Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2933269 A1 2015/06/25

(21) 2 933 269

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2014/12/15
(87) Date publication PCT/PCT Publication Date: 2015/06/25
(85) Entrée phase nationale/National Entry: 2016/06/09
(86) N° demande PCT/PCT Application No.: CA 2014/051211
(87) N° publication PCT/PCT Publication No.: 2015/089657
(30) Priorité/Priority: 2013/12/16 (US61/916,336)

(51) Cl.Int./Int.Cl. *F28F 27/02* (2006.01), *F02G 5/02* (2006.01), *F02M 31/20* (2006.01), *F28F 9/02* (2006.01)

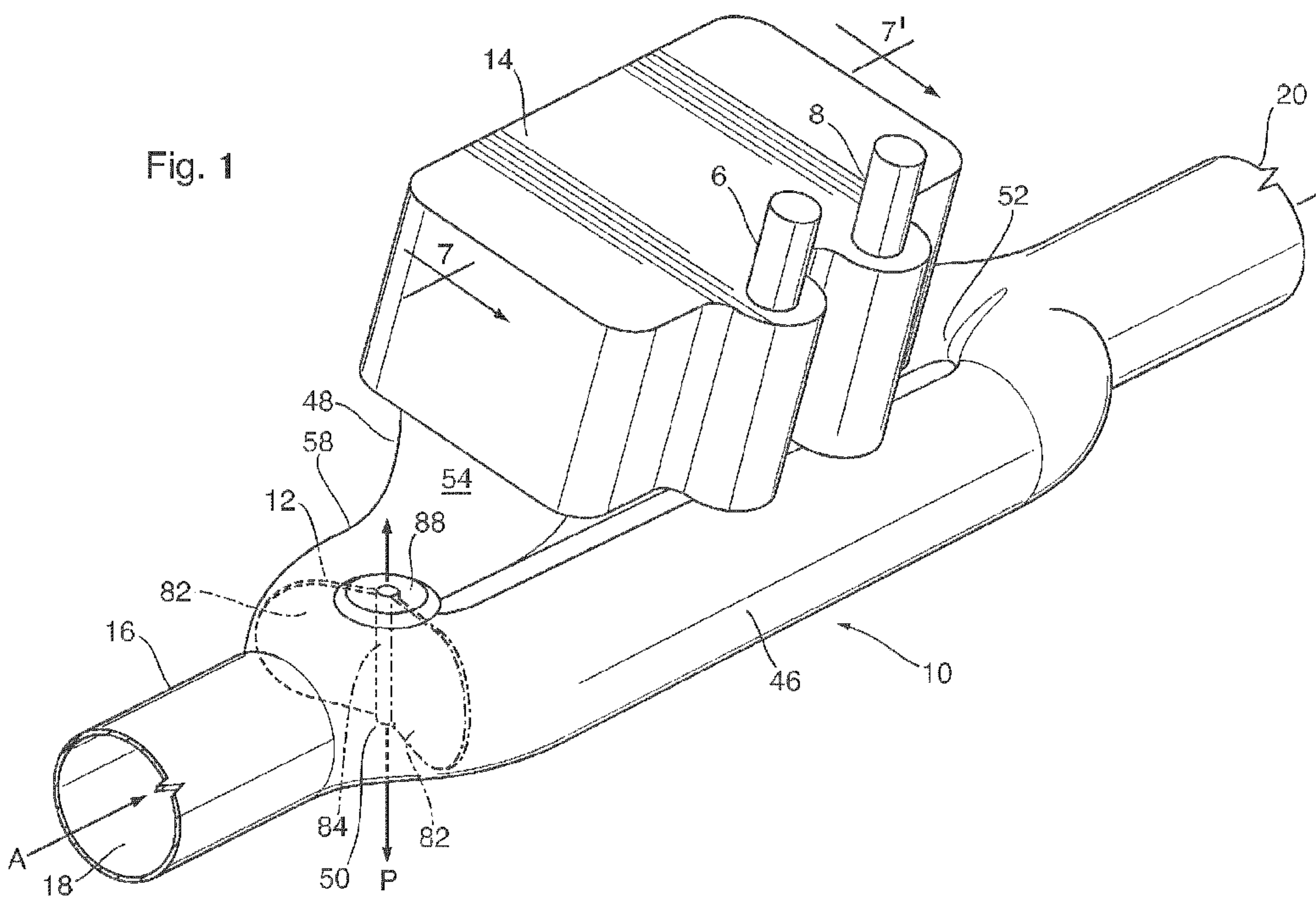
(71) Demandeur/Applicant:
DANA CANADA CORPORATION, CA

