 87) and two side gears 90 that are arranged at the two sides of the central gear 89, engage the central gear 89 and transmit, each, the motion towards a corresponding compressor 49 (i.e., each side gear 90 is bound to a shaft of a corresponding compressor 49). Between each side gear 90 and the corresponding compressor 49, a drive 91 is interposed that increases the rotation speed, so that the compressor 49 can rotate more quickly than the side gear 90.

[0093] Overall, the compressors 49 rotate much more quickly than the drive shaft 20 (i.e., than the basket 64 of the transmission 7): the compressors 49 rotate around ten times more quickly than the drive shaft 20 (i.e., the compressors 49 can reach 100,000 revolutions/min. while the drive shaft 20 can reach 10,000 revolutions/min.).

[0094] According to what is illustrated in Figures 22 and 25, each compressor 49 comprises an axial inlet 51 arranged on the opposite side of the actuation system 83 and a radial outlet 52. As described above, the joining duct 53 is provided (not illustrated in Figures 22-25), which is connected to both outlets 52 of the two compressors 49 so as to receive and join the compressed air from both compressors 49.

[0095] In the embodiment illustrated in Figures 9-12, two exhaust pipes 41 are provided that originate from the cylinders 18 and end in the muffler 44 and are completely separate and independent from the cylinders 18 to the muffler 44. In contrast, in the embodiment illustrated in Figures 18-21, an exhaust pipe 92 is provided, wherein both the exhaust pipes 41 merge and that ends in the muffler 44; i.e., the exhaust pipes 41 join together upstream of the muffler 44 merging together in the exhaust pipe 92 that is grafted on the muffler 44. In other words, the exhaust system 32 comprises a single exhaust pipe 92 that receives the exhaust gases from both the exhaust pipes 41; i.e., the two exhaust pipes 41 join to converge towards the sole exhaust pipe 92. The exhaust pipe 92 starts from the convergence of the two exhaust pipes 41 and ends in the muffler 44.

[0096] In the embodiment illustrated in the attached figures, the compressor assembly 37 comprises two twin compressors 49; according to a different embodiment not illustrated, the compressor assembly 37 comprises a single compressor 49.

[0097] In the embodiment illustrated in the attached figures, the turbine assembly 42 (when present) comprises two twin turbines 43; according to a different embodiment not illustrated, the turbine assembly 42 (when present) comprises a single turbine 43.

[0098] The embodiments described herein may be combined between them without departing from the scope of protection of this invention.

[0099] Numerous advantages are achieved with the car 1 described above.

[0100] In the first place, the car 1 described above makes it possible to combine, at the same time, a great capacity for storing hydrogen (thus being able to offer satisfying autonomy) with very high dynamic performance thanks to an optimal wheelbase, overall weight, and distribution of weight. These results are obtained thanks to the particular shape and arrangement of the internal combustion engine 5 and the transmission system 6 that make it possible to create a lot of free space to house the hydrogen tanks 9 and 10 without penalising the dynamic performance of the car 1.

[0101] The car 1 described above makes it possible to create a rear aerodynamic diffuser (extractor) with relatively large dimensions thus permitting the generation of a very high aerodynamic load without any penalisation of the forward aerodynamic resistance.

[0102] In the car 1 described above, you can hear, inside the passenger compartment 15 (particularly in the driver's position 16 where the driver is seated), an exhaust noise that has both a sufficiently high intensity, and an excellent sound quality; this result is obtained thanks to the fact that the outlet opening is found very close to the passenger compartment 15 and on the side of the driver's position 16, since this solution makes it possible both to *"concentrate"* the sound intensity near the passenger compartment 15 and to have very natural exhaust noise (i.e. not created or, in any case, artificially changed). In other words, the exhaust noise is not artificially *"shot"* towards the passenger compartment 15 through artificial transmission channels, but, on the contrary, the exhaust noise reaches the passenger compartment 15 only passing through the exhaust system, i.e., following the natural outlet of the exhaust noise.

[0103] In the car 1 described above, including thanks to the particular shape of the dual-clutch transmission 7 wherein the basket 64 is arranged on the opposite side of the internal combustion engine, it is possible to obtain a particularly favourable placement of all the elements of the drivetrain system (i.e., compact while being very functional) to minimise the length of the wheelbase (i.e., the distance between the front axle and the rear axle).

[0104] In the car 1 described above, including thanks to the particular shape of the compressor assembly 37 wherein the two twin compressors 49 are arranged coaxial to the opposite sides of the electric motor 50, it is possible to obtain a particularly favourable placement of all the elements of the drivetrain system (i.e., compact though being very functional); at the same time, the presence of two twin compressors 49 makes it possible to compress very high flows of air.

[0105] In the car 1 described above, including thanks to the particular shape of the turbine assembly 42 wherein the two twin turbines 42 are arranged side by side to drive the common electric generator 54, it is possible to obtain a particularly favourable placement of all the elements of the drivetrain system (i.e., compact though being very functional); at the same time, the presence of two twin turbines 42 makes it possible to recover a large quantity of energy from the exhaust gas.

[0106] In the car 1 described above (in particular in the embodiment illustrated in Figures 18-26), the shape of the intake ducts 34 and 38 is optimal both for size and for head losses without the need to resort to electric actuation of the compressor assembly 37; this result is obtained by withdrawing the motion necessary to rotate the two compressors 49 of the compressor assembly 37 directly from the basket 64 of the dual-clutch transmission 7 that is located in a very favourable position for the positioning of the compressor assembly 37.

[0107] In the car 1 described above, the particular shape and particular positioning of the two intercoolers 39 and 40 make it possible to maximise the efficacy and efficiency of the cooling of compressed air without requiring too onerous constraints on the placement of all the other components of the internal combustion engine 5.

[0108] In the car 1 described above, the aerodynamic extractor 75 has one very large dimension (thus it is possible to generate a high aerodynamic load in response to a modest increase in the aerodynamic resistance to moving forward) even if the internal combustion engine 5 is placed in a central/rear position (thus having an optimal distribution of the masses between the front axle and the rear axle) and, at the same time, the wheelbase is relatively short (i.e. the car 1 has extremely high-performance dynamic behaviour). This result is obtained by positioning the internal combustion engine 5 with the drive shaft 20 arranged high up: in this way, the transmission 7 can also be arranged higher up, freeing, as a result, in the lower part of the car's rear zone, the space necessary to house the aerodynamic extractor 75 having a very large dimension.

[0109] In the car 1 described above, accessibility to all the areas of the internal combustion engine 5 is excellent and complete; this result is obtained thanks to the accessibility from below that, once the car 1 is raised, always allows a technician to be arranged precisely below the component on which to work. In other words, the accessibility from below to the internal combustion engine 5 makes maintenance easier and simpler, since the technicians are not limited by the profile of the car 1 but can easily move in all the areas of the internal combustion engine 5 the car 1 being raised.

[0110] In the car 1 described above, the fact that the removable panel is at least partially transparent constitutes, in addition to an undoubted technical advantage as explained above, an aesthetic innovation and makes the removable panel an aesthetic element as well; it is important to note that, thanks to the large aerodynamic extractor 75 it is relatively easy to see at least part of the internal combustion engine 5 through the transparent part of the removable panel without needing to lean excessively.

[0111] In the car 1 described above, the body 12 is particularly rigid and resistant thanks to the complete absence of an opening for accessing the engine compartment 78 (and normally closed by a bonnet). In this way, with the same stiffness, it is possible to reduce the overall mass of the body 12. In addition, the absence of an opening for accessing the engine compartment 78 also makes the body 12 completely continuous (i.e., without interruptions) thus reducing the aerodynamic efficiency. The possibility of eliminating an opening to access the engine compartment 78 through the body 12 is given by the fact that the internal combustion engine 5 does not necessitate any maintenance in the upper part (consisting of the base 17) and, as a result, it is no longer necessary to access the engine compartment 78 from above. In fact, all the main components of the internal combustion engine 5 are found in the lower part of the engine compartment 78 and are easily accessible from the bottom 14 through the closed opening 79 from the removable panel 80.

[0112] In the car 1 described above, the lubricating pumps 60 and 61 and the cooling pump 63 have an optimal position that enables the minimisation of the number of components necessary to rotate the pumps 60, 61, and 63 and, at the same time, to make it possible to keep the head losses in the lubricating circuit 59 and in the cooling circuit 62 low. In other words, the combination and simultaneous driving of the four pumps 60, 61, and 63 using the two cam shafts 23 and 26 makes the solution more economical, lighter, and more compact compared to the known solutions currently on the market.

REFERENCE NUMBER LIST FOR FIGURES

[0113]

1	car
2	front wheels
3	electric machine
4	rear wheels
5	internal combustion engine
6	transmission system
7	transmission
8	rear differential
9	passenger compartment
10	driver's position
11	steering wheel
12	body
13	doors
14	bottom
15	tank
16	tank
17	base
18	cylinders
19	pistons
20	drive shaft
21	cylinder head
22	intake valves
23	cam shaft
24	belt transmission
25	outlet valves
26	cam shaft
27	fuel injector
28	spark plug
29	intake system
30	intake manifold
31	throttle valve
32	exhaust system
33	treatment device
34	intake ducts
35	air intakes
36	air filter
37	compressor assembly
38	intake duct
39	intercooler
40	intercooler

41 exhaust pipes
42 turbine assembly
43 turbines
44 muffler
45 end pipe
46 outlet opening
47 shaft
48 rotation axis
49 compressor
50 electric motor
51 axial inlet
52 radial outlet
53 joining duct
54 electric generator
55 rotation axis
56 transmission device
57 radial inlet
58 axial outlet
59 lubricating circuit
60 lubricating pump
61 lubricating pump
62 cooling circuit
63 cooling pump
64 basket
65 clutches
66 primary shafts
67 transmission shaft
68 secondary shaft
69 axle shafts
70 primary gear
71 secondary gear
72 synchronizers
73 containment body
74 bottom wall
75 aerodynamic extractor
76 chassis
77 side bars
78 engine compartment
79 opening
80 removable panel
81 transparent window
82 screws
83 actuation system
84 variator device
85 rotation axes
86 rotation axis
87 intermediate shaft
88 rotation axis
89 central gear
90 side gears
91 drive
92 exhaust pipe

Claims

1. A car (1) comprising:

two front wheels (2);
two rear drive wheels (4);
a passenger compartment (9) arranged between the front wheels (2) and the rear wheels (4);
a supercharged internal combustion engine (5), which is arranged behind the passenger compartment (9) and is provided with a plurality of cylinders (18), where respective pistons (19) slide on the inside, and is also provided with a drive shaft (20) connected to the pistons (19) and is longitudinally oriented, i.e., parallel to a forward direction of the car (1);
at least one compressor (49), which is arranged along an intake duct (34, 38) and is configured to compress air to be sucked up by the supercharged internal combustion engine (5) ;
a first intercooler (39) arranged along the intake duct (34, 38) downstream of the compressor (49);
a second intercooler (40), which is arranged along the intake duct (34, 38) downstream of the first intercooler (39) and, hence, is connected in series to the first intercooler (39); and
a transmission (7) connected to the drive shaft (20) of the internal combustion engine (5);
the car (1) is **characterised in that:**

the transmission (7) is arranged longitudinally behind an engine block of the internal combustion engine (5); and
the first intercooler (39) has a parallelepiped shape having the two bigger walls oriented horizontally, is arranged above the transmission (7) and, thus, is arranged longitudinally further behind the engine block of the internal combustion engine (5), and is arranged higher than the engine block of the internal combustion engine (5).

2. The car (1) according to claim 1, wherein the first intercooler (39) is an air-to-air intercooler.

3. The car (1) according to claim 1 or 2, wherein the second intercooler (40) is an air-to-air intercooler.

4. The car (1) according to claim 1, 2, or 3, wherein the first intercooler (39) has a greater volume than a volume of the second intercooler (40).

5. The car (1) according to one of the claims from 1 to 4, wherein the second intercooler (40) is arranged on one side of the car (1) beside the engine block of the internal combustion engine (5) and in front of a rear drive wheel (4) .

6. The car (1) according to one of the claims from 1 to 5, wherein the internal combustion engine (5) is ori-

ented with the drive shaft (20) arranged higher than the cylinders (18) .

7. The car (1) according to one of the claims from 1 to 6, wherein, in the internal combustion engine (5), the cylinders (18) are arranged in line.

8. The car (1) according to one of the claims from 1 to 7 and comprising two compressors (49) that are twins, separate from and independent of one another and both supply the first intercooler (39) with the compressed air to be sucked up by the supercharged internal combustion engine (5) .

9. The car (1) according to claim 8, wherein:

each compressor (49) comprises an axial inlet (51) and a radial outlet (52); and
a joining duct (53) is provided, which is connected to both outlets (52) of the two compressors (49) so as to receive and join compressed air from both compressors (49).

10. The car (1) according to claim 8 or 9, wherein the two compressors (49) are arranged longitudinally behind the first intercooler (39).

11. The car (1) according to one of the claims from 1 to 10, wherein the transmission (7) comprises at least one primary shaft (66) that is coaxial to the drive shaft (20) of the internal combustion engine (5).

