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

(11) EP 3 303 793 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
07.08.2019 Bulletin 2019/32

(21) Application number: **16730039.1**

(22) Date of filing: **27.05.2016**

(51) Int Cl.:
F01N 13/10 *(2010.01)*

(86) International application number:
PCT/SE2016/050489

(87) International publication number:
WO 2016/195573 (08.12.2016 Gazette 2016/49)

(54) **EXHAUST MANIFOLD**

ABGASSAMMLER

COLLECTEUR DE GAZ D'ÉCHAPPEMENT

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **04.06.2015 SE 1550729**

(43) Date of publication of application:
11.04.2018 Bulletin 2018/15

(73) Proprietor: **Scania CV AB**
151 87 Södertälje (SE)

(72) Inventors:
- **PETERSSON, Kim**
  117 64 Stockholm (SE)
- **KONSTANZER, Dennis**
  163 54 Spånga (SE)
- **SVENSSON, Thomas**
  554 59 Jönköping (SE)
- **ANDERSSON, Jenny**
  151 68 Södertälje (SE)

(74) Representative: **Scania CV AB**
Patents, GP 117kv
151 87 Södertälje (SE)

(56) References cited:
DE-C- 842 873
JP-A- 2000 104 545
US-A1- 2006 236 687
US-A1- 2008 302 095

EP 3 303 793 B1

Description

TECHNICAL FIELD

[0001] The present invention relates to an exhaust manifold for a four-stroke internal combustion engine.

BACKGROUND

[0002] An exhaust manifold of an internal combustion engine conducts exhaust gas from usually two or more cylinders towards a common exhaust conduit for the two or more cylinders. The common conduit leads to further parts of an exhaust system, such as e.g. a turbocharger, an exhaust gas cleaning system, and/or a silencer. Since the exhaust manifold is connected to more than one cylinder of the combustion engine, it has to be ensured that the flows of exhaust gas from the respective cylinders are directed towards an outlet end of the exhaust manifold.

[0003] WO 97/04222 discloses a collector for the primary pipes of an exhaust manifold of an internal combustion engine. The collector comprises a plurality of primary pipes, each leading from a cylinder of the combustion engine. An outlet end of each of the primary pipes has a cross-sectional area which is less than the main cross-sectional area of the primary pipe. Each outlet end of reduced cross-sectional area is in direct communication with a common cavity of the collector, at one end of the cavity. The reduction in area is sufficient to provide a pulse conversion effect so that the pressure waves of one cylinder do not negatively affect the gas flows of other cylinders. The area reduction is in the order of 5-10%.

[0004] US 5860278 discloses an exhaust manifold with several inlet ports and a combination of diffuser and nozzle portions associated with each inlet port for producing a high flow rate and a low pressure drop from entry to exit. The diffuser and nozzle portions are arranged in series and designed into the manifold at each inlet port and slightly upstream of the next downstream positioned inlet port. The diffuser portion decreases the velocity of exhaust gases as they enter the manifold and are then turned substantially ninety degrees into a longitudinal direction of the manifold. This diffuser action slows the velocity and reduces pressure losses as the turn of exhaust flow is accomplished. The next in series nozzle portion increases the velocity of exhaust gases to cause the exhaust flow to accelerate past a neighboring downstream engine exhaust port.

[0005] Similarly, US 2006/236687 discloses an exhaust manifold with deflector members positioned between downstream gas inlets from cylinders of an internal combustion engine and a main gas passage. The deflector members redirect the flow of exhaust gas from the inlets into the general direction of the gas flowing in the main passage at an angle of less than 90 degrees as the exhaust gas enters the main passage. At the deflector member towards the inlet passage, the formed cross section area is no less than that of the inlet passage. At the deflector member in the main passage, at least the same cross section area as an upstream inlet passage is provided. As the upstream exhaust gas flow passes by the outside surface of the deflector member in the main passage, a low pressure area is created on the inlet passage side of the deflector.

[0006] DE 842 873 relates to an exhaust gas collector for supercharged internal combustion engines with downstream exhaust gas turbine.

[0007] JP 2000 104545 relates to an exhaust manifold connected to each cylinder of an engine and guiding exhaust gas from combustion chambers of these cylinders to a supercharger, a muffler or the like.

[0008] US 2008/302095 relates to an improved exhaust manifold for controlling combustion gases and more particularly to arrangements for reducing pneumatic interaction between cylinders and optimizing exhaust flow in an exhaust manifold.

SUMMARY

[0009] It is an object of the present invention to provide an exhaust manifold wherein inter-cylinder disturbance of exhaust gas flow is at least alleviated.

[0010] According to an aspect of the invention, the object is achieved by an exhaust manifold for a four-stroke internal combustion engine, the exhaust manifold forming at least two inlet passages and one main passage having an outlet end arranged downstream of the at least two inlet passages. A first inlet passage of the at least two inlet passages connects to the main passage at a junction. An intersecting wall portion between the first inlet passage and the main passage forms an upstream end portion of the junction. A first portion of the first inlet passage at the intersecting wall portion has a first inlet passage cross sectional area, and the first inlet passage cross sectional area is smaller than a second inlet passage cross sectional area of a second portion of the first inlet passage located upstream of the first portion of the first inlet passage. The first inlet passage is connected to the main passage downstream of a second inlet passage of the at least two inlet passages. The main passage comprises a first main passage portion at the intersecting wall portion, the first main passage portion having a first main passage cross sectional area. The first main passage cross sectional area is smaller than a second main passage cross sectional area of a second main passage portion of the main passage located upstream of the junction.

[0011] It has been realised by the inventors that in addition to exhaust gas flow from one cylinder in an exhaust manifold towards an outlet of the exhaust manifold, a portion of exhaust gas will tend to flow also backwards in the exhaust manifold towards an upstream cylinder. Such flow backwards will affect exhaust gas discharge from the upstream cylinder, which may reduce overall available exhaust gas power to be utilised in e.g. a downstream turbocharger connected to the outlet end of the exhaust manifold.

[0012] Accordingly, a charge of exhaust gas from a cylinder connected to the first inlet passage is accelerated past the junction by the smaller first inlet passage cross sectional area, compared to the second inlet passage cross sectional area. Moreover, the first main passage cross sectional area being smaller than the second main passage cross sectional area reduces the flow of exhaust gas in an upstream direction in the main passage towards the second inlet. Thus, exhaust gas from the first inlet passage disturbing flow of exhaust gas from the second inlet passage is reduced compared to if the first main passage cross sectional area were not reduced. As a result, the accelerated exhaust gas from the first inlet passage, when entering the main passage, is further subjected to a comparatively high flow resistance in the upstream direction, promoting flow of exhaust gas from the first inlet passage in a downstream direction in the main passage.

[0013] The exhaust manifold is configured for conducting exhaust gas from each cylinder connected to the at least two inlet passages into the main passage. The main passage forms a common exhaust conduit for the cylinders connected to the at least two inlet passages. The main passage leads to further parts of an exhaust system. For instance, the outlet end of the main passage may be connected to e.g. a turbocharger, and/or an exhaust gas cleaning system, and/or a silencer.