(72) Inventeurs/Inventors:
GERGES, IHAB EDWARD, CA;
CHEADLE, BRIAN E., CA

(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : DISPOSITIF DE RECUPERATION DE CHALEUR AVEC SUPPORT D'ECARTEMENT D'ECHANGEUR THERMIQUE
(54) Title: HEAT RECOVERY DEVICE WITH STANDOFF HEAT EXCHANGER MOUNT

Fig. 1



(57) Abrégé/Abstract:
A heat recovery device comprises a gas flow conduit, a gas/liquid heat exchanger and a gas diverter valve provided in the gas flow conduit, the valve being movable between a bypass position and a heat exchange position. The gas flow conduit includes a

(57) Abrégé(suite)/Abstract(continued):
divergent branch point at which it is divided into a bypass branch conduit and a heat exchange branch conduit. The bypass branch conduit bypasses the heat exchanger, and the heat exchange branch conduit includes an upstream conduit portion and a downstream conduit portion. The gas flow direction from the upstream conduit portion into the gas inlet opening of the heat exchanger diverges in a direction away from the overall gas flow direction, permitting the heat exchanger to be spaced away from the exhaust gas conduit.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 June 2015 (25.06.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/089657 A1

(51) International Patent Classification:
F28F 27/02 (2006.01) *F02M 31/20* (2006.01)
F02G 5/02 (2006.01) *F28F 9/02* (2006.01)

(21) International Application Number:
PCT/CA2014/051211

(22) International Filing Date:
15 December 2014 (15.12.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/916,336 16 December 2013 (16.12.2013) US

(71) Applicant: DANA CANADA CORPORATION [CA/CA]; 656 Kerr Street, Oakville, Ontario L6K 3E4 (CA).

(72) Inventors: GERGES, Ihab Edward; 2176 Hillmount Drive, Oakville, Ontario L6M 0H9 (CA). CHEADLE, Brian E.; 13 Hazelwood Court, Brampton, Ontario L6S 1B5 (CA).

(74) Agent: RIDOUT & MAYBEE LLP; 250 University Avenue, 5th Floor, Toronto, Ontario M5H 3E5 (CA).