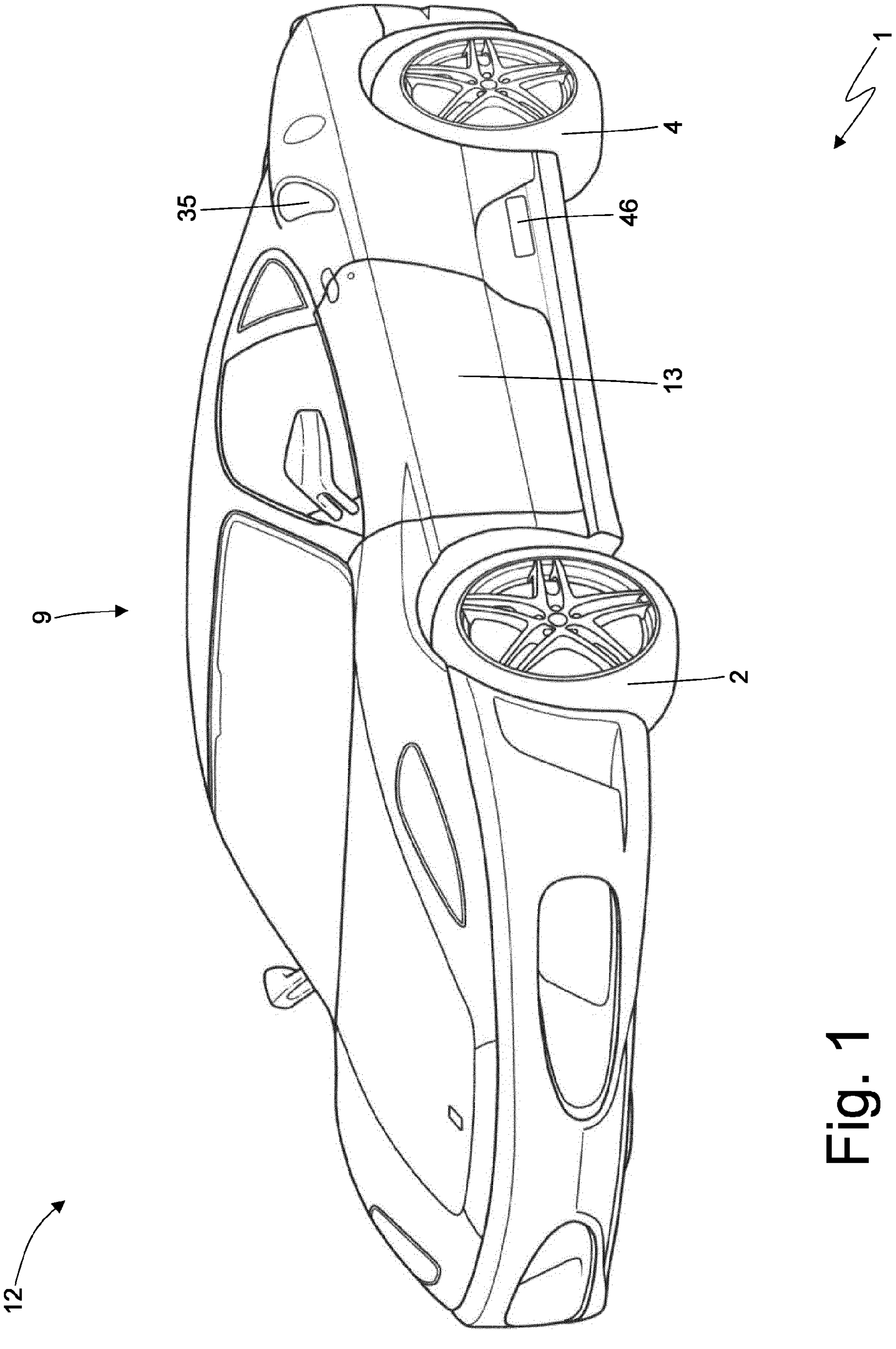


Fig. 1

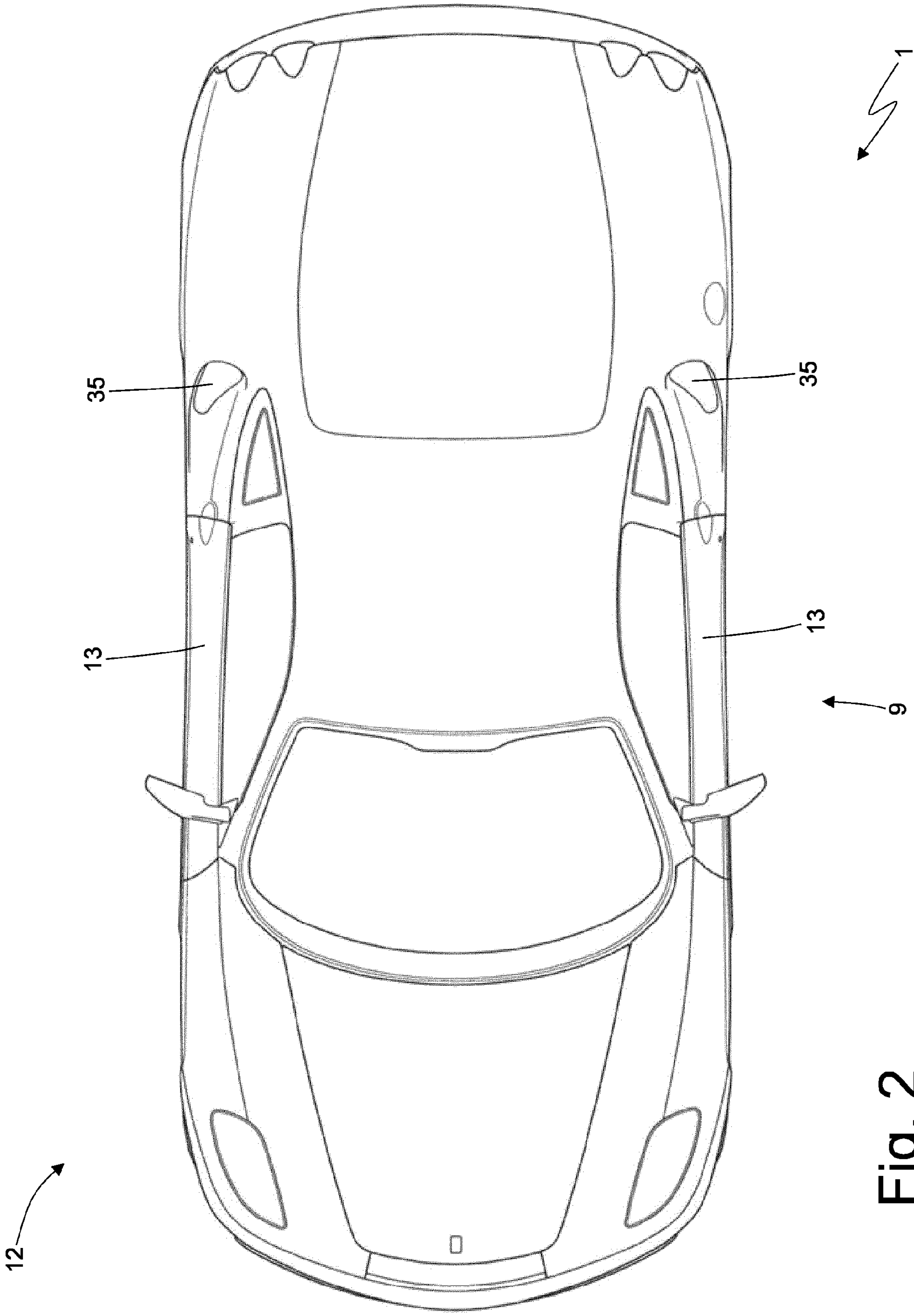


Fig. 2

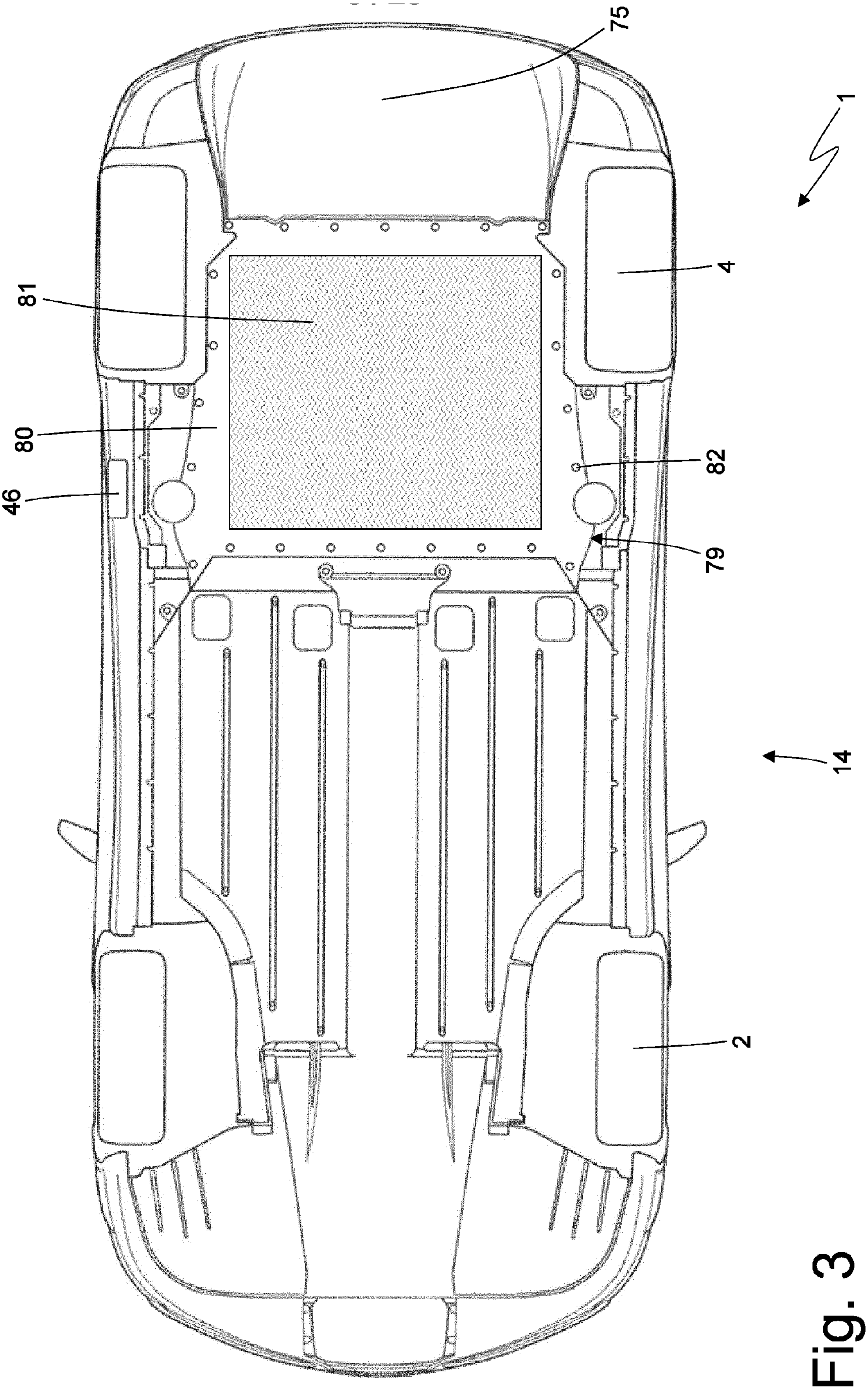


Fig. 3

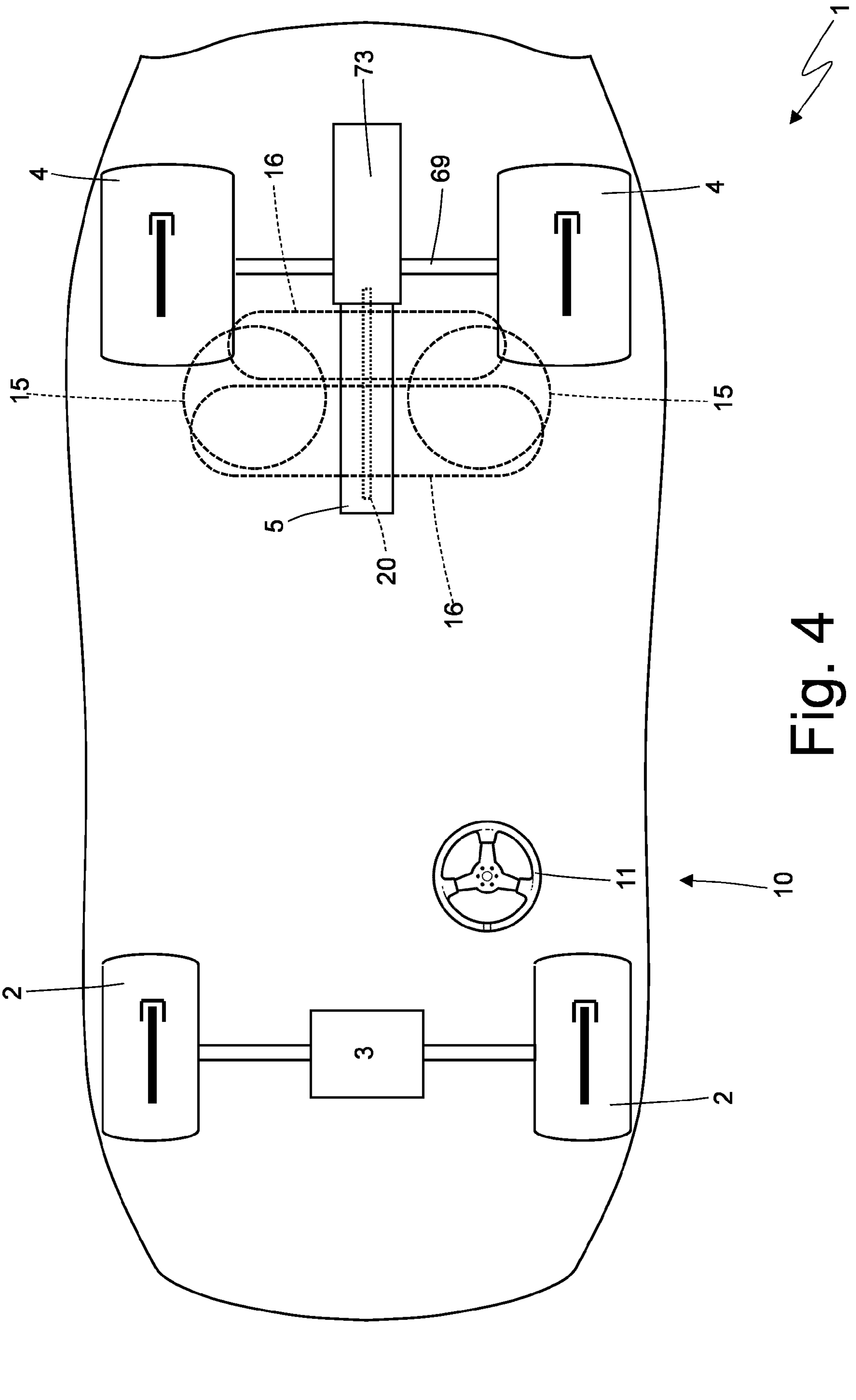


Fig. 4

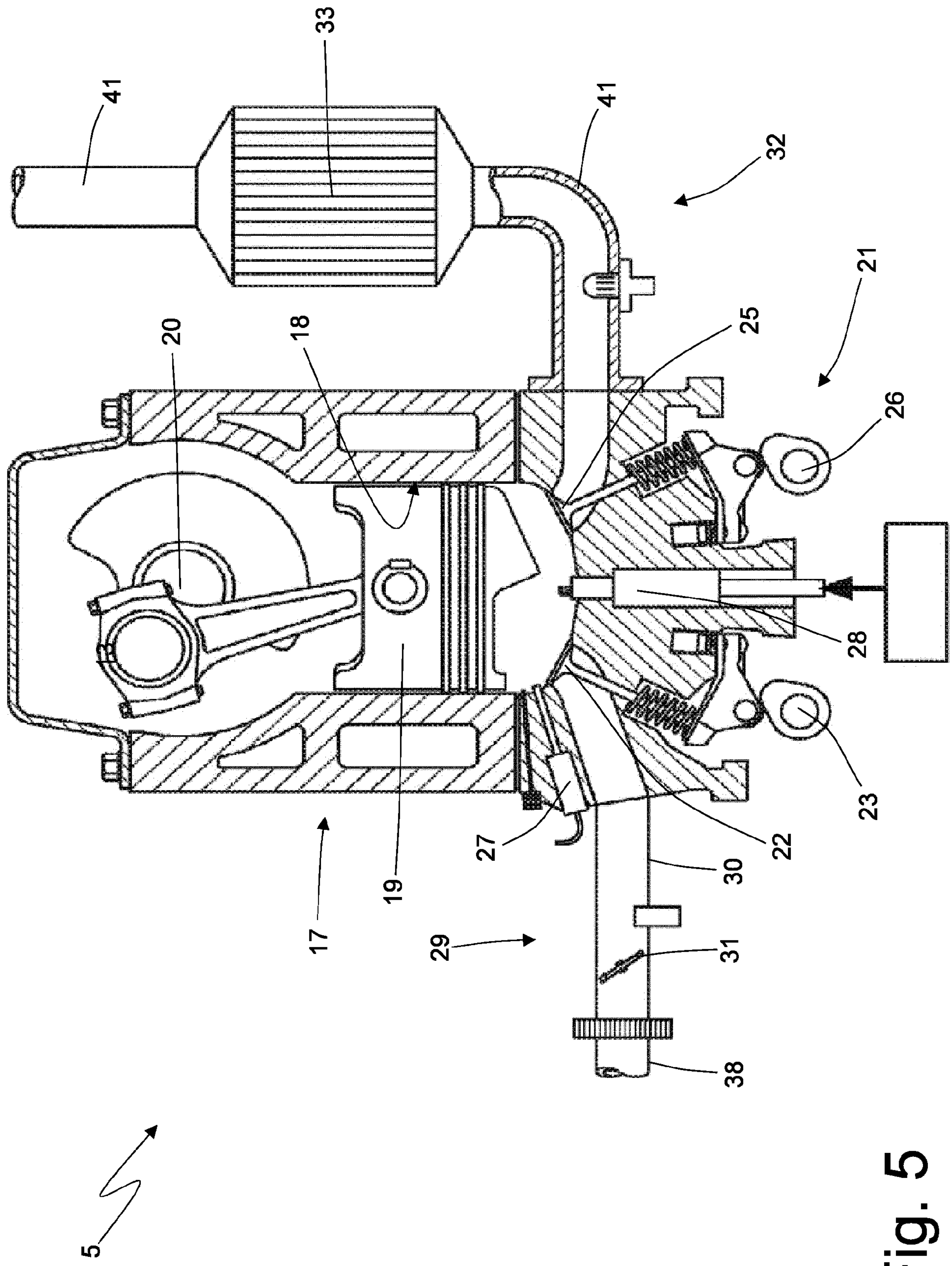