[0014] According to embodiments, a main passage axis may extend centrally through the second main passage portion in a straight line past the junction and centrally through a third main passage portion of the main passage located downstream of the first main passage portion. According to embodiments, a centre axis of the first inlet passage at the first portion of the first inlet passage may extend at an acute angle to an upstream direction of the main passage axis. In this manner the exhaust gas emanating from a cylinder connected to the first inlet passage may be directed in a downstream direction in the main passage, towards the outlet end of the main passage. Moreover, the acceleration of the exhaust gas caused by the reduced first inlet passage portion cross sectional area may be utilised to ensure that the exhaust gas may reliably pass the junction in the downstream direction,

[0015] According to some embodiment the centre axis of the first inlet passage, at the first portion of the first inlet passage, may extend at an angle within a range of 30 - 45 degrees to the upstream direction of the main passage axis. In this manner it may be ensured that the exhaust gas from the cylinder connected to the first inlet passage is safely directed in the downstream direction in the main passage. Moreover, at an angle within such a range, the acceleration of the exhaust gas caused by the reduced first inlet passage portion cross sectional area may be utilised to ensure that the exhaust gas may reliably pass the junction in the downstream direction, which may reduce the amount of exhaust gases flowing in an upstream direction past the junction towards the second inlet passage.

[0016] According to embodiments, the intersecting wall portion may form at least part of a deflector arranged between the first inlet passage and the main passage. The deflector may extend towards the main passage axis. In this manner exhaust gas from the first inlet passage may be directed in a downstream direction in the main passage by the deflector. Moreover, exhaust gas in the main passage, e.g. from the second inlet passage, may be directed away from the junction by the deflector. Thus, the deflector may direct exhaust gas from both the first inlet passage and the second inlet passage.

[0017] According to embodiments, the deflector may comprise a first wall portion forming a delimiting surface of the main passage. The first wall portion may extend at an acute angle to the upstream direction of the main passage axis being smaller than the angle of the centre axis of the first portion of the first inlet passage to the upstream direction. In this manner exhaust gas in the main passage, e.g. from the second inlet passage, may be directed away from the junction by the first wall portion of the deflector. It has been discovered that an angle of the first wall portion smaller than the angle of the centre axis of the first portion of the first inlet passage may be sufficient to reduce a tendency of the exhaust gas from the second inlet passage to flow into the first inlet passage.

[0018] According to the invention, the main passage comprises a widening section extending at least upstream of the first main passage portion, which widening section widens the main passage in a first direction. The first direction extends in a first cross sectional plane, which first cross sectional plane extends through the first inlet passage, through at least a portion of the main passage, extends along the main passage axis, and includes the main passage axis. The first direction is directed away from the first inlet passage. Since the widening section is arranged at least upstream of the junction in the main passage and widens in a direction away from the first inlet passage, exhaust gas from the first inlet passage flowing upstream in the main passage will flow into the widening section and form a circulating flow of exhaust gas therein. Accordingly, the first fraction of a charge of exhaust gas from the first inlet passage will form a vortex in the widening section, which vortex reduces the effective flow area in the widening section for the remaining portion of the charge of exhaust gas from the first inlet passage. The effective flow area reduced by the vortex prevents further partial amounts of the exhaust gas from the first inlet passage to flow in an upstream direction from the junction.

[0019] The widening section may form a bulging portion of the main passage, which bulging portion bulges in a direction away from the first inlet passage. Whereas the widening section widens the main passage in the first direction e.g. compared to the second main passage portion, the widening section, along a different cross-sectional direction, may have a smaller dimension than the second main passage portion.

[0020] According to embodiments, an inner surface of the main passage, opposite to the first inlet passage, at a transition between the widening section and the second main passage portion may form an abrupt directional change, such that a vortex may be formed in exhaust gases during use of the exhaust manifold. In this manner the abrupt directional change may assist in forming of the vortex in the widening section. Put differently, the inner surface may be provided with an abrupt directional change at a point of the inner surface, to which a vortex in the widening section extends. The abrupt directional change may be provided opposite to the first inlet passage, seen in the first cross sectional plane. The vortex in the widening section is formed by the first fraction of each charge of exhaust gas from the first inlet passage.

[0021] According to embodiments, the widening section may extend upstream of an end point of the intersecting wall portion over a distance having a length within a range of 1,2 - 1,7 times a hydraulic diameter of the second main passage portion. In this manner a vortex may be formed in the widening section, which vortex reduces flow of exhaust gas upstream of the junction, but which vortex does not affect flow of exhaust gas in a downstream direction from the junction to any particular extent. Seen in the first cross sectional plane, the widening section may extend upstream of the end point of the intersecting wall portion to the abrupt directional change.

[0022] According to embodiments, the widening section may extend downstream of the end point of the intersecting wall portion over a distance having a length within a range of 2 - 3 times a hydraulic diameter of the second main passage portion. In this manner the downstream end of the widening section does not promote flow of exhaust gas from the first inlet passage in the upstream direction in the main passage.

[0023] Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Various aspects of the invention, including its particular features and advantages, will be readily understood from the example embodiments discussed in the following detailed description and the accompanying drawings, in which:

Fig. 1 illustrates a cross section through an exhaust manifold according to exemplary embodiments adapted for use with a four-stroke internal combustion engine, and

Figs. 2 and 3 illustrate cross sections through part of the exhaust manifold of Fig. 1.

DETAILED DESCRIPTION

[0025] Aspects of the present invention will now be described more fully. Like numbers refer to like elements throughout. Well-known functions or constructions will not necessarily be described in detail for brevity and/or clarity.

[0026] Herein the term charge of exhaust gas refers to the exhaust gas discharged from one combustion cycle of one cylinder. Since fuel combusts in the different cylinders of the combustion engine at different angles of a crankshaft of the engine, charges of exhaust gas flow through different inlet passages of an exhaust manifold at different points in time. The term downstream relates to the flow direction in an exhaust manifold from a respective cylinder to an outlet end of the exhaust manifold. The term upstream relates to the opposite flow direction in the exhaust manifold.

[0027] Herein the term hydraulic diameter will be used for the purpose of comparing cross sectional sizes and distances of various portions and sections of an exhaust manifold. The hydraulic diameter is a commonly used term when calculating flow related parameters in noncircular passages, such as tubes or channels. Using the hydraulic diameter, parameters of a passage may be calculated in the same manner as for a circular passage. The hydraulic diameter, D_H, is defined as:

$$D_H = 4A/P$$

where A is the actual cross sectional area of a relevant passage portion, and P is the wetted perimeter, i.e. in this case the length of the inner perimeter, of the relevant cross-section.

[0028] Herein a cross sectional area of a passage portion is always calculated based on the hydraulic diameter of the relevant cross sectional area. Accordingly, herein a cross sectional area of a passage portion, A_H, is defined as:

$$A_H = \pi D_H^2/4$$

[0029] This entails for instance that the actual cross sectional areas, A, of two passage portions may be the same, whereas the cross sectional areas, A_H, based on the hydraulic diameters of the two passage portions may be of different sizes due to the two passage portions having different cross sectional shapes.

[0030] If not defined otherwise, herein a cross section of a passage portion extends perpendicularly to a centre line of the relevant passage portion.