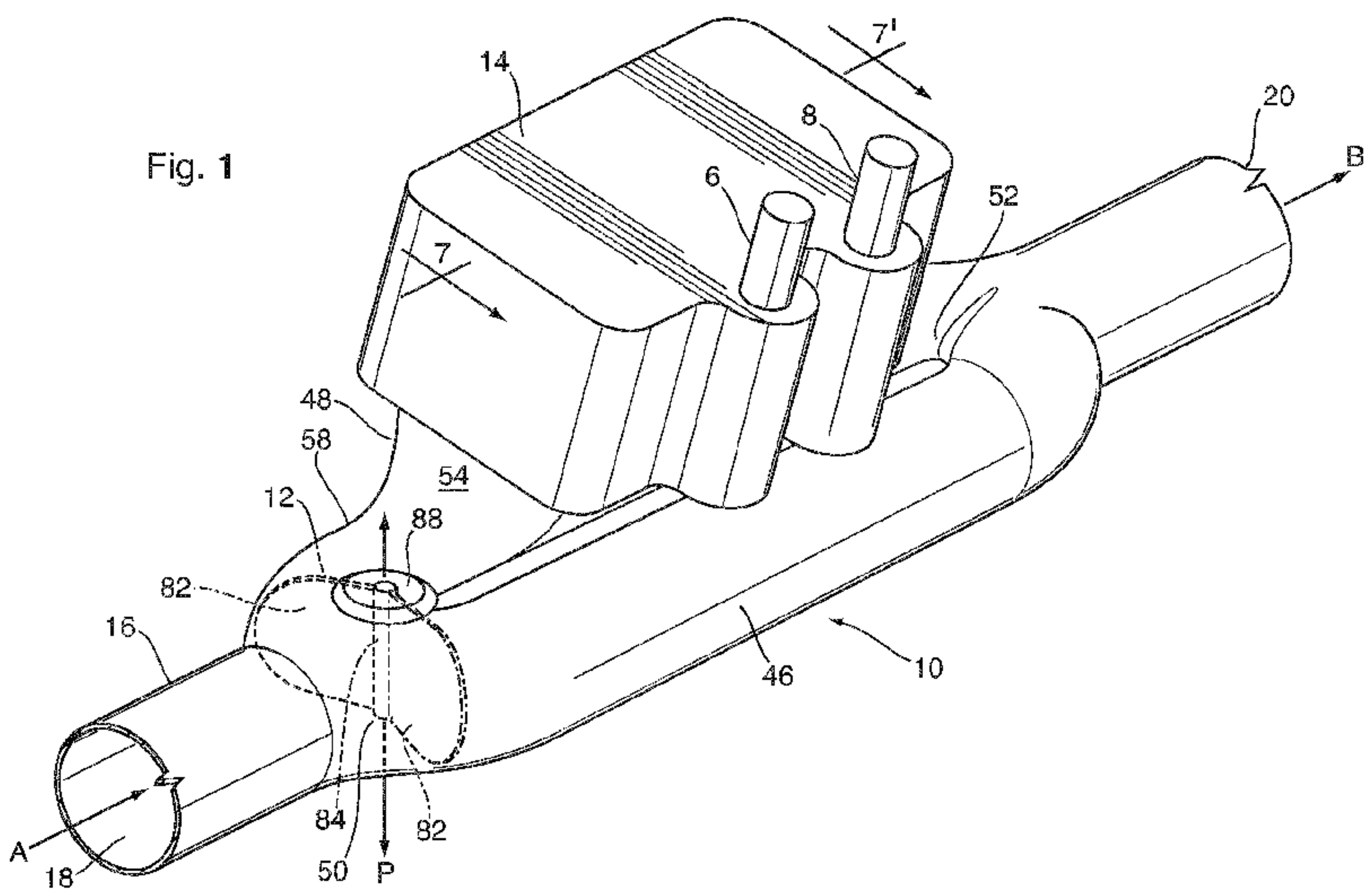
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP,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

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

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

(54) Title: HEAT RECOVERY DEVICE WITH STANDOFF HEAT EXCHANGER MOUNT

Fig. 1



(57) Abstract: A heat recovery device comprises a gas flow conduit, a gas/liquid heat exchanger and a gas diverter valve provided in the gas flow conduit, the valve being movable between a bypass position and a heat exchange position. The gas flow conduit includes a divergent branch point at which it is divided into a bypass branch conduit and a heat exchange branch conduit. The bypass branch conduit bypasses the heat exchanger, and the heat exchange branch conduit includes an upstream conduit portion and a downstream conduit portion. The gas flow direction from the upstream conduit portion into the gas inlet opening of the heat exchanger diverges in a direction away from the overall gas flow direction, permitting the heat exchanger to be spaced away from the exhaust gas conduit.