Fig. 5

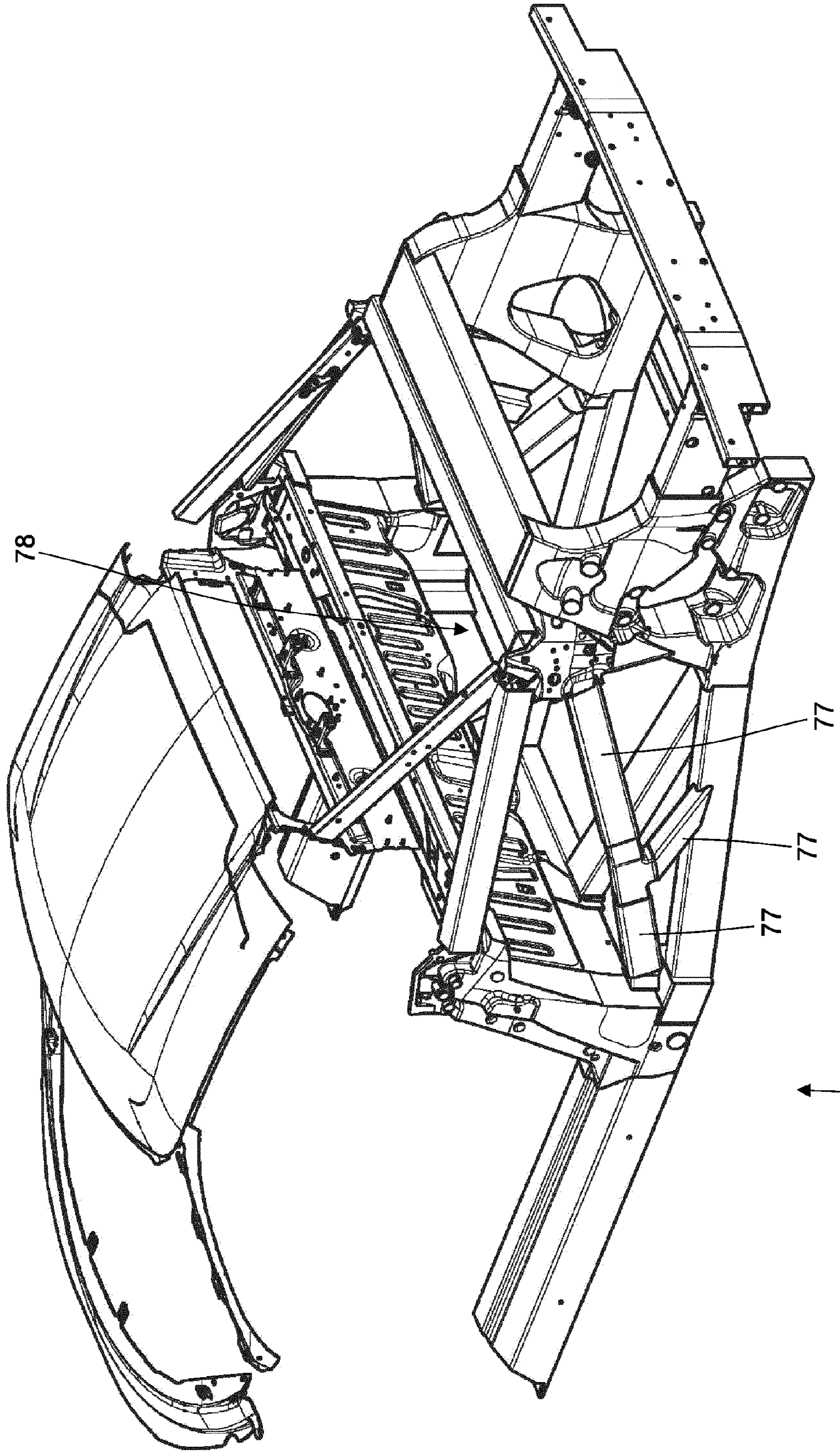


Fig. 6

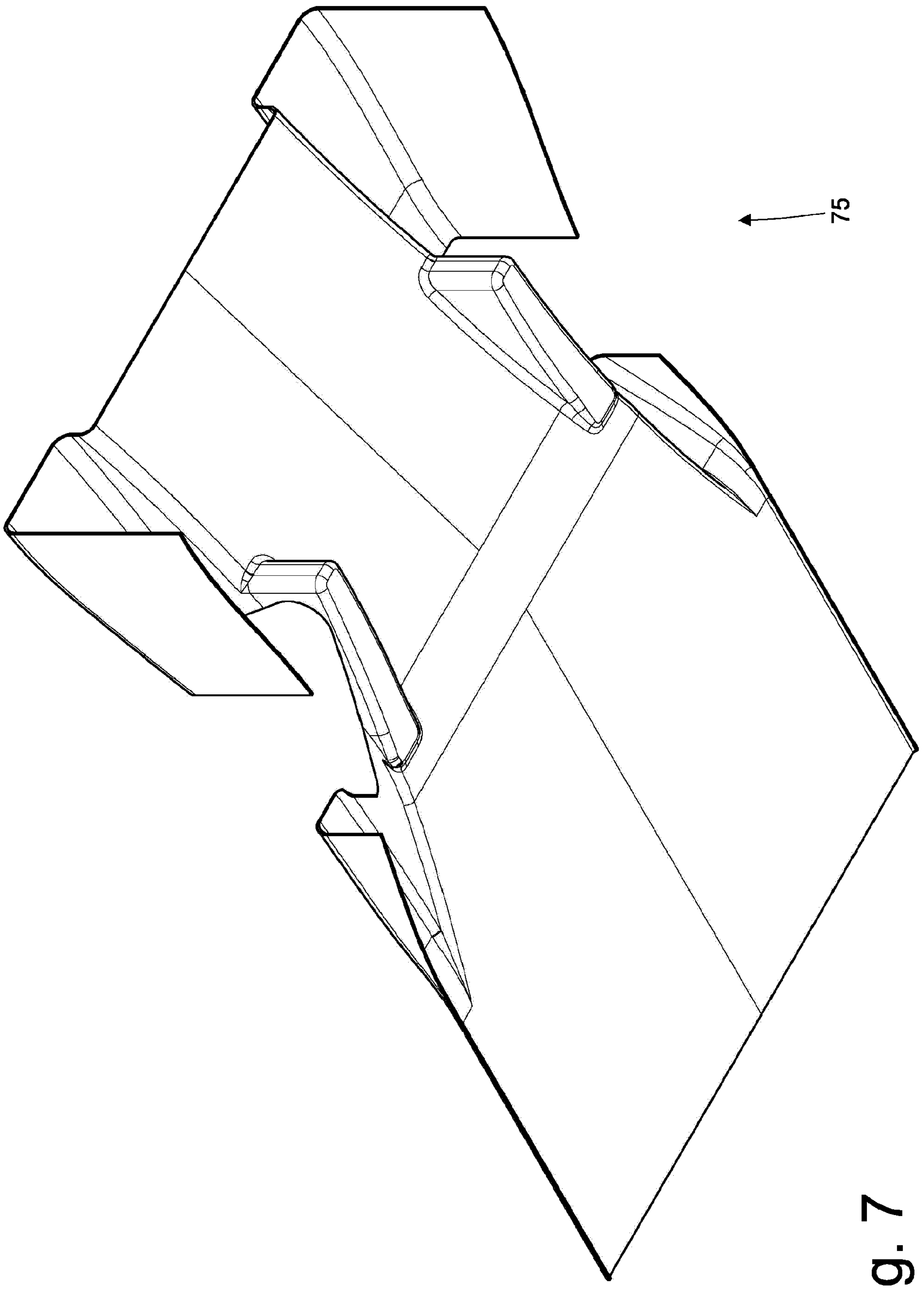


Fig. 7

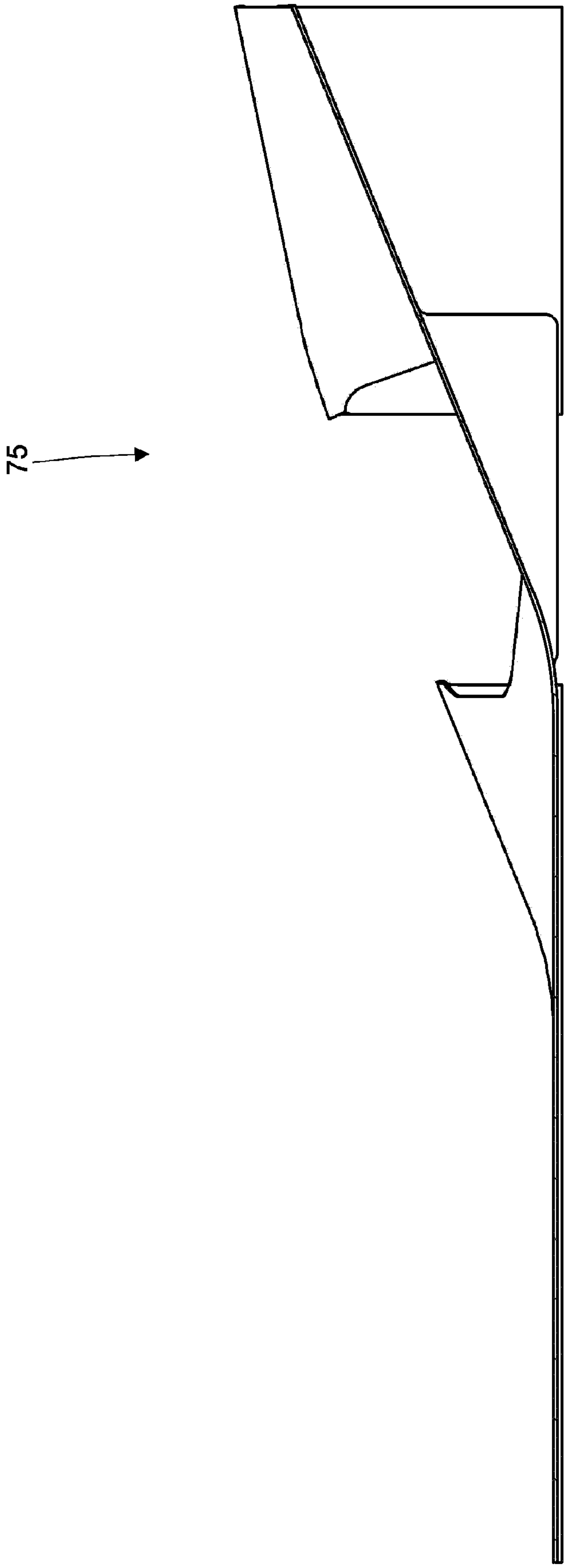


Fig. 8

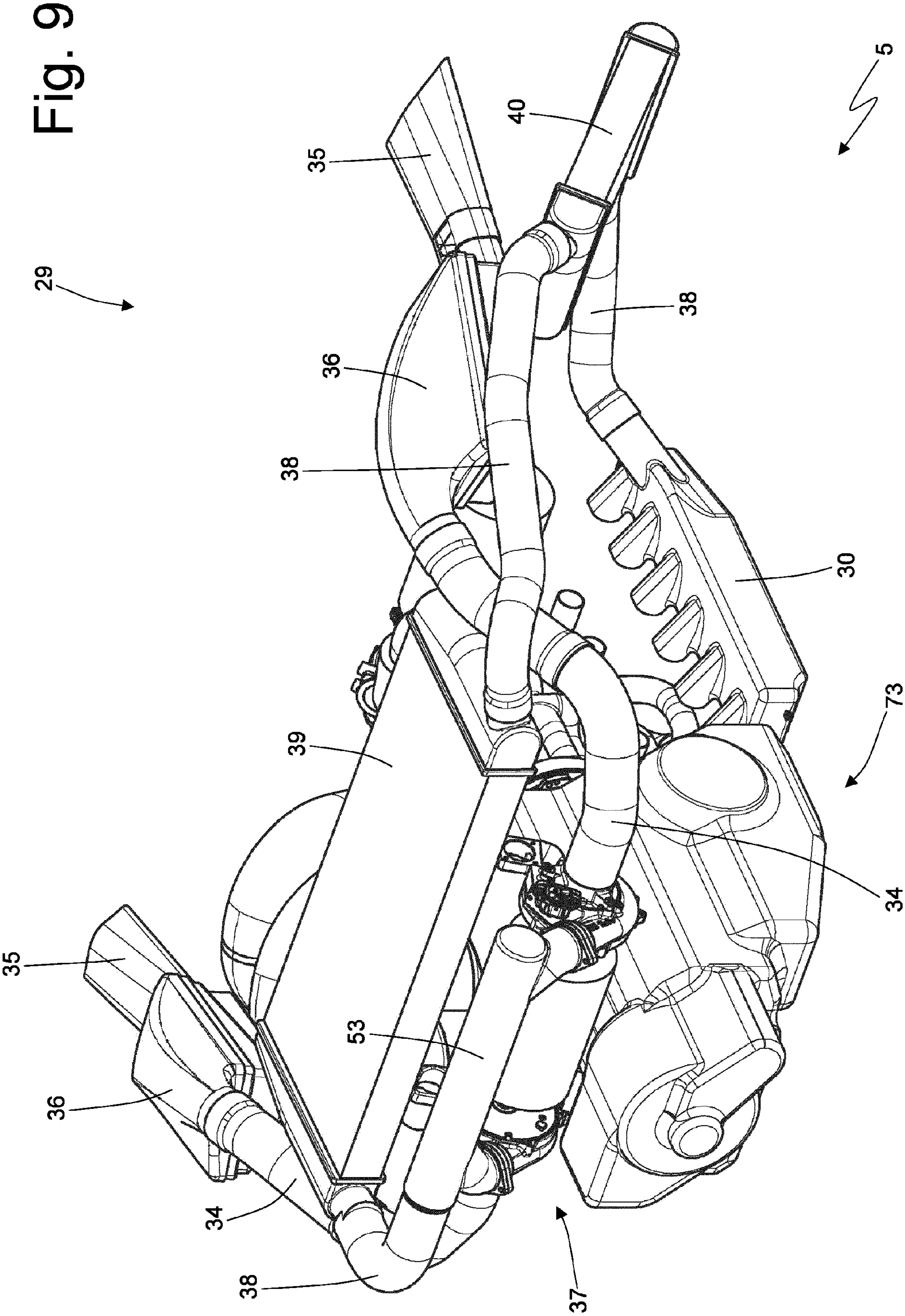


Fig. 9

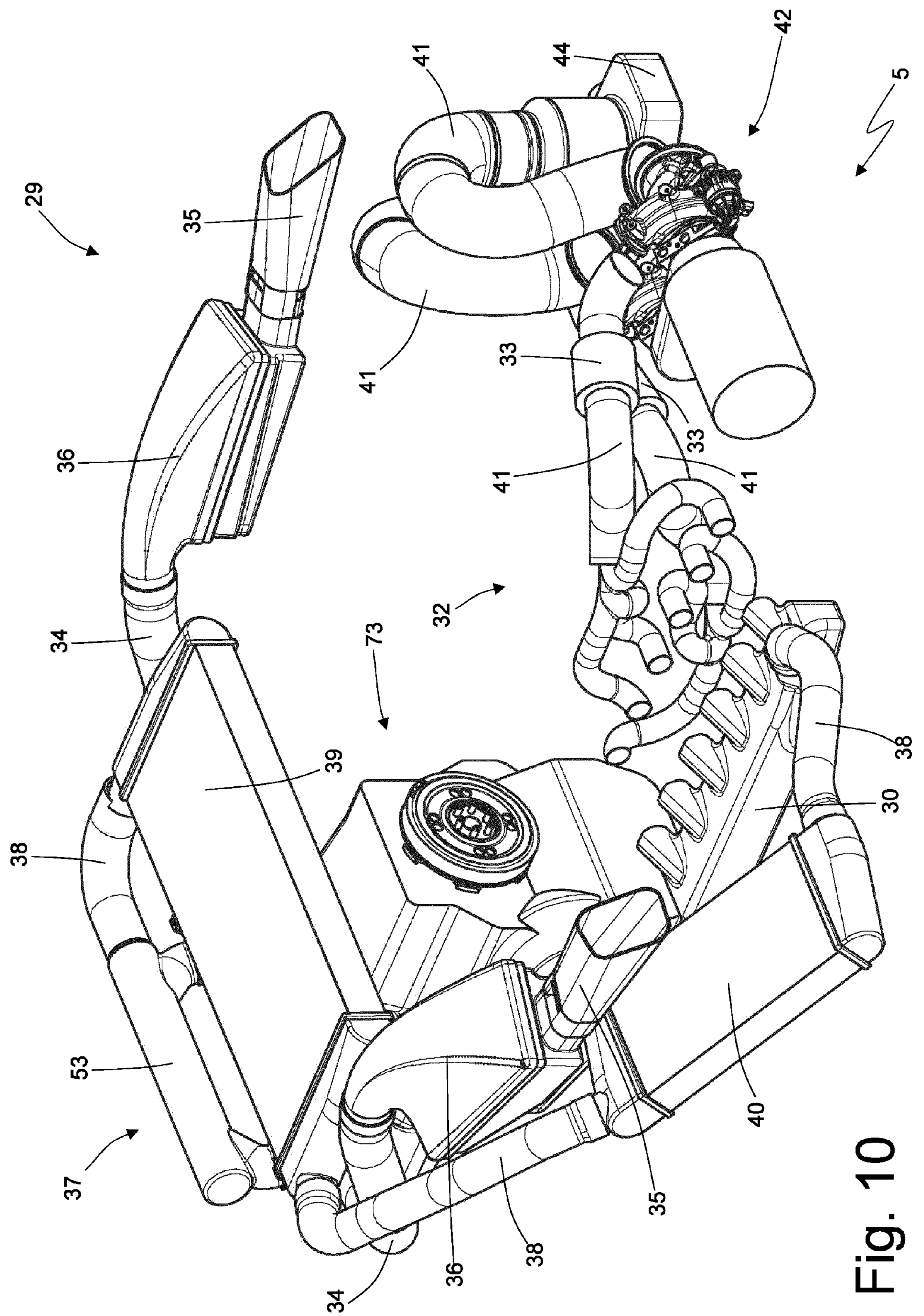