[0031] **Fig. 1** illustrates a cross section through an exhaust manifold 2 according to exemplary embodiments adapted for use with a four-stroke internal combustion engine. In the illustrated embodiment, the exhaust manifold 2 is adapted to be attached to three cylinders of the internal combustion engine (not shown). The internal combustion engine may be e.g. of a type having three or more cylinders arranged in a straight line, or of a type having cylinders arranged in a V configuration, such as in a V-6 or V-8 engine.

[0032] The exhaust manifold 2 forms a plurality of exhaust gas inlet branches 4 arranged in series and connected to a main branch 6. In these embodiments, the exhaust manifold 2 comprises three exhaust gas inlet branches 4. In alternative embodiments an exhaust gas manifold may comprise only two exhaust gas inlet branches, or more than three inlet branches, depending inter alia on the cylinder configuration of a relevant internal combustion engine. Each exhaust gas inlet branch 4 defines an inlet passage 8, 10, 14. The inlet passages 8, 10, 14 each receive a charge of exhaust gas from an associated exhaust opening (not shown) of a cylinder head of the internal combustion engine. The main branch 6 defines a main passage 12. The exhaust manifold 2 comprises walls having inner surfaces. The inner surfaces delimit the inlet passages 8, 10, 14 and the main passage 12. Cross sectional areas of the passages 8, 10, 14, 12 are delimited by the inner surfaces.

[0033] The exhaust manifold 2 forms at least two inlet passages 8, 10, 14 and one main passage 12. The main passage 12 has an outlet end 16 arranged downstream of the at least two inlet passages 8, 10, 14.

[0034] The exhaust manifold 2 generally extends longitudinally with a closed forward end portion and the open outlet end 16. When attached to the associated engine cylinder head, the manifold 2 is secured so as to align its inlet passages 8, 10, 14, with exhaust gas outlet openings of the cylinder head. As each exhaust valve opens for an associated cylinder, a charge of exhaust gas flows from the cylinder head into the associated inlet passage 8, 10, 14, and from the inlet passage into the main passage 12. The outlet end 16 of the main passage 12 may be connected to e.g. a turbocharger of the internal combustion engine. The exhaust manifold 2 may be provided with non-shown flanges for connecting the exhaust manifold 2 to the cylinder head, exhaust conduits, etc.

[0035] A first inlet passage 8 of the at least two inlet passages connects to the main passage 12 at a junction 18. The at least two inlet passages 8, 10, 14 are connected in series to the main passage 12. The first inlet passage 8 is connected to the main passage 12 downstream of a second inlet passage 10 of the at least two inlet passages 8, 10, 14. A third inlet passage 14 of the at least two inlet passages 8, 10, 14 is connected to the main passage 12 downstream of the first inlet passage 8. The third inlet passage 14 and its connection to the main passage 12 are substantially identical to the first inlet passage 8 and its connection to the main passage 12. The difference between the second inlet passage 10, and the first and third inlet passages 8, 14 is that the second inlet passage 10 does not have any inlet passage arranged upstream thereof along the main passage 12. Accordingly, a charge of exhaust gas flowing from the second inlet passage 10 into the main passage 12 is subjected to different flow conditions than charges of exhaust gas flowing from the first or third inlet passage 8, 14 into the main passage 12.

[0036] The exhaust manifold 2 may be manufactured e.g. by sand casting. Different parts of the exhaust manifold 2 may be cast separately and thereafter joined to form the exhaust manifold.

[0037] **Figs. 2 and 3** illustrate cross sections through part of the exhaust manifold 2 of Fig. 1. More specifically, the cross sections of Figs. 2 and 3 illustrate a portion of the main passage 12 and the first inlet passage 8 connecting thereto.

[0038] An intersecting wall portion 20 between the first inlet passage 8 and the main passage 12 forms an upstream end portion of the junction 18. A first portion 22 of the first inlet passage 8 at the intersecting wall portion 20 has a first inlet passage cross sectional area 24. A second portion 26 of the first inlet passage 8 arranged upstream of the first portion 22 of the first inlet passage 8 has a second inlet passage cross sectional area 28. The second portion 26 of the first inlet passage 8 is in these embodiments arranged at an inlet 29 of the first inlet passage 8. The first inlet passage cross sectional area 24 is smaller than the second inlet passage cross sectional area 28. Thus, also the hydraulic diameter of the first inlet passage cross sectional area 24 is smaller than the hydraulic diameter of the second inlet passage cross sectional area 28.

[0039] The main passage 12 comprises a first main passage portion 30 at the intersecting wall portion 20. The first main passage portion 30 has a first main passage cross sectional area 32. The main passage 12 comprises a second main passage portion 40 upstream of the junction 18. The second main passage portion 40 has a second main passage cross sectional area 48. The first main passage cross sectional area 32 is smaller than the second main passage cross sectional area 48. Thus, also the hydraulic diameter of the first main passage cross sectional area 32 is smaller than the hydraulic diameter of the second main passage cross sectional area 48.

[0040] The first portion 22 of the first inlet passage 8 may be positioned at an end portion 37 of the intersecting wall portion 20. Also the first main passage portion 30 may be positioned at the end portion 37 of the intersecting wall portion 20.

[0041] A main passage axis 38 extends centrally through the second main passage portion 40 in a straight line past the junction 18 and centrally through a third main passage portion 34 downstream of the first main passage portion 30. The first main passage cross sectional area 32 extends perpendicularly to the main passage axis 38.

[0042] A centre axis 42 of the first inlet passage 8 at the first portion 22 of the first inlet passage 8 extends at an acute angle α to an upstream direction 44 of the main passage axis 38. The angle α may be within a range of

30 - 45 degrees. Thus, a charge of exhaust gas flowing through the first inlet passage 8 is directed in a downstream direction 46 in the main passage 12. Due to the reduction of the cross sectional area of the first inlet passage 8 from the second portion 26 of the first inlet passage 8 to the first portion 22 of the first inlet passage 8, the charge of exhaust gas is accelerated past the junction 18, in the downstream direction 46 of the main passage 12. The acute angle α to the upstream direction 44 of the main passage axis 38 entails that the acute angle α points in the downstream direction 46 of the main passage axis 38.

[0043] The smaller first main passage cross sectional area 32 compared to the second main passage cross sectional area 48 reduces the portion of a charge of exhaust gas from the first inlet passage 8 flowing in the upstream direction 44 in the main passage 12.

[0044] According to embodiments, the first inlet passage cross sectional area 24 may have a hydraulic diameter within a range of 0,65 - 0,85 times a hydraulic diameter of the second inlet passage cross sectional area 28. Preferably, the first inlet passage cross sectional area 24 may have a hydraulic diameter within a range of 0,68 - 0,75 times the hydraulic diameter of the second inlet passage cross sectional area 28. In this manner a charge of exhaust gas from a cylinder connected to the first inlet passage 8 is accelerated at a rate promoting flow of exhaust gas from the junction 18, in the downstream direction 46 in the main passage 12.