WO 2015/089657 A1

HEAT RECOVERY DEVICE WITH STANDOFF HEAT EXCHANGER MOUNT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of United States Provisional Patent Application No. 61/916,336 filed December 16, 2013, the contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The invention relates to devices for removing heat from gas streams, such as heat recovery devices for removing heat from motor vehicle intake and exhaust gas systems.

BACKGROUND OF THE INVENTION

[0003] The need to remove heat from gas streams arises in numerous applications. In motor vehicles, for instance, it may be necessary to remove heat from the intake and/or exhaust gas streams. For example, intake air (or "charge air") requires cooling in some applications, for example in turbocharged or supercharged engines. In vehicles incorporating exhaust gas recirculation (EGR) or exhaust gas heat recovery (EGHR) systems, heat is removed from the exhaust gas stream. The heat removed from the intake or exhaust gas stream is typically transferred to a liquid coolant in a heat exchanger.

[0004] In EGHR systems, for example, heat from vehicle exhaust gases is transferred to other vehicle components via a liquid coolant or oil in order to provide faster heating of air and vehicle fluids on start-up of the vehicle, thereby reducing fuel consumption. Air heated by the exhaust gases can be used for rapid heating of the passenger compartment and for window defrosting, reducing the need for long idling periods during start-up in cold weather. Heat extracted from the exhaust and used to heat up vehicle fluids such as engine oil and transmission fluid makes them less viscous and improves fuel economy during start-up. After the initial start-up period the recovery of heat from the exhaust gases is no longer required. Therefore, EGHR systems typically include a bypass to minimize heat transfer from the exhaust gases to the liquid coolant once the vehicle reaches normal operating temperature. This helps to minimize the load on the cooling system and minimizes the risk of boiling or thermal degradation of the liquid coolant.

[0005] An EGHR system therefore incorporates a gas-to-liquid heat exchanger for extracting heat from the vehicle exhaust gas and transferring the heat to a liquid coolant, typically a water/glycol engine coolant, although direct heat transfer to an oil is also possible. The EGHR system also includes a gas diverter valve for directing at least a portion of the exhaust gas flow through the heat exchanger during vehicle start-up, and for bypassing the heat exchanger once the heat from the exhaust gas is no longer required. The heat exchanger and the valve need to be connected to the exhaust gas system piping. An actuator is also provided in order to control operation of the valve. The valve may be operated by means of an electronically controlled solenoid, a wax motor, engine vacuum or a bimetal or shape memory alloy (SMA) actuator.

[0006] To save space and to reduce cost and vehicle weight, the valve and heat exchanger may be integrated into a single unit, referred to herein as an EGHR device. In many integrated EGHR devices, however, the heat exchanger is heated by the exhaust gases whether the device is in heat exchange mode or bypass mode. This may be due to exhaust gas leakage past the valve and/or thermal conduction. This increases the amount of heat transferred to the coolant, increasing the load on the cooling system, and risking cumulative thermal degradation of the coolant or induced thermal stresses which can cause damage to the heat exchanger.

[0007] EGHR devices have been developed to address some of these issues. For example, commonly assigned US Provisional Patent Application No. 61/771,608 filed on March 1, 2013, and US Patent Application No. 13/599,339 filed on August 30, 2012 (published as US 2013/0061584 A1 on March 14, 2013), have a substantially T-shaped or U-shaped configuration. This configuration has a shorter module length in the gas flow direction, which may allow it to be located in the engine compartment, closer to the source of the hot exhaust gas. Also, the T-shaped configuration also permits the heat exchanger to be spaced away from the exhaust gas conduit, reducing the amount of heat transferred from the exhaust gas to the coolant with the device in bypass mode. However, this design requires a separate valve body or flow duct between the exhaust gas conduit and the heat exchanger, with a solid flange interface between the heat exchanger and the valve body or flow duct. This structural constraint affects the ability of the EGHR device to expand under different operating gas temperatures and, in particular, affects the flexibility of the heat exchanger body between its inlet and outlet ports, which are at significantly different temperatures. This may lead to high thermal stresses in the heat exchanger, and potential failure of the heat exchanger plates close to the flange interface.