Fig. 10

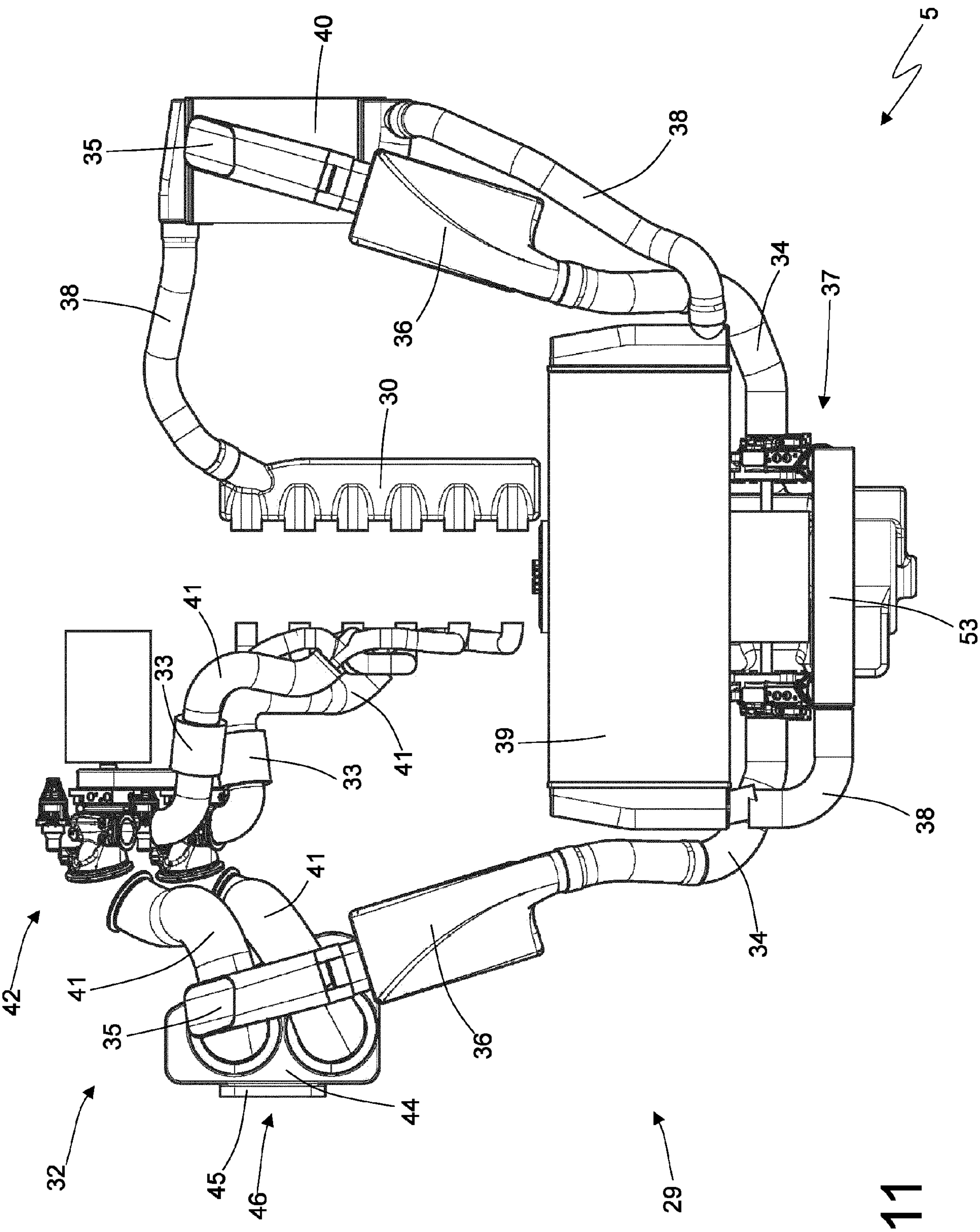

5
40
38
35
38
36
34
37
30
41
33
53
39
41
33
38
41
42
41
34
35
36
32
44
45
46
29

Fig. 11

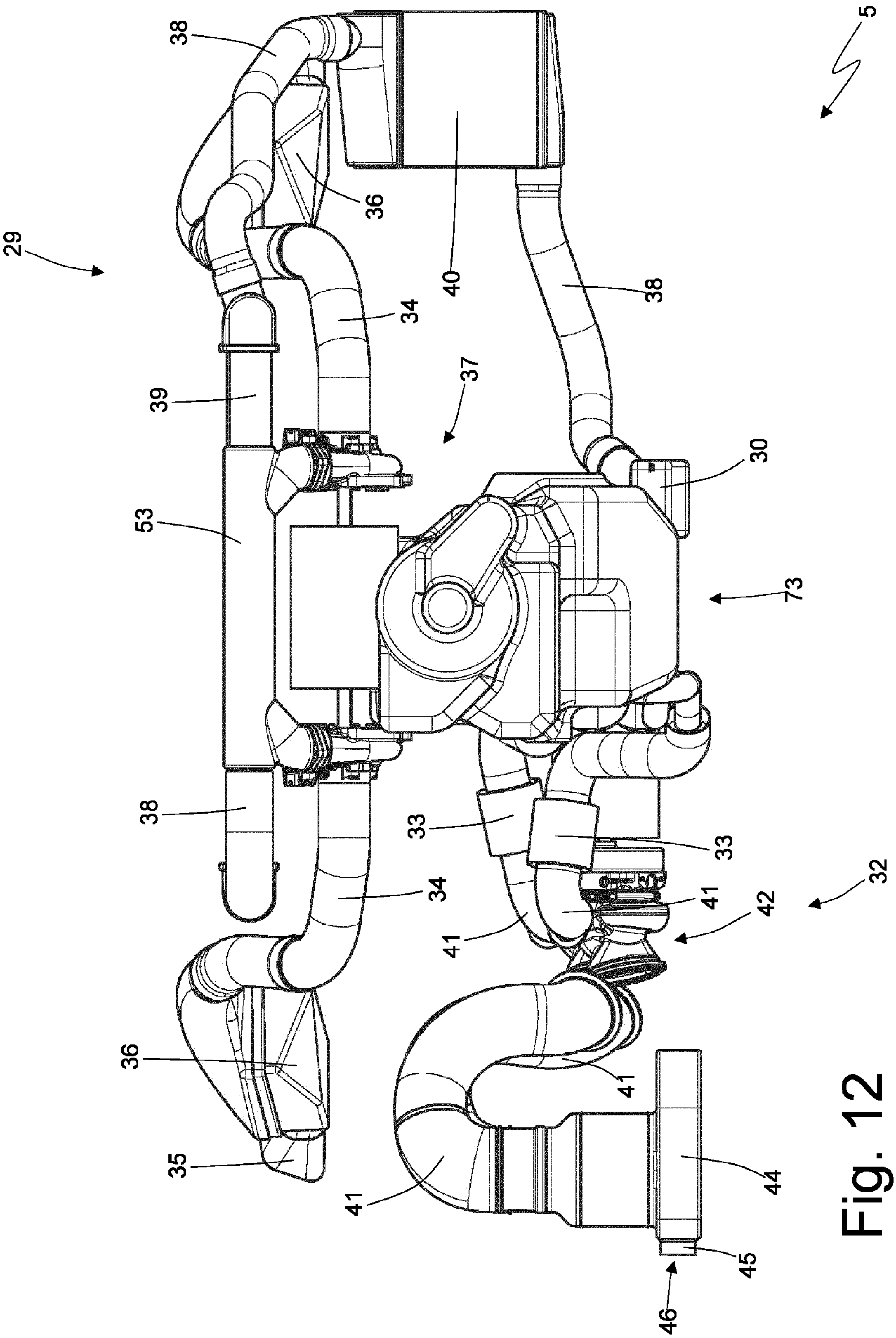
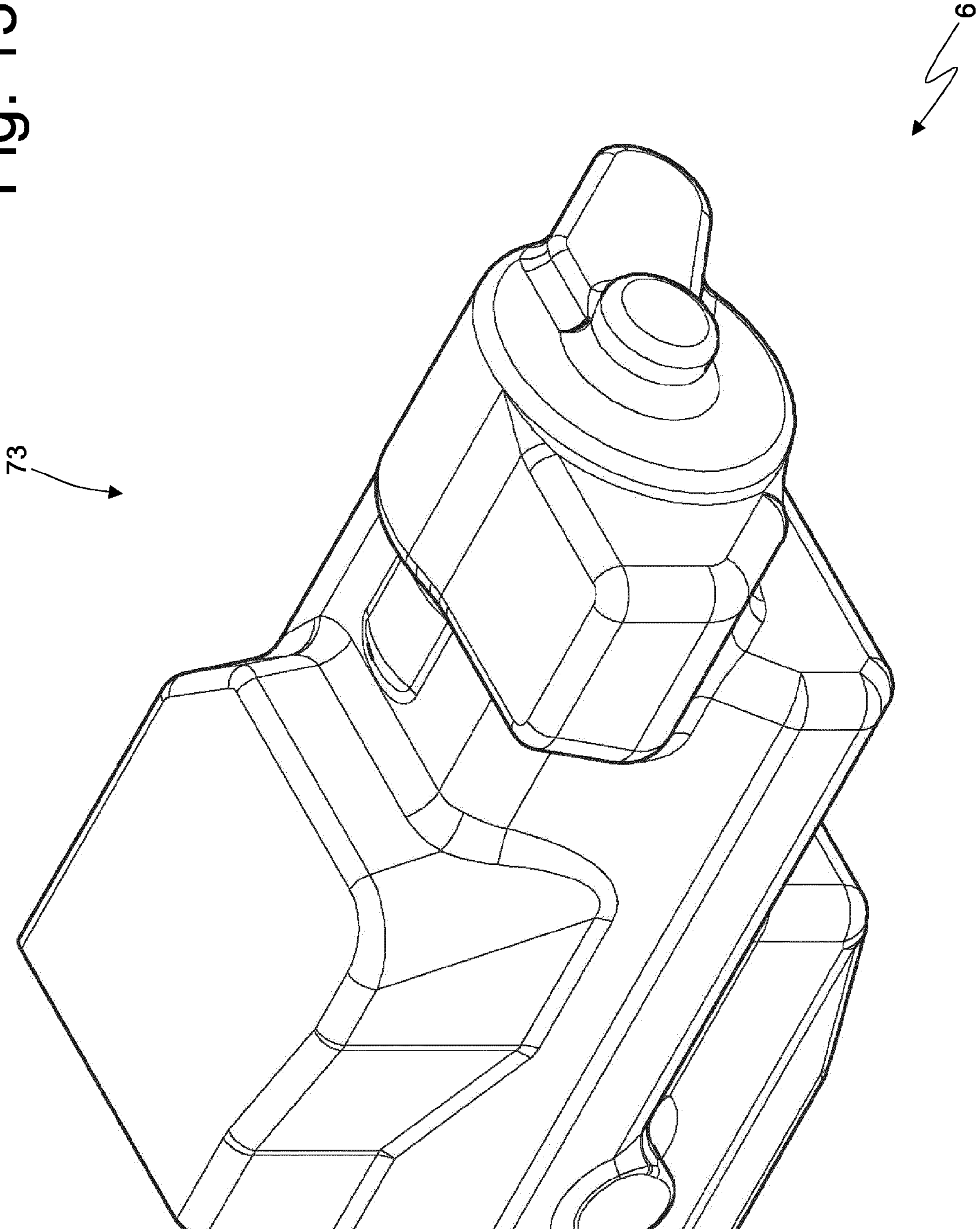