[0045] According to embodiments, the first main passage cross sectional area 32 may have a hydraulic diameter within a range of 0,8 - 0,99 times a hydraulic diameter of the second main passage cross sectional area 48. Preferably, the first main passage cross sectional area 32 may have a hydraulic diameter within a range of 0,92 - 0,98 times the hydraulic diameter of the second main passage cross sectional area 48. In this manner the flow of exhaust gas from the first inlet passage 8 in the upstream direction 44 in the main passage 12 is reduced compared to if the first and second main passage portions 30, 40 had more similar cross sectional areas, while flow of exhaust gas from the upstream located second inlet passage towards the outlet end of the main passage 12 is affected less negatively, or even not at all.

[0046] According to embodiments, the second inlet passage cross sectional area 28 and a third main passage cross sectional area 36 of the third main passage portion 34 may have hydraulic diameters of substantially the same size. In this manner exhaust gas pressure and flow from the first inlet passage 8 may remain consistent downstream of the junction 18 with those at the inlet 29 of the first inlet passage 8 thus, providing consistent exhaust gas properties towards the outlet end of the exhaust manifold 2. The hydraulic diameters of the second inlet passage cross sectional area 28 and the third main passage cross sectional area 36 may differ within the range of 1 - 3 %.

[0047] According to embodiments, the second main passage cross sectional area 48 may have a same hydraulic diameter as the third main passage cross sectional area 36. In this manner exhaust gas pressure and flow from the second inlet passage upstream of the first inlet passage 8 may remain consistent downstream of the junction 18 with those upstream of the junction 18 thus, providing consistent exhaust gas properties towards the outlet end of the exhaust manifold 2.

[0048] According to some embodiments a hydraulic diameter of a cross sectional area of the outlet end 16 of the exhaust manifold 2, see Fig. 1, may have substantially a same hydraulic diameter as those of the second and third main passage cross sectional areas 48, 36. Thus, consistent exhaust gas properties may be maintained along portions of the main passage 12 and towards the outlet end 16 of the exhaust manifold 2. Mentioned purely as an example, the second and third cross sectional areas 48, 36 of the exhaust manifold 2 may have hydraulic diameters of 42 mm, for a V8 diesel engine having a total displacement of 16 litres.

[0049] The intersecting wall portion 20 forms at least part of a deflector 50 arranged between the first inlet passage 8 and the main passage 12. The deflector 50 extends into the main passage 12. That is, the deflector 50 extends towards the main passage axis 38. The deflector 50 comprises a first wall portion 52 forming a delimiting surface of the main passage 12. The first wall portion 52 extends at an acute angle β to the upstream direction 44 of the main passage axis 38 smaller than the angle α of the centre axis 42 of the first portion 22 of the first inlet passage 8 to the upstream direction 44. In case the first wall portion 52 is slightly curved, e.g. as in the illustrated embodiments, this feature entails that a general outline of the first wall portion 52 extends at an acute angle β to the upstream direction 44 of the main passage axis 38 smaller than the angle α. For instance, a tangent of such a slightly curved wall portion may extend at an acute angle β to the upstream direction 44 of the main passage axis 38 smaller than the angle α. The angle β may be at least 1 degree. The acute angle β to the upstream direction 44 of the main passage axis 38 entails that the acute angle β points in the downstream direction 46 of the main passage axis 38.

[0050] The main passage 12 comprises a widening section 54 extending at least upstream of the first main passage portion 30. The widening section 54 widens the main passage 12 in a first direction 56. The first direction 56 is directed away from the first inlet passage 8 in a first cross sectional plane. The first cross sectional plane extends through the first inlet passage 8, through at least a portion of the main passage 12, extends along the main passage axis 38, and includes the main passage axis 38. The first cross sectional plane also includes the centre axis 42 of the first inlet passage 8. That is, the cross sections of Figs. 2 and 3 are placed in the first cross sectional plane. In these embodiments, the widening section 54 also extends downstream of the first main passage portion 30. The widening section 54 may extend between the second and third main passage portions 40, 34.

[0051] A portion of a charge of exhaust gas from the first inlet passage 8 will flow upstream in the main passage 12, despite the first main passage portion 30 having a smaller cross sectional area than the second main passage portion 40. The widening section 54 will cause the exhaust gas to form a vortex 58 in the main passage 12, upstream of the first passage portion 30. The vortex 58 reduces the effective flow area 60 of the main passage 12. Thus, for a latter portion of a charge of exhaust gas from the first inlet passage 8, the vortex 58 reduces the flow of exhaust gas in a direction upstream of the first main passage portion 30.

[0052] An inner surface 61 of the main passage 12, opposite to the first inlet passage 8 seen in the first cross sectional plane, at a transition between the widening section 54 and the second main passage portion 40 forms an abrupt directional change 63, such that a vortex is formed in exhaust gases during use of the exhaust manifold 2. The vortex in the widening section is formed by the first fraction of each charge of exhaust gas from the first inlet passage 8. The inner surface 61 is an inner surface of a second wall portion 62 extending along the widening section 54 and the second main passage portion 40. Seen in the first cross sectional plane, the widening section 54 extends upstream of an end point 64 of the intersecting wall portion 20 over a distance having a length within a range of 1,2 - 1,7 times a hydraulic diameter of the second main passage portion 40. The widening section 54 may extend upstream of the end point 64 to the abrupt directional change 63. Seen in the first cross sectional plane, the widening section 54 extends downstream of the end point 64 of the intersecting wall portion 20 over a distance having a length within a range of 2 - 3 times a hydraulic diameter of the second main passage portion 40. Suitably, a transition between the widening section 54 and the third main passage portion 34 is gradual. The gradual transition between the widening section 54 and the third main passage portion 34 promotes a laminar flow of exhaust gas in the downstream direction 46. Thus, no vortex is formed at the gradual transition, as opposed to at the abrupt directional change 63 at the upstream end of the widening section 54 where a vortex is formed.

[0053] The end portion 37 of the intersecting wall portion 20 comprises the end point 64 in the first cross sectional plane.

[0054] In Fig. 3, outlines 66 of three inner perimeters of the main passage 12 according to an embodiment are illustrated.

[0055] This invention should not be construed as limited to the embodiments set forth herein. A person skilled in the art will realize that different features of the embodiments disclosed herein may be combined to create embodiments other than those described herein, without departing from the scope of the present invention, as defined by the appended claims.

[0056] As used herein, the term "comprising" or "comprises" is open-ended, and includes one or more stated features, elements, steps, components or functions but does not preclude the presence or addition of one or more other features, elements, steps, components, functions or groups thereof.