[0008] Therefore, there remains a need for simple and effective heat recovery devices for motor vehicle intake and exhaust gas systems which minimize usage of space, weight, and number of components, which are readily integratable into existing exhaust system piping, and which also minimize thermal stresses and unwanted heat transfer to the coolant in bypass mode.

SUMMARY

[0009] In an embodiment, there is provided a heat recovery device, comprising: a gas flow conduit having an inlet and an outlet, wherein an overall gas flow direction through the gas flow conduit is defined between the inlet and the outlet thereof; a gas/liquid heat exchanger having a gas inlet opening and a gas outlet opening; a gas diverter valve provided in the gas flow conduit, wherein the valve is movable between a bypass position and a heat exchange position. The gas flow conduit includes a divergent branch point at which the gas flow conduit is divided into a bypass branch conduit and a heat exchange branch conduit. The bypass branch conduit bypasses the heat exchanger, and the heat exchange branch conduit includes an upstream conduit portion and a downstream conduit portion. The upstream conduit portion has a first end in flow communication with said gas flow conduit at said divergent branch point, and a second end in flow communication with the gas inlet opening of the heat exchanger. The downstream conduit portion has a first end in flow communication with the gas outlet opening of the heat exchanger. The gas flow direction into the gas inlet opening of the heat exchanger diverges in a direction away from the overall gas flow direction through the gas flow conduit.

[0010] According to one aspect, the heat recovery further comprises a convergent branch point at which the bypass branch conduit and the heat exchange branch conduit converge, the convergent branch point being located upstream of the outlet of the gas flow conduit. The downstream conduit portion may have a second end in flow communication with the gas flow conduit at the convergent branch point.

[0011] According to another aspect, a first plane passes through the inlet and outlet of the gas flow conduit, the first branch point and the bypass branch conduit. A second plane may pass through the second end of the upstream conduit portion and the first end of the downstream conduit portion, wherein portions of the first and second planes passing through heat recovery device are spaced apart from one another. The second end of the upstream conduit portion and the first end of the downstream conduit portion may be secured to the heat exchanger at the respective gas inlet opening and gas outlet opening, in said second plane.

[0012] According to yet another aspect, the upstream conduit portion and the downstream conduit portion curve away from the first plane toward the second plane.

[0013] According to yet another aspect, the second end of the upstream conduit portion and the first end of the downstream conduit portion are free from connection to each other or to other portions of the gas flow conduit.

[0014] According to yet another aspect, the gas flow direction at the gas inlet opening of the heat exchanger is at an angle of about 90 degrees to the overall gas flow direction through the gas flow conduit.

[0015] According to yet another aspect, the gas flow direction at the gas outlet opening of the heat exchanger is at an angle of about 90 degrees to the overall gas flow direction through the gas flow conduit.

[0016] According to yet another aspect, the gas flow direction at the second end of the upstream conduit portion and the first end of the downstream conduit portion is at an angle of about 90 degrees to the overall gas flow direction through the gas flow conduit.

[0017] According to yet another aspect, the heat exchanger is constructed from a stack of plates defining alternating gas flow passages and liquid flow passages extending substantially parallel to the overall gas flow direction through the gas flow conduit.

[0018] According to yet another aspect, the heat exchanger further comprises a gas inlet manifold communicating with the gas inlet opening and a gas outlet manifold communicating with the gas outlet opening, and wherein a gas flow direction through each of the gas inlet manifold and the gas outlet manifold is at an angle to the overall gas flow direction through the gas flow conduit.

[0019] According to yet another aspect, the gas diverter valve is located at the divergent branch point. With the gas diverter valve in the bypass position, gas flow to the heat exchange branch conduit may be substantially completely blocked; and with the gas diverter valve in the heat exchange position, gas flow to the bypass branch conduit may be substantially completely blocked.