5
29
38
36
40
38
34
39
37
30
53
73
38
33
33
34
32
41
42
41
36
41
35
41
44
45
46

Fig. 12

Fig. 13



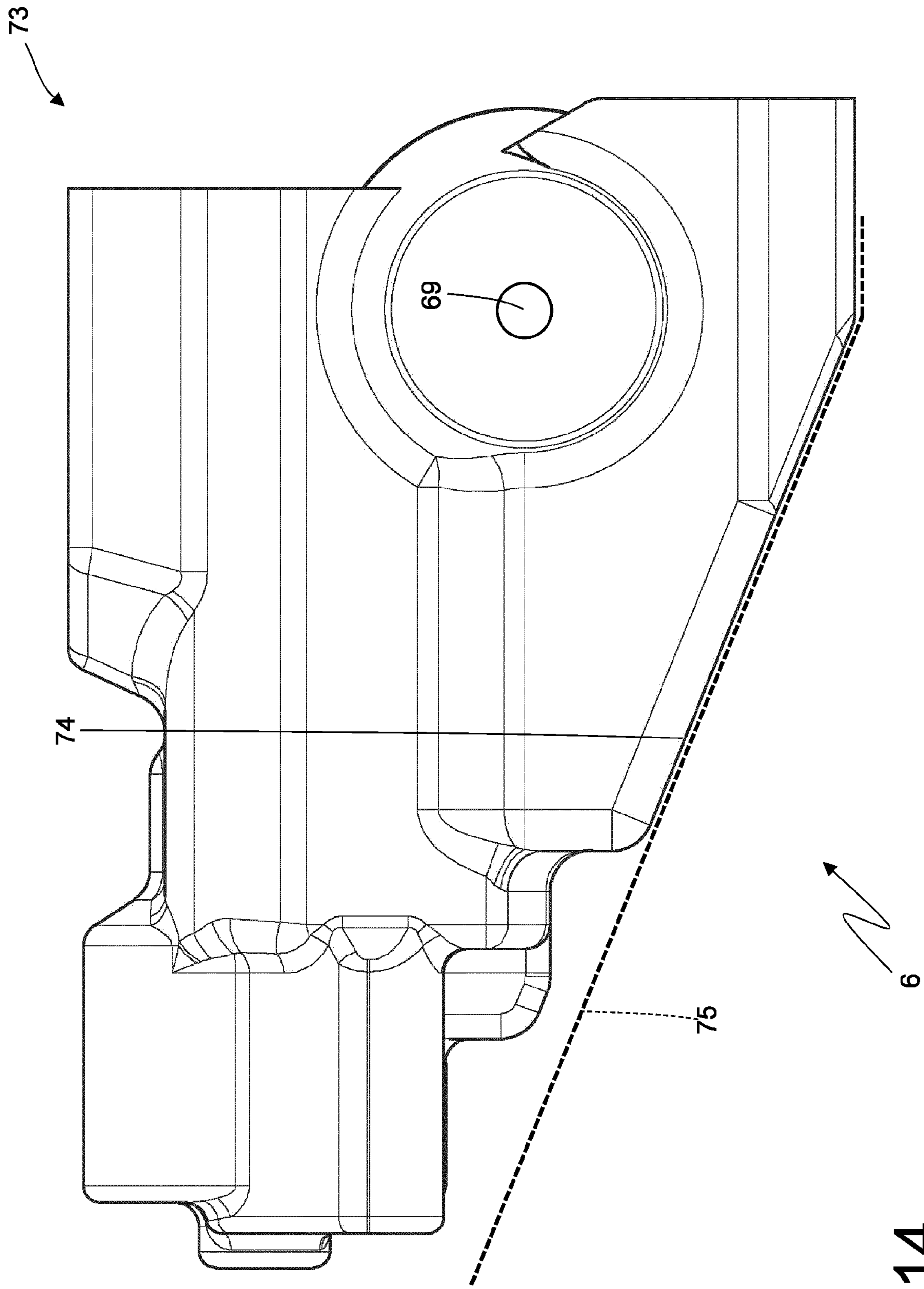


Fig. 14

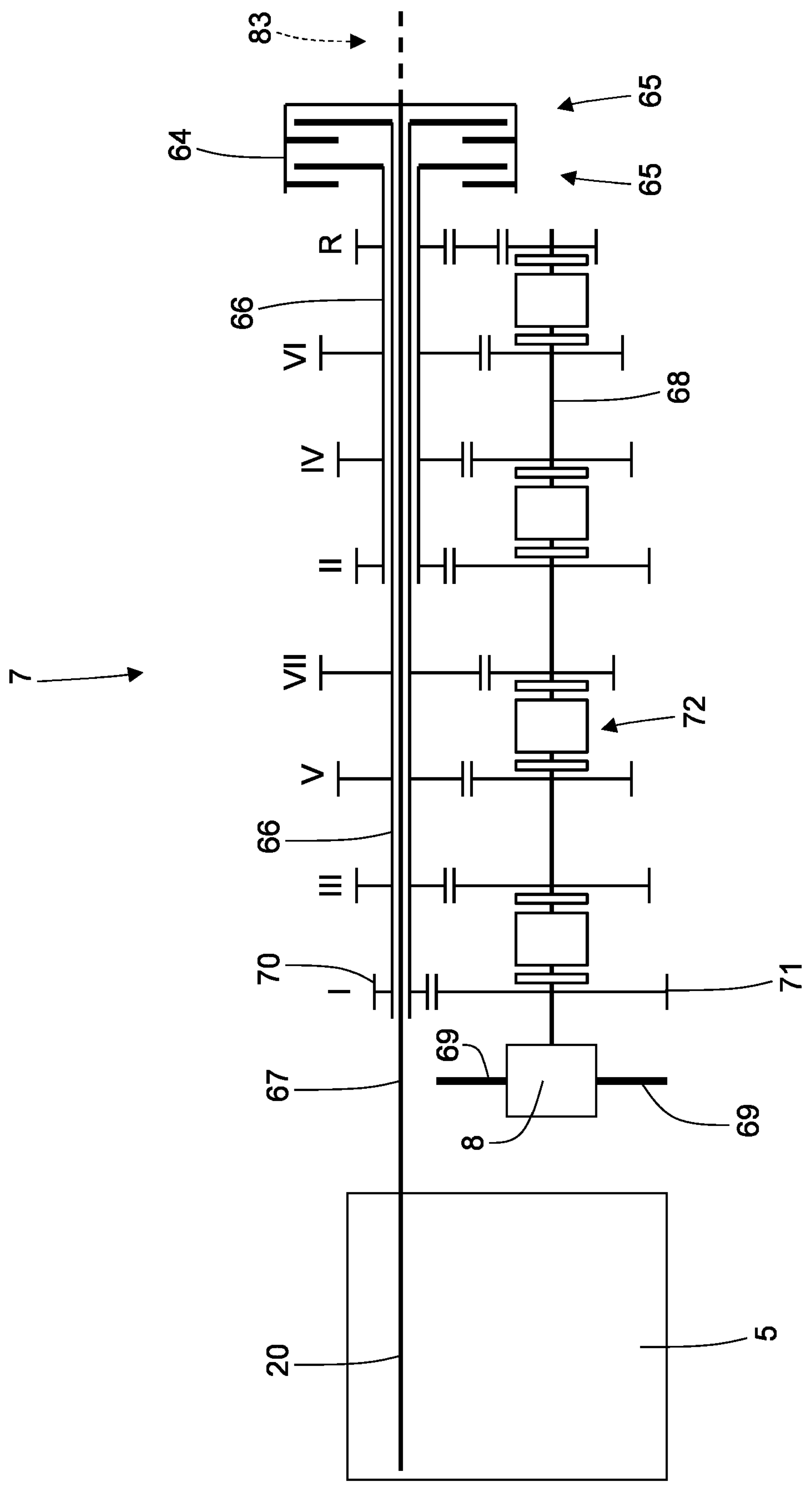


Fig. 15

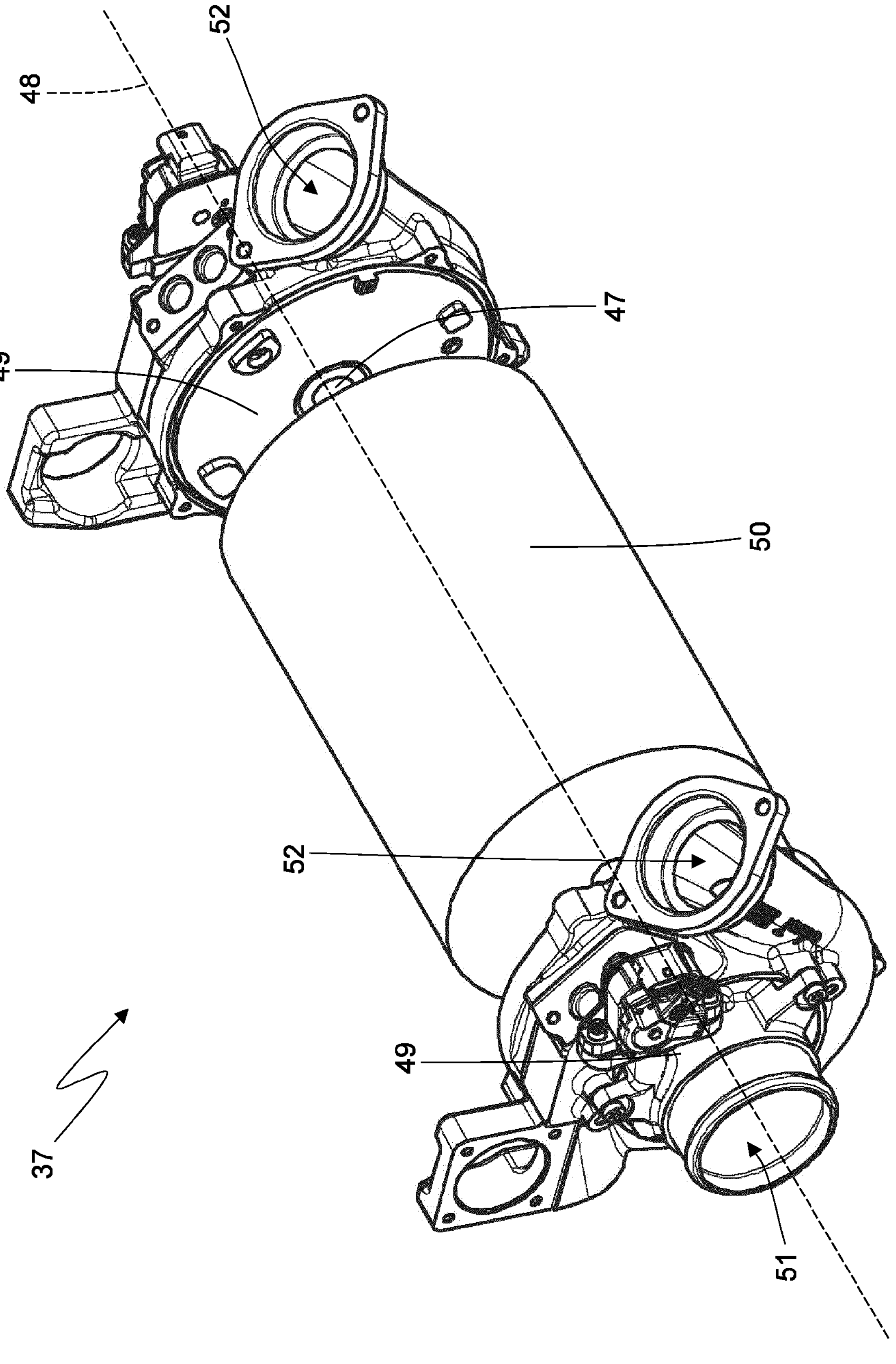


Fig. 16

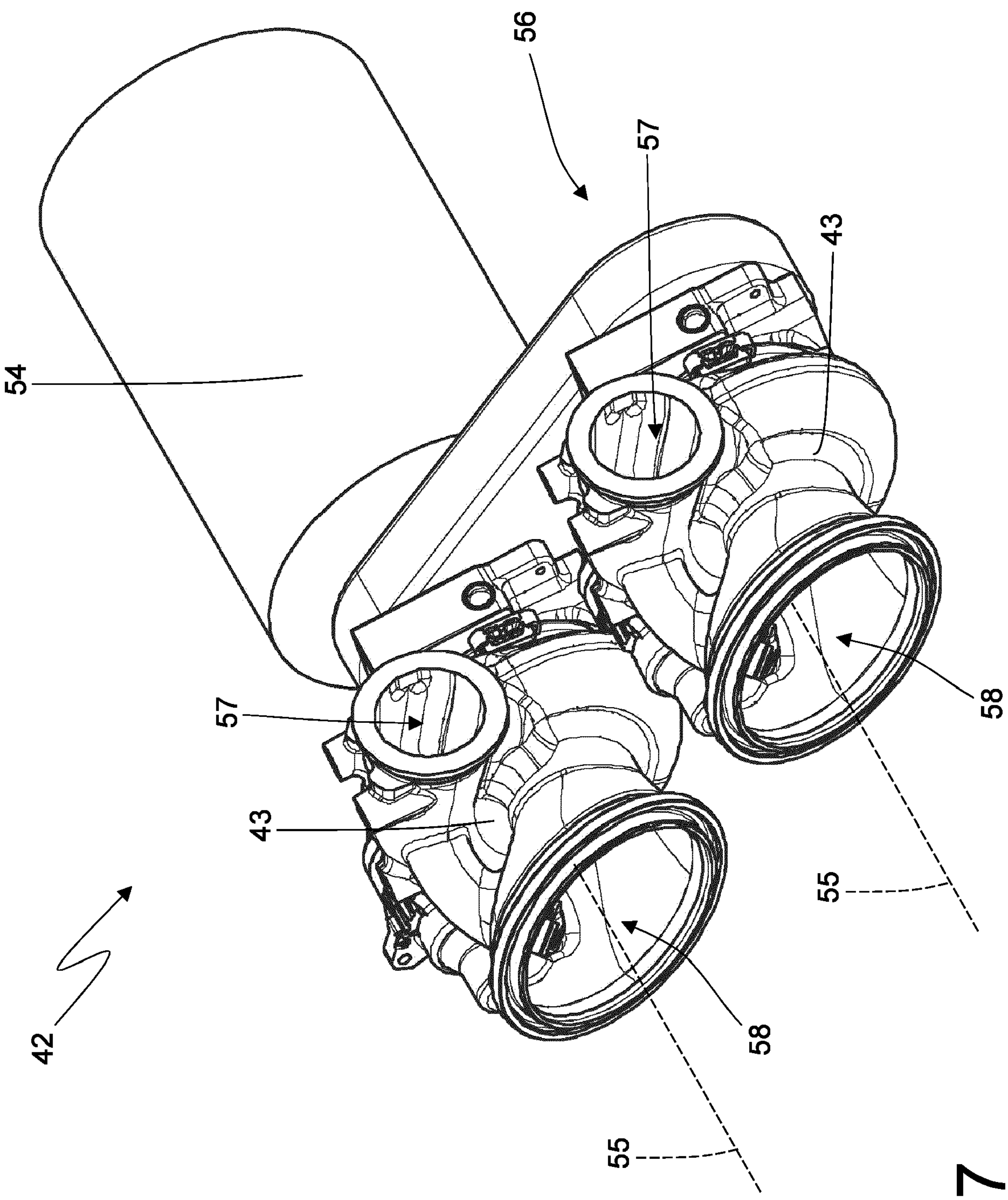
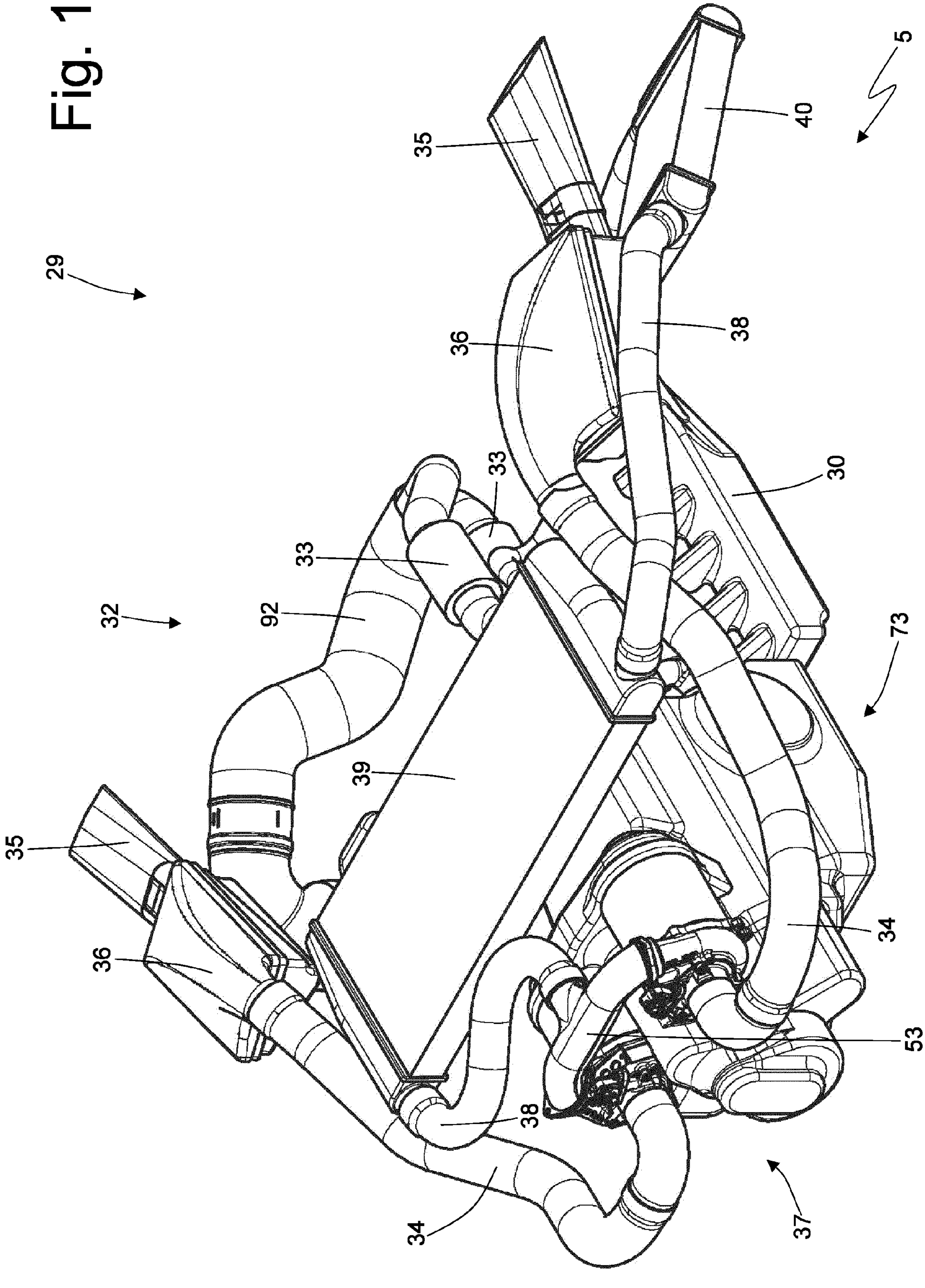