Claims

1. An exhaust manifold (2) for a four-stroke internal combustion engine, the exhaust manifold (2) forming at least two inlet passages and one main passage (12) having an outlet end (16) arranged downstream of the at least two inlet passages,

 wherein a first inlet passage (8) of the at least two inlet passages connects to the main passage (12) at a junction (18),
 wherein an intersecting wall portion (20) between the first inlet passage (8) and the main passage (12) forms an upstream end portion of the junction (18),
 wherein a first portion (22) of the first inlet passage (8) at the intersecting wall portion (20) has a first inlet passage cross sectional area (24),
 wherein the first inlet passage cross sectional area (24) is smaller than a second inlet passage cross sectional area (28) of a second portion (26) of the first inlet passage (8) located upstream of the first portion (22) of the first inlet passage (8), and
 whereby the cross sectional area of a passage portion is calculated based on the hydraulic diameter of the relevant cross sectional area,
 wherein
 the first inlet passage (8) is connected to the main passage (12) downstream of a second inlet passage (10) of the at least two inlet passages,
 wherein the main passage (12) comprises a first main passage portion (30) at the intersecting wall portion (20), the first main passage portion (30) having a first main passage cross sectional area (32), and
 wherein the first main passage cross sectional area (32) is smaller than a second main passage cross sectional area (48) of a second main passage portion (40) of the main passage (12) located upstream of the junction (18),
 characterised in that
 the main passage (12) comprises a widening section (54) extending at least upstream of the first main passage portion (30), which widening section (54) widens the main passage (12) in a first direction (56), the first direction (56) extending in a first cross sectional plane, which first cross sectional plane extends through the first inlet passage (8), through at least a portion of

the main passage (12), extends along the main passage axis (38), and includes the main passage axis (38), and wherein the first direction (56) is directed away from the first inlet passage (8).

2. The exhaust manifold (2) according to claim 1, wherein a main passage axis (38) extends centrally through the second main passage portion (40) in a straight line past the junction (18) and centrally through a third main passage portion (34) of the main passage (12) located downstream of the first main passage portion (30).

3. The exhaust manifold (2) according to claim 2, wherein a centre axis (42) of the first inlet passage (8) at the first portion (22) of the first inlet passage (8) extends at an acute angle (α) to an upstream direction (44) of the main passage axis (38), preferably at an angle (α) within a range of 30 - 45 degrees.

4. The exhaust manifold (2) according to any one of claims 2 or 3, wherein the intersecting wall portion (20) forms at least part of a deflector (50) arranged between the first inlet passage (8) and the main passage (12), and wherein the deflector (50) extends towards the main passage axis (38).

5. The exhaust manifold (2) according to claims 2 - 4, wherein the deflector (50) comprises a first wall portion (52) forming a delimiting surface of the main passage (12), and wherein the first wall portion (52) extends at an acute angle (β) to the upstream direction (44) of the main passage axis (38) being smaller than the angle (α) of the centre axis (42) of the first portion (22) of the first inlet passage (8) to the upstream direction (44).

6. The exhaust manifold (2) according to anyone of claim 1-5, wherein an inner surface (61) of the main passage (12), opposite to the first inlet passage (8), at a transition between the widening section (54) and the second main passage portion (40) forms an abrupt directional change (63), such that a vortex is formed in exhaust gases during use of the exhaust manifold (2).

7. The exhaust manifold (2) according to anyone of claims 1- 6, wherein the widening section (54) extends upstream of an end point (64) of the intersecting wall portion (20) over a distance having a length within a range of 1,2 - 1,7 times a hydraulic diameter of the second main passage portion (40).

8. The exhaust manifold (2) according to any one of claims 1 - 7, wherein the widening section (54) extends downstream of an end point (64) of the intersecting wall portion (20) over a distance having a length within a range of 2 - 3 times a hydraulic diameter of the second main passage portion (40).

9. The exhaust manifold (2) according to any one of the preceding claims, wherein the second portion (26) of the first inlet passage (8) is arranged at an inlet (29) of the first inlet passage (8), and wherein the first inlet passage cross sectional area (24) has a hydraulic diameter within a range of 0,65 - 0,85 times a hydraulic diameter of the second inlet passage cross sectional area (28), preferably within a range of 0,68 - 0,75 times the hydraulic diameter of the second inlet passage cross sectional area (28).

10. The exhaust manifold (2) according to claim 9, wherein the first main passage cross sectional area (32) has a hydraulic diameter within a range of 0,8 -0,99 times a hydraulic diameter of the second main passage cross sectional area (48), preferably within a range of 0,92 - 0,98 times the hydraulic diameter of the second main passage cross sectional area (48).

11. The exhaust manifold (2) according to claim 9 or 10, wherein the second inlet passage cross sectional area (28) and a third main passage cross sectional area (36) of the third main passage potion (34) have hydraulic diameters of substantially the same size.

12. The exhaust manifold (2) according to any one of the preceding claims, wherein the second main passage cross sectional area (48) has a same hydraulic diameter as a third main passage cross sectional area (36) of the third main passage portion (34).

Patentansprüche

1. Abgaskrümmer (2) für einen Viertaktverbrennungsmotor, wobei der Abgaskrümmer (2) zumindest zwei Einlasskanäle und einen Hauptkanal (12) mit einem Auslassende (16) bildet, das stromabwärts der zumindest zwei Einlasskanäle angeordnet ist,
wobei ein erster Einlasskanal (8) der zumindest zwei Einlasskanäle an einer Anschlussstelle (18) mit dem Hauptkanal (12) in Verbindung steht,
wobei ein kreuzender Wandabschnitt (20) zwischen dem ersten Einlasskanal (8) und dem Hauptkanal (12) einen stromaufwärtigen Endabschnitt der Anschlussstelle (18) bildet,
wobei ein erster Abschnitt (22) des ersten Einlasskanals (8) an dem kreuzenden Wandabschnitt (20) eine erste Einlasskanalquerschnittsfläche (24) hat,
wobei die erste Einlasskanalquerschnittsfläche (24) kleiner ist als eine zweite Einlasskanalquerschnittsfläche (28) eines zweiten Abschnitts (26) des ersten Einlasskanals (8), der stromaufwärts des ersten Abschnitts (22) des ersten Einlasskanals (8) angeord-

net ist, und
wobei die Querschnittsfläche eines Kanalabschnitts basierend auf dem hydraulischen Durchmesser der betreffenden Querschnittsfläche berechnet ist,
wobei
der erste Einlasskanal (8) stromabwärts eines zweiten Einlasskanals (10) der zumindest zwei Einlasskanäle mit dem Hauptkanal (12) verbunden ist,
wobei der Hauptkanal (12) einen ersten Hauptkanalabschnitt (30) an dem kreuzenden Wandabschnitt (20) aufweist, wobei der erste Hauptkanalabschnitt (30) eine erste Hauptkanalquerschnittsfläche (32) hat, und
wobei die erste Hauptkanalquerschnittsfläche (32) kleiner ist als eine zweite Hauptkanalquerschnittsfläche (48) eines zweiten Hauptkanalabschnitts (40) des Hauptkanals (12), der stromaufwärts der Anschlussstelle (18) angeordnet ist,
dadurch gekennzeichnet, dass
der Hauptkanal (12) einen Verbreiterungsabschnitt (54) aufweist, der zumindest stromaufwärts des ersten Hauptkanalabschnitts (30) verläuft, wobei der Verbreiterungsabschnitt (54) den Hauptkanal (12) in einer ersten Richtung (56) verbreitert, wobei die erste Richtung (56) in einer ersten Querschnittsebene verläuft, die sich durch den ersten Einlasskanal (8) erstreckt, durch zumindest einen Teil des Hauptkanals (12), sich längs der Hauptkanalachse (38) erstreckt und die Hauptkanalachse (38) einschließt, und wobei die erste Richtung (56) von dem ersten Einlasskanal (8) weggerichtet ist.