Fig. 17

Fig. 18



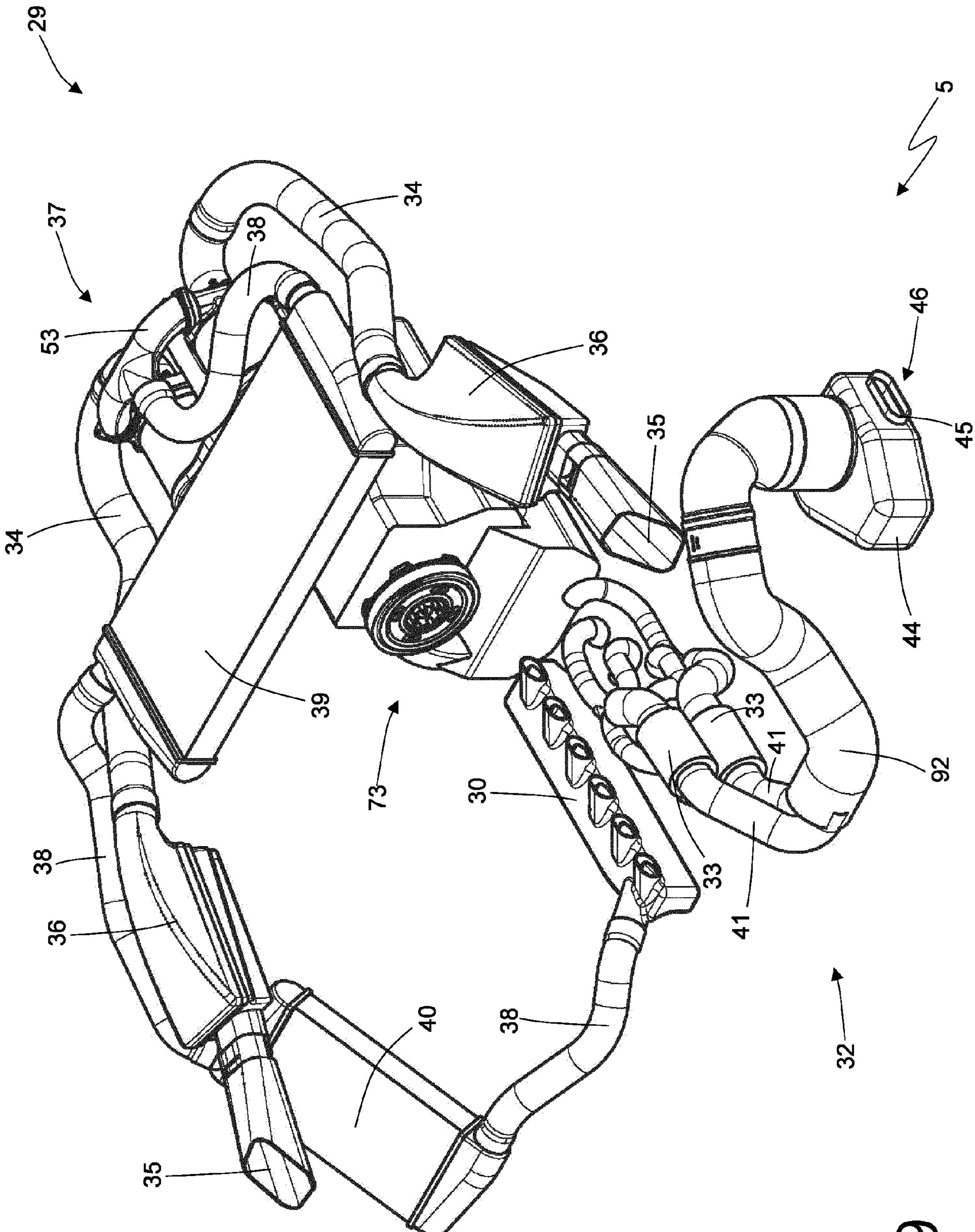

29
5
34
37
38
53
36
35
46
45
34
44
39
33
73
41
92
30
33
41
38
36
40
38
32
35

Fig. 19

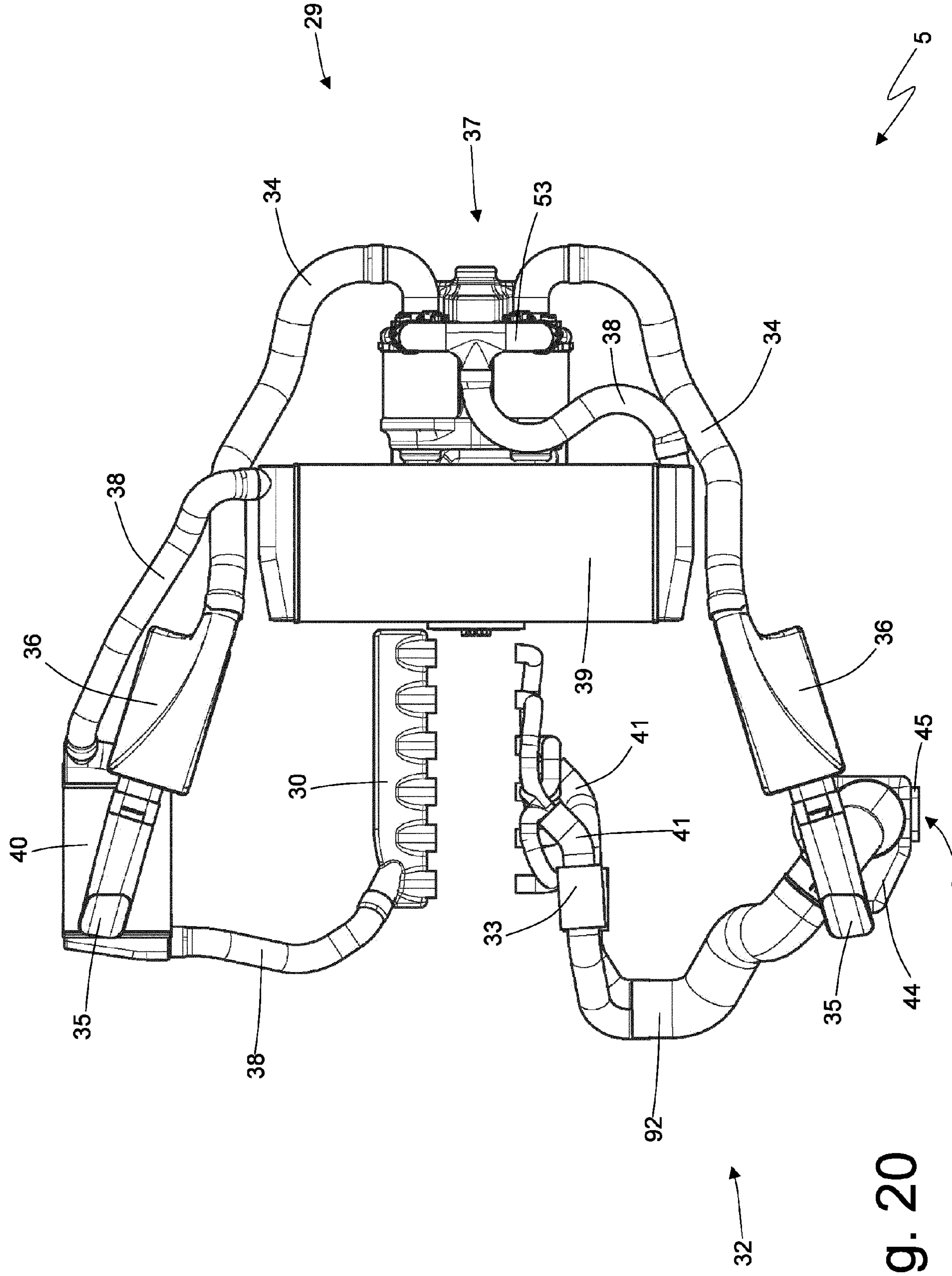


Fig. 20

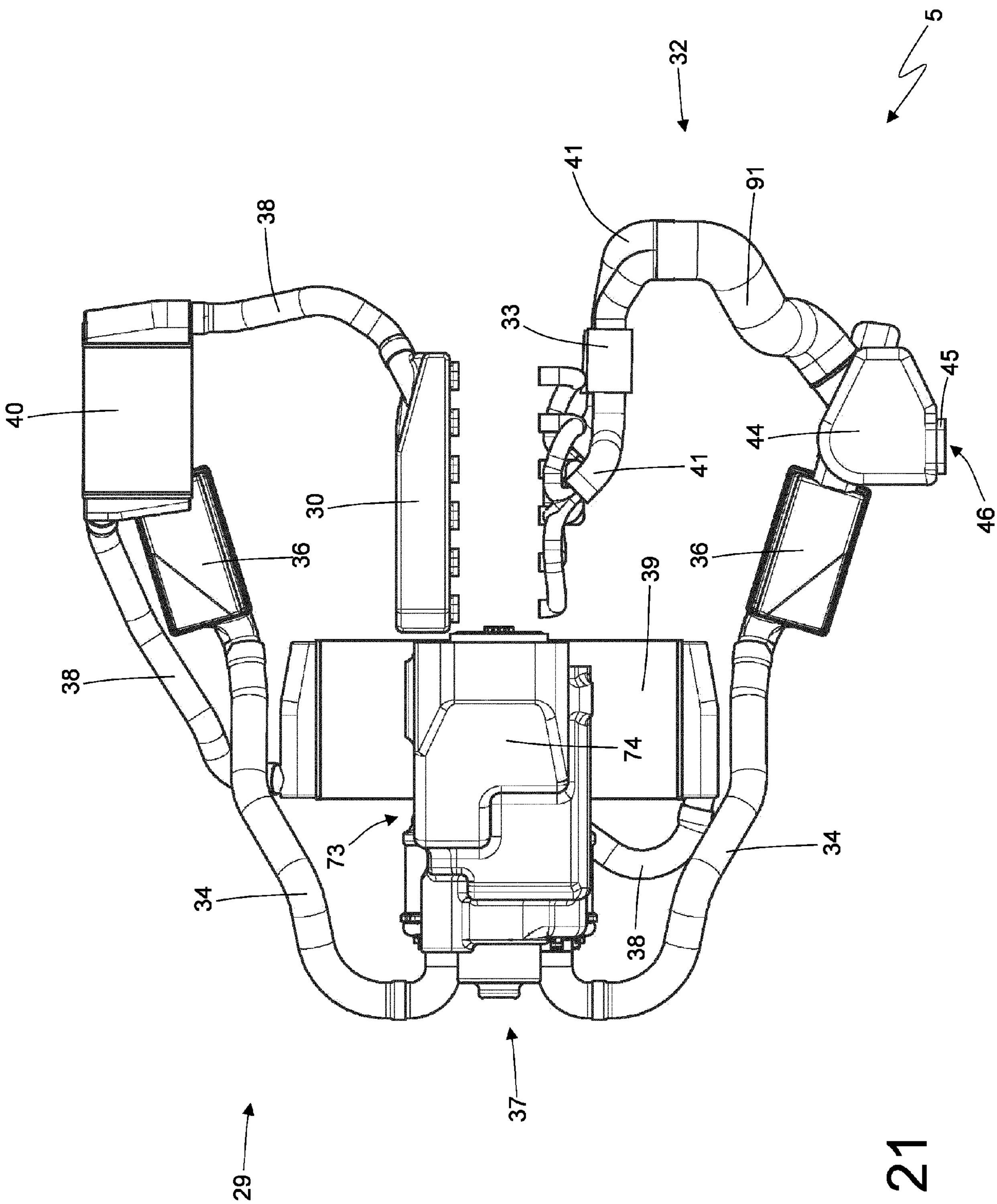