2. Abgaskrümmer (2) nach Anspruch 1, wobei eine Hauptkanalachse (38) sich mittig durch den zweiten Hauptkanalabschnitt (40) in einer geraden Linie an der Anschlussstelle (18) vorbei und mittig durch einen dritten Hauptkanalabschnitt (34) des Hauptkanals (12) erstreckt, der stromabwärts des ersten Hauptkanalabschnitts (30) angeordnet ist.

3. Abgaskrümmer (2) nach Anspruch 2, wobei eine Mittelachse (42) des ersten Einlasskanals (8) sich an dem ersten Abschnitt (22) des ersten Einlasskanals (8) unter einem spitzen Winkel (α) zu einer Stromaufwärtsrichtung (44) der Hauptkanalachse (38) erstreckt, vorzugsweise unter einem Winkel (α) in einem Bereich von 30 bis 45 Grad.

4. Abgaskrümmer (2) nach einem der Ansprüche 2 oder 3, wobei der kreuzende Wandabschnitt (20) zumindest einen Teil eines Abweisers (50) bildet, der zwischen dem ersten Einlasskanal (8) und dem Hauptkanal (12) angeordnet ist, und wobei der Abweiser (50) sich in Richtung auf die Hauptkanalachse (38) erstreckt.

5. Abgaskrümmer (2) nach den Ansprüchen 2 bis 4, wobei der Abweiser (50) einen ersten Wandabschnitt (52) aufweist, der eine Begrenzungsfläche des Hauptkanals (12) bildet, und wobei der erste Wandabschnitt (52) sich unter einem spitzen Winkel (β) zu der Stromaufwärtsrichtung (44) der Hauptkanalachse (38) erstreckt, der kleiner ist als der Winkel (α) der Mittelachse (42) des ersten Abschnitts (22) des ersten Einlasskanals (8) zu der Stromaufwärtsrichtung (44).

6. Abgaskrümmer (2) nach einem der Ansprüche 1 bis 5, wobei eine Innenfläche (61) des Hauptkanals (12) gegenüber dem ersten Einlasskanal (8) an einem Übergang zwischen dem Verbreiterungsabschnitt (54) und dem zweiten Hauptkanalabschnitt (40) eine abrupte Richtungsänderung (63) ausbildet, sodass während einer Benutzung des Abgaskrümmers (2) in Abgasen ein Wirbel gebildet wird.

7. Abgaskrümmer (2) nach einem der Ansprüche 1 bis 6, wobei der Verbreiterungsabschnitt (54) sich stromaufwärts eines Endpunktes (64) des kreuzenden Wandabschnitts (20) über eine Distanz erstreckt, die eine Länge innerhalb eines Bereichs von 1,2 bis 1,7 mal einem hydraulischen Durchmesser des zweiten Hauptkanalabschnitts (40) hat.

8. Abgaskrümmer (2) nach einem der Ansprüche 1 bis 7, wobei der Verbreiterungsabschnitt (54) sich stromabwärts eines Endpunktes (64) des kreuzenden Wandabschnitts (20) über eine Distanz erstreckt, die eine Länge innerhalb eines Bereichs von 2 bis 3 mal einem hydraulischen Durchmesser des zweiten Hauptkanalabschnitts (40) hat.

9. Abgaskrümmer (2) nach einem der vorhergehenden Ansprüche, wobei der zweite Abschnitt (26) des ersten Einlasskanals (8) an einem Einlass (29) des ersten Einlasskanals (8) angeordnet ist, und wobei die erste Einlasskanalquerschnittsfläche (24) einen hydraulischen Durchmesser innerhalb eines Bereichs von 0,65 bis 0,85 mal einem hydraulischen Durchmesser der zweiten Einlasskanalquerschnittsfläche (28) hat, vorzugsweise innerhalb eines Bereichs von 0,68 bis 0,75 mal dem hydraulischen Durchmesser der zweiten Einlasskanalquerschnittsfläche (28).

10. Abgaskrümmer (2) nach Anspruch 9, wobei die erste Hauptkanalquerschnittsfläche (32) einen hydraulischen Durchmesser innerhalb eines Bereichs von 0,8 bis 0,99 mal einem hydraulischen Durchmesser der zweiten Hauptkanalquerschnittsfläche (48) hat, vorzugszweise innerhalb eines Bereichs von 0,92 bis 0,98 mal dem hydraulischen Durchmesser der zweiten Hauptkanalquerschnittsfläche (48).

11. Abgaskrümmer (2) nach Anspruch 9 oder 10, wobei die zweite Einlasskanalquerschnittsfläche (28) und eine dritte Hauptkanalquerschnittsfläche (36) des

dritten Hauptkanalabschnitts (34) hydraulische Durchmesser von im Wesentlichen derselben Größe haben.

12. Abgaskrümmer (2) nach einem der vorhergehenden Ansprüche, wobei die zweite Hauptkanalquerschnittsfläche (48) denselben hydraulischen Durchmesser wie eine dritte Hauptkanalquerschnittsfläche (36) des dritten Hauptkanalabschnitts (34) hat.

Revendications

1. Collecteur d'échappement (2) pour un moteur à combustion interne à quatre temps, le collecteur d'échappement (2) formant au moins deux passages d'entrée et un passage principal (12) ayant une extrémité de sortie (16) disposée en aval de l'au moins deux passages d'entrée,

dans lequel un premier passage d'entrée (8) de l'au moins deux passages d'entrée se connecte au passage principal (12) à une jonction (18),
dans lequel une partie de paroi d'intersection (20) entre le premier passage d'entrée (8) et le passage principal (12) forme une partie d'extrémité en amont de la jonction (18),
dans lequel une première partie (22) du premier passage d'entrée (8) au niveau de la partie de paroi d'intersection (20) a une aire de section transversale du premier passage d'entrée (24),
dans lequel l'aire de section transversale du premier passage d'entrée (24) est inférieure à une aire de section transversale du deuxième passage d'entrée (28) d'une deuxième partie (26) du premier passage d'entrée (8) située en amont de la première partie (22) du premier passage d'entrée (8), et
par lequel l'aire de section transversale d'une partie du passage est calculée en fonction du diamètre hydraulique de l'aire de section transversale concernée,
dans lequel le premier passage d'entrée (8) est relié au passage principal (12) en aval d'un deuxième passage d'entrée (10) de l'au moins deux passages d'entrée,
dans lequel le passage principal (12) comprend une première partie du passage principal (30) à la partie de paroi d'intersection (20), la première partie du passage principal (30) ayant une première aire de section transversale du passage principal (32), et
dans lequel la première aire de section transversale du passage principal (32) est plus petite qu'une deuxième aire de section transversale du passage principal (48) d'une deuxième partie du passage principal (40) du passage principal (12) situé en amont de la jonction (18),

caractérisé en ce que
le passage principal (12) comprend une section d'élargissement (54) qui s'étend au moins en amont de la première partie du passage principal (30), laquelle section d'élargissement (54) élargit le passage principal (12) dans une première direction (56), la première direction (56) s'étendant dans un premier plan de section transversal, lequel premier plan de section transversal s'étend à travers le premier passage d'entrée (8), via au moins une partie du passage principal (12), s'étend le long de l'axe de passage principal (38), et inclut l'axe de passage principal (38), et dans lequel la première direction (56) est dirigée vers l'extérieur du premier passage d'entrée (8).