Fig. 21

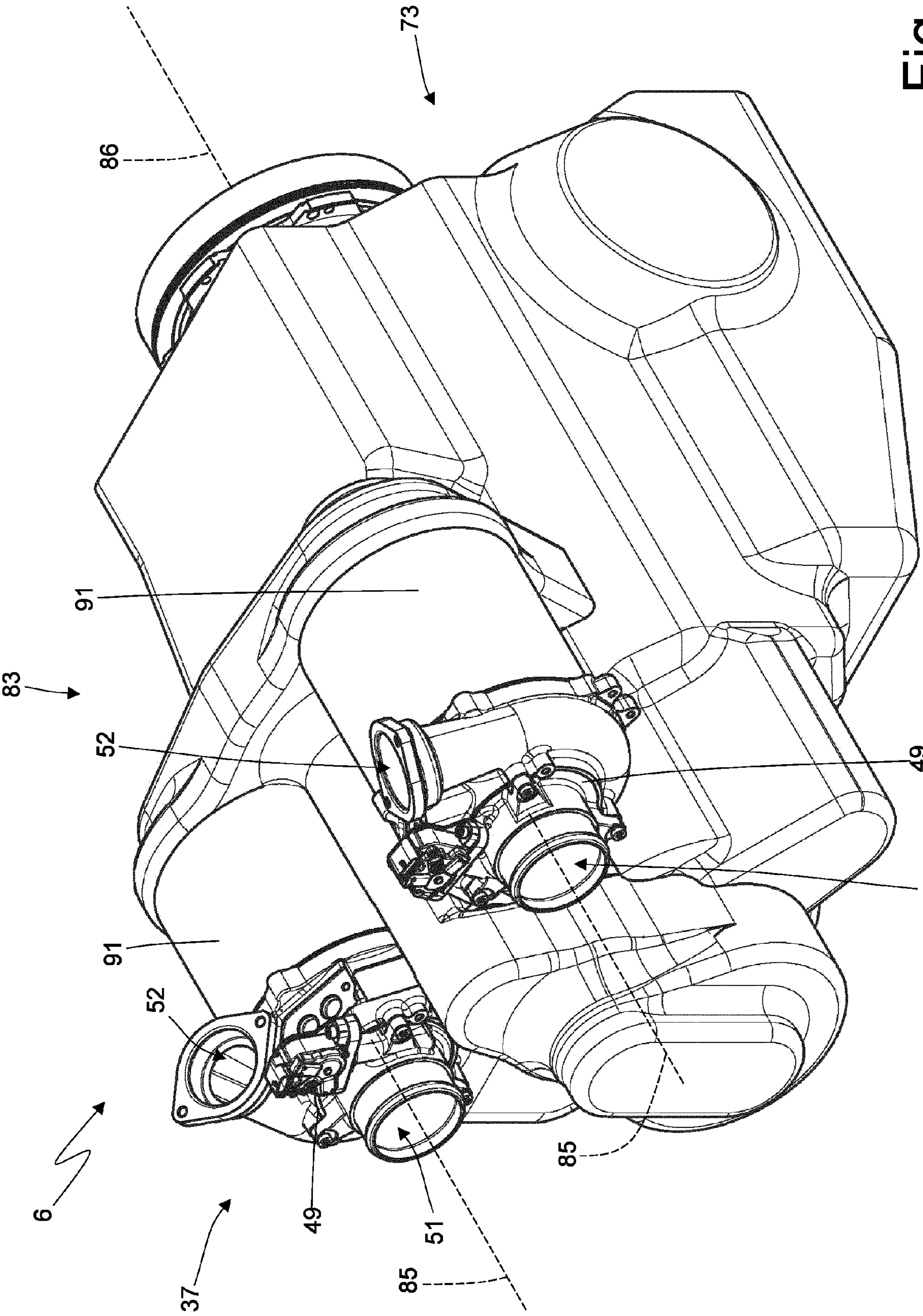


Fig. 22

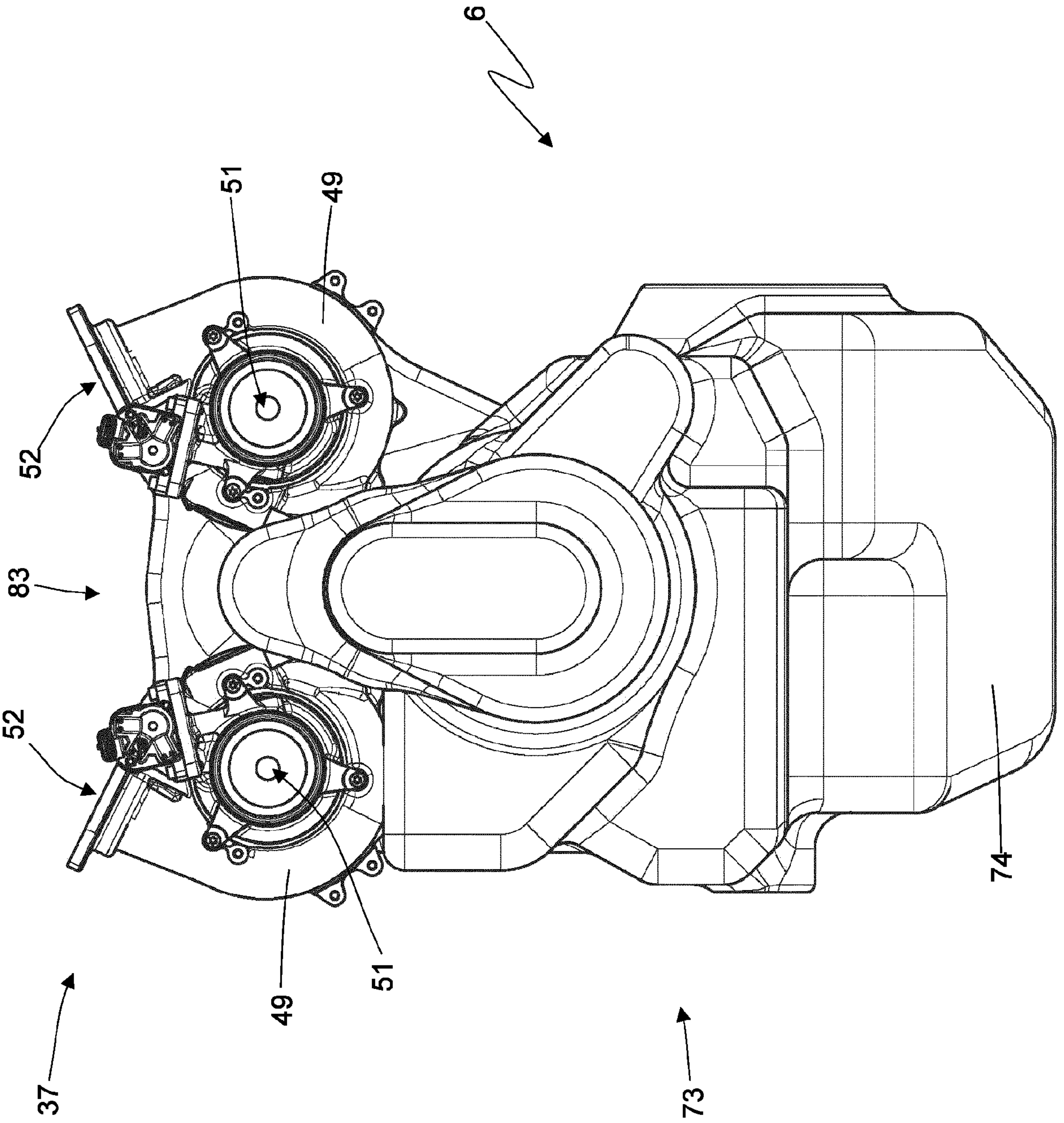


Fig. 23

Fig. 24

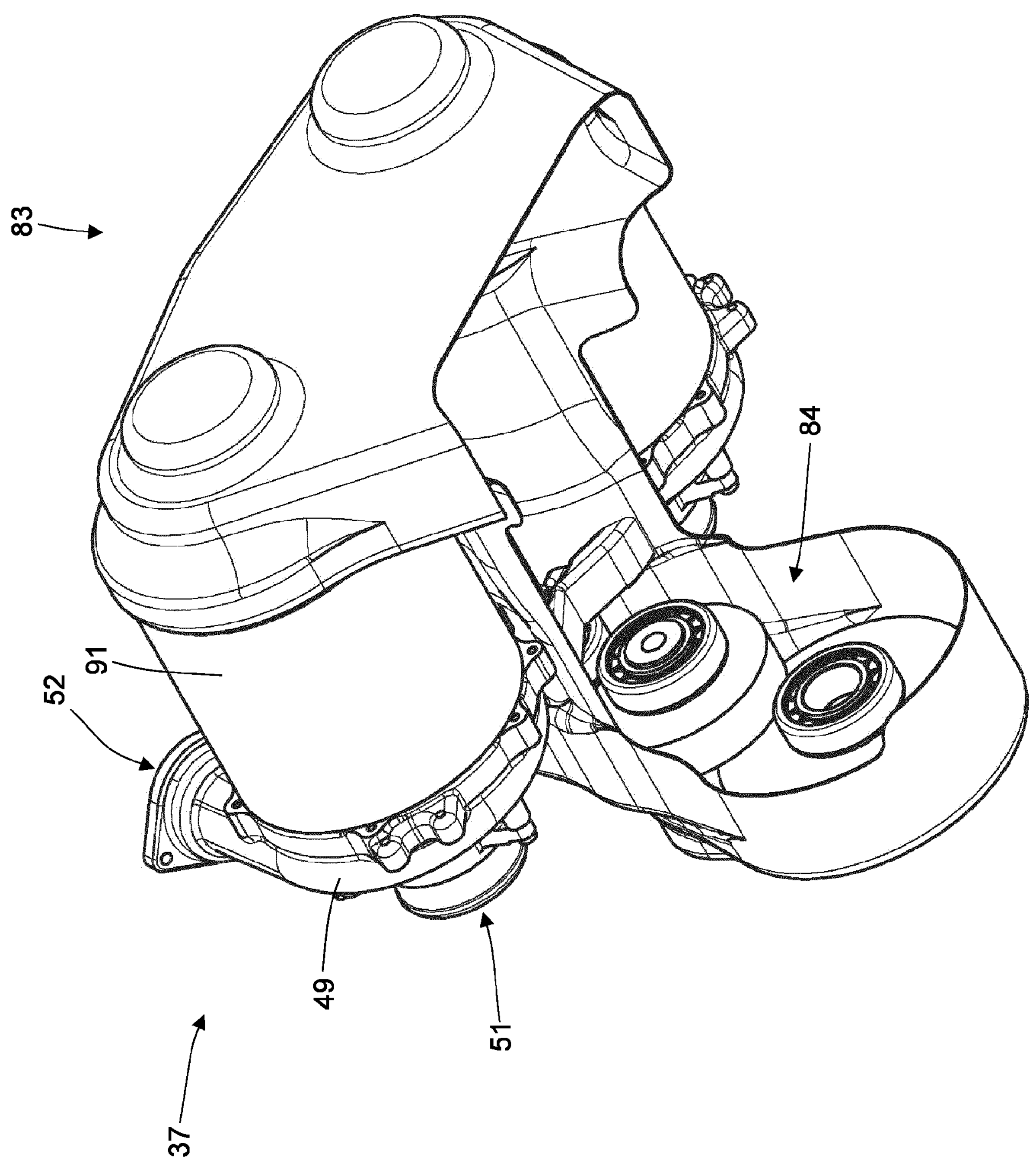
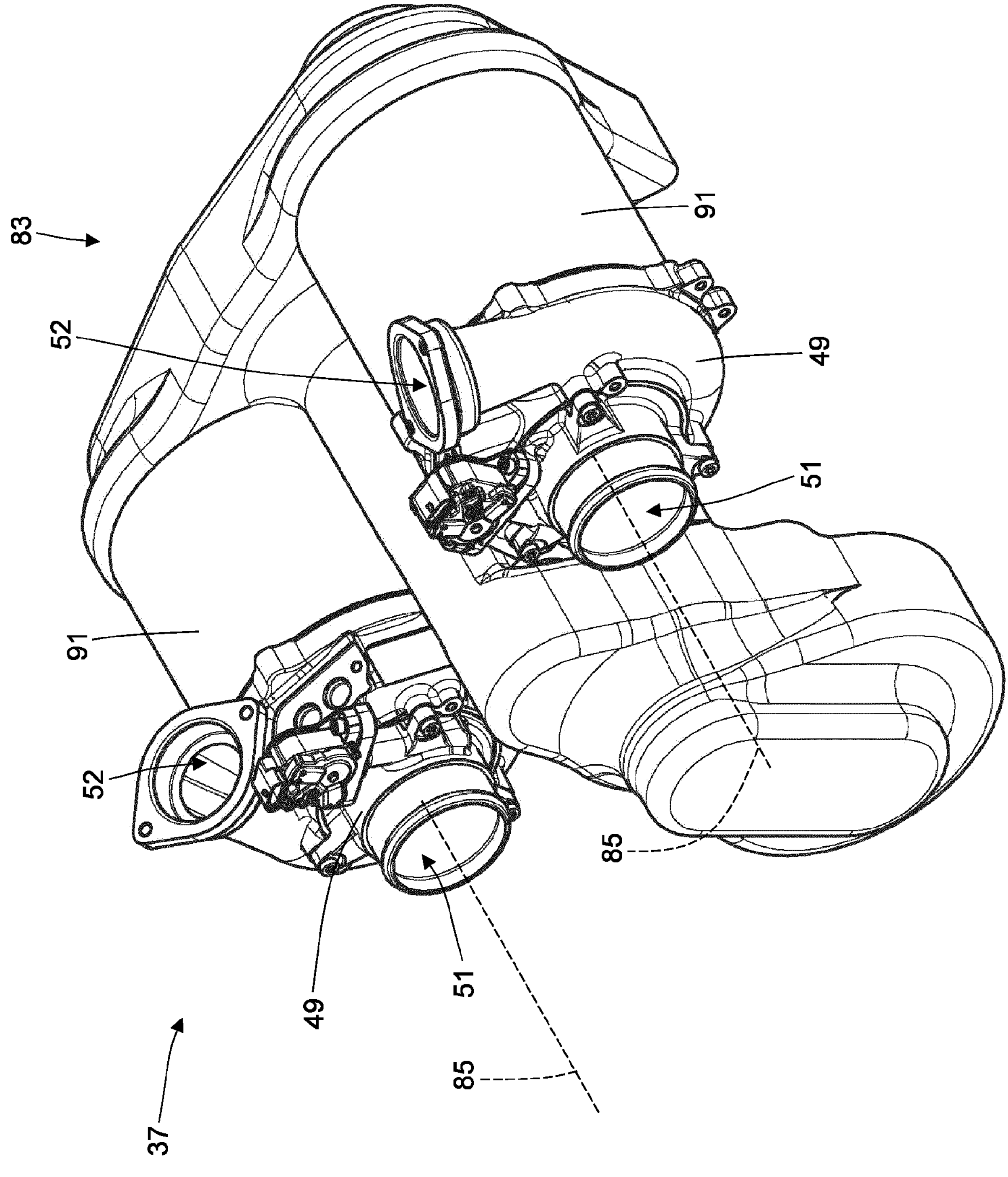


Fig. 25



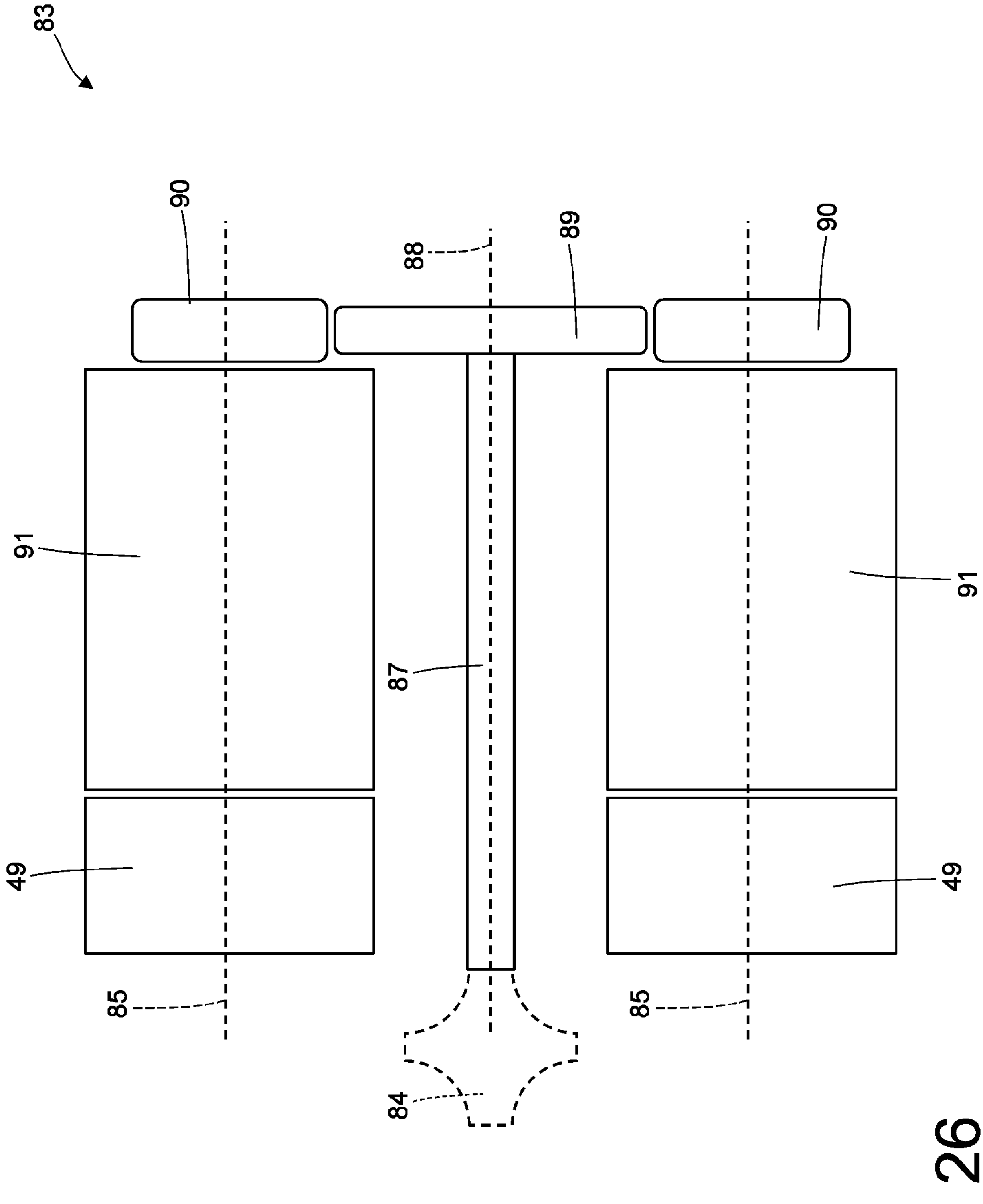


Fig. 26

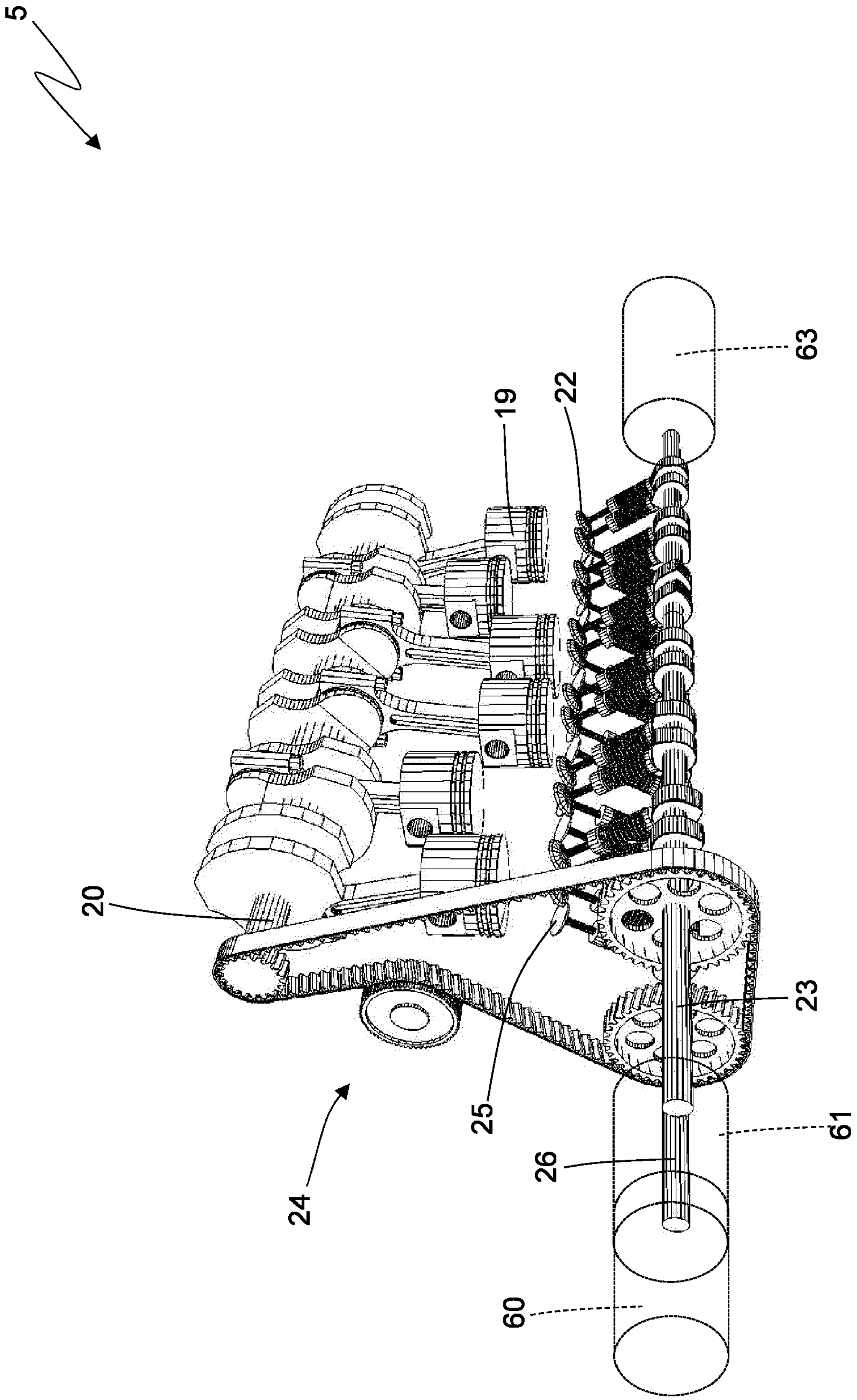


Fig. 27

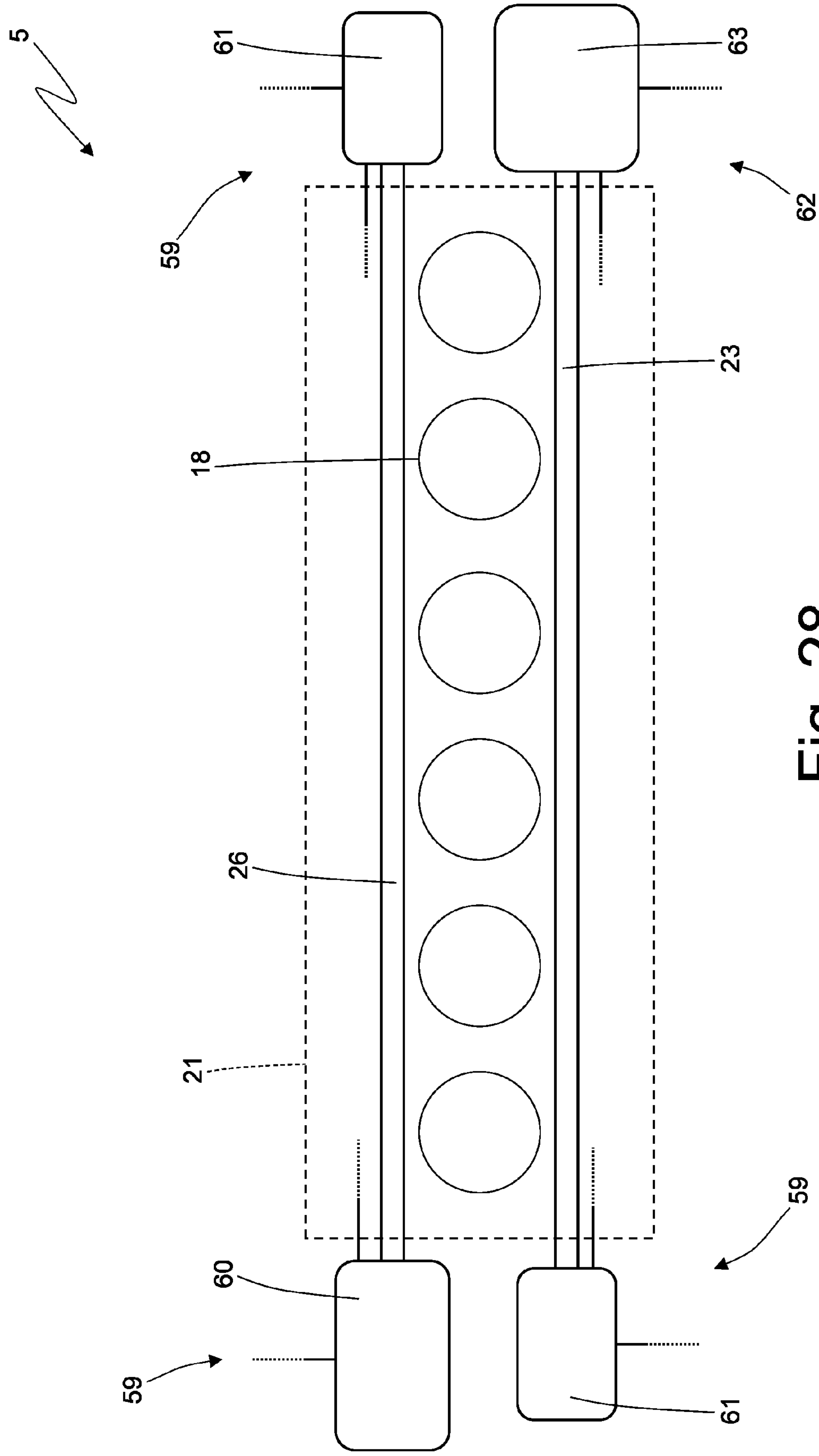


Fig. 28

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 19 2419

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2015/184580 A1 (ROOZENBOOM STEPHAN D [US] ET AL) 2 July 2015 (2015-07-02) * paragraph [0016] - paragraph [0020]; figure 1 * -----	1-11	INV. F02B29/04 F02B37/007
Y	US 7 490 462 B2 (CATERPILLAR INC [US]) 17 February 2009 (2009-02-17) * column 3, line 54 - column 4, line 57; figures 1-3 * -----	1-11	
Y	DE 10 2010 009874 A1 (PORSCHE AG [DE]) 25 August 2011 (2011-08-25) * paragraph [0013] - paragraph [0014]; figure 1 * -----	1-11	
Y	US 11 041 456 B2 (QUEST ENGINES LLC [US]; BLOM STEVE [US]) 22 June 2021 (2021-06-22) * column 4, line 11 - line 27 * * column 6, line 66 - column 7, line 9 * * column 19, line 53 - column 20, line 21; figures 10a-d * -----	6	TECHNICAL FIELDS SEARCHED (IPC)
A	US 2012/118658 A1 (SABATINI DANIELE [IT]) 17 May 2012 (2012-05-17) * the whole document * -----	1-11	F02B

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	23 October 2023	Tietje, Kai

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 19 2419

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-10-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015184580 A1	02-07-2015	CN 204386728 U	10-06-2015
		EP 2902602 A1	05-08-2015
		US 2015184580 A1	02-07-2015
US 7490462 B2	17-02-2009	NONE	
DE 102010009874 A1	25-08-2011	CN 102762401 A	31-10-2012
		DE 102010009874 A1	25-08-2011
		EP 2539170 A1	02-01-2013
		JP 2013518756 A	23-05-2013
		KR 20120112815 A	11-10-2012
		US 2012312620 A1	13-12-2012
		WO 2011103898 A1	01-09-2011
US 11041456 B2	22-06-2021	NONE	
US 2012118658 A1	17-05-2012	IT 1402425 B1	04-09-2013
		US 2012118658 A1	17-05-2012

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- IT 102022000017595 **[0001]**
- US 2015184580 A1 **[0006]**
- US 7490462 B2 **[0007]**