2. Collecteur d'échappement (2) selon la revendication 1, dans lequel un axe de passage principal (38) s'étend de manière centrale via la deuxième partie du passage principal (40) dans une ligne droite passée au-delà de la jonction (18) et centralement via une troisième partie du passage principal (34) du passage principal (12) située en aval de la première partie du passage principal (30).

3. Collecteur d'échappement (2) selon la revendication 2, dans lequel un axe central (42) du premier passage d'entrée (8) à la première partie (22) du premier passage d'entrée (8) s'étend selon un angle aigu (α) à une direction en amont (44) de l'axe de passage principal (38), de préférence à un angle (α) dans une plage de 30 à 45 degrés.

4. Collecteur d'échappement (2) selon l'une quelconque des revendications 2 ou 3, dans lequel la partie de paroi d'intersection (20) forme au moins une partie d'un déflecteur (50) disposée entre le premier passage d'entrée (8) et le passage principal (12), et dans lequel le déflecteur (50) s'étend vers l'axe de passage principal (38).

5. Collecteur d'échappement (2) selon les revendications 2 à 4, dans lequel le déflecteur (50) comprend une première partie de paroi (52) formant une surface de délimitation du passage principal (12), et dans lequel la première partie de paroi (52) s'étend à un angle aigu (β) à la direction en amont (44) de l'axe de passage principal (38) étant plus petit que l'angle (α) de l'axe central (42) de la première partie (22) du premier passage d'entrée (8) vers la direction en amont (44) .

6. Collecteur d'échappement (2) selon l'une quelconque des revendications 1 à 5, dans lequel une surface intérieure (61) du passage principal (12), opposée au premier passage d'entrée (8), lors d'une transition entre la section d'élargissement (54) et la deuxième partie du passage principal (40) forme un changement directionnel brusque (63), de sorte qu'un tourbillon se forme dans les gaz d'échappement pendant l'utilisation du collecteur d'échappement (2).

7. Collecteur d'échappement (2) selon l'une quelconque des revendications 1 à 6, dans lequel la section d'élargissement (54) s'étend en amont d'un point d'extrémité (64) de la partie de paroi d'intersection (20) sur une distance ayant une longueur comprise dans une plage de 1,2 à 1,7 fois un diamètre hydraulique de la deuxième partie du passage principal (40).

8. Collecteur d'échappement (2) selon l'une quelconque des revendications 1 à 7, dans lequel la section d'élargissement (54) s'étend en aval d'un point d'extrémité (64) de la partie de paroi d'intersection (20) sur une distance ayant une longueur comprise dans une plage de 2 à 3 fois un diamètre hydraulique de la deuxième partie du passage principal (40).

9. Collecteur d'échappement (2) selon l'une quelconque des revendications précédentes, dans lequel la deuxième partie (26) du premier passage d'entrée (8) est disposée à une entrée (29) du premier passage d'entrée (8), et dans lequel l'aire de section transversale du premier passage d'entrée (24) a un diamètre hydraulique compris dans une plage de 0,65 à 0,85 fois un diamètre hydraulique de l'aire de section transversale du deuxième passage d'entrée (28), de préférence compris dans une plage de 0,68 à 0,75 fois le diamètre hydraulique de l'aire de section transversale du deuxième passage d'entrée(28).

10. Collecteur d'échappement (2) selon la revendication 9, dans lequel la première aire de section transversale du passage principal (32) a un diamètre hydraulique dans une plage de 0,8 à 0,99 fois un diamètre hydraulique de la deuxième aire de section transversale du passage principal (48), de préférence dans une plage de 0,92 à 0,98 fois le diamètre hydraulique de la deuxième aire de section transversale du passage principal (48) .

11. Collecteur d'échappement (2) selon la revendication 9 ou 10, dans lequel l'aire de la section transversale du deuxième passage d'entrée (28) et une troisième aire de section transversale du passage principal (36) de la troisième partie du passage principal (34) ont des diamètres hydrauliques de taille sensiblement identique.

12. Collecteur d'échappement (2) selon l'une quelconque des revendications précédentes, dans lequel la deuxième aire de section transversale du passage principal (48) a le même diamètre hydraulique que la troisième aire de section transversale du passage principal (36) de la troisième partie du passage principal (34).

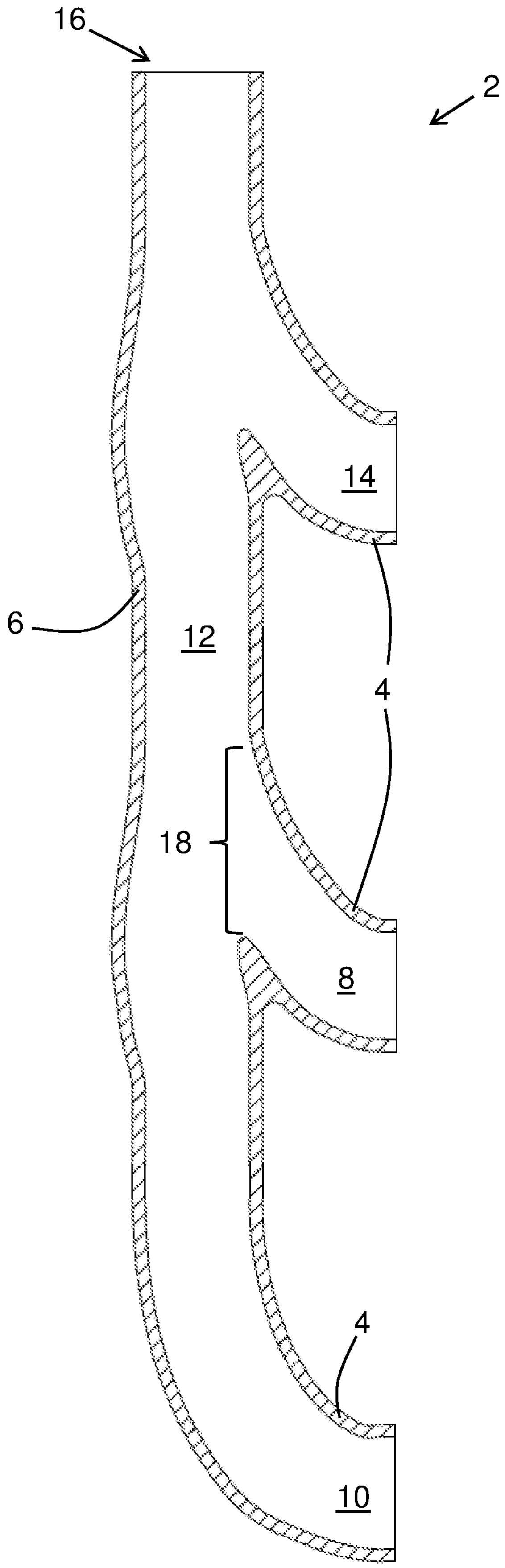

Fig. 1

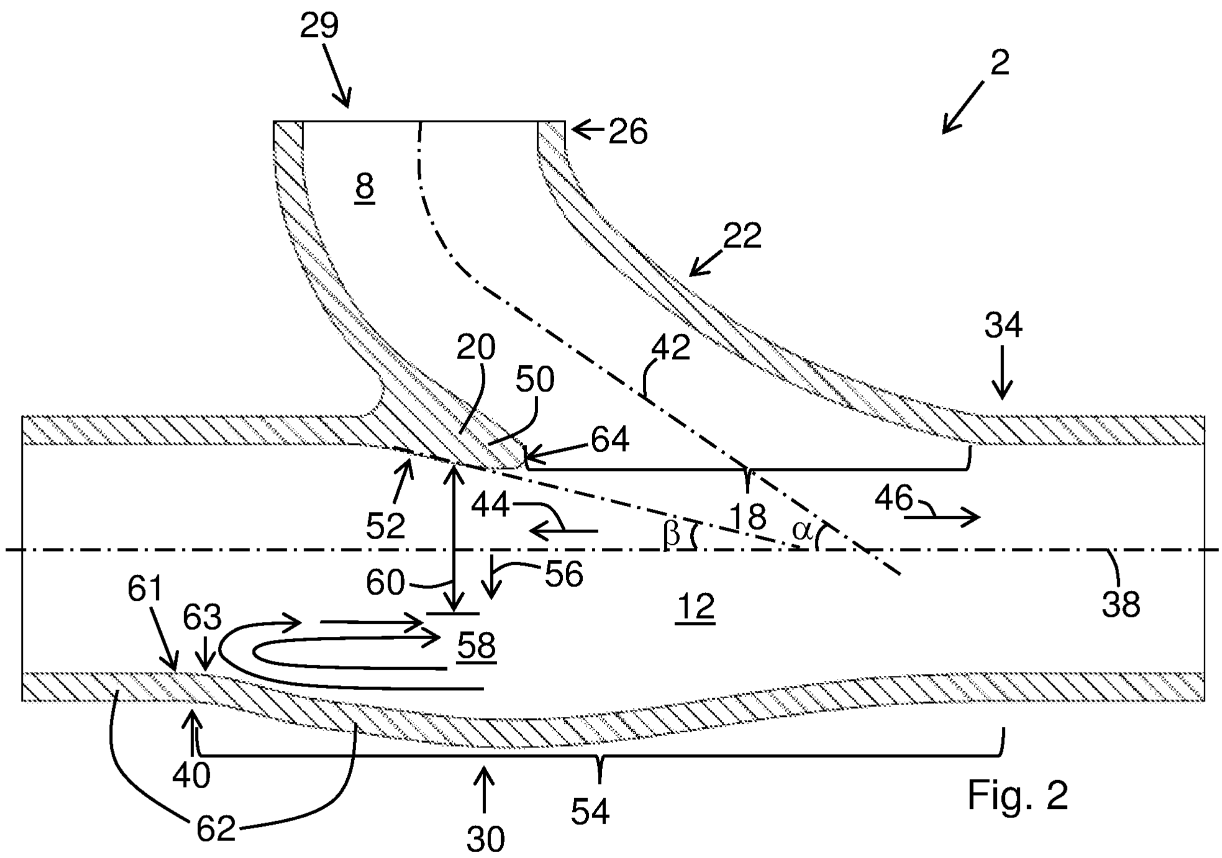
29
2
26
8
22
20
50
42
34
64
52
44
18
46
β
α
60
56
38
61
63
12
58
40
30
54
62

Fig. 2

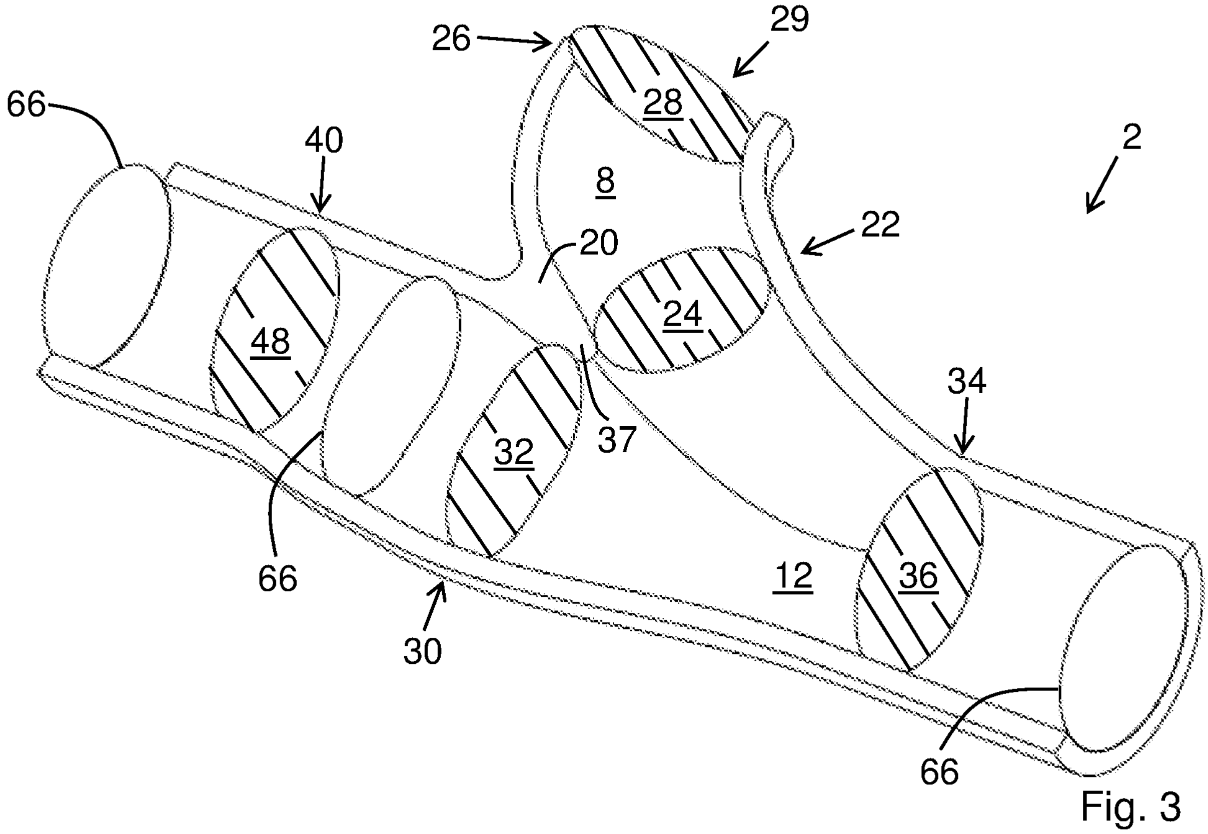
26
29
28
66
40
2
8
22
20
24
48
32
37
34
66
12
36
30
66

Fig. 3

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

- WO 9704222 A **[0003]**
- US 5860278 A **[0004]**
- US 2006236687 A **[0005]**
- DE 842873 **[0006]**
- JP 2000104545 A **[0007]**
- US 2008302095 A **[0008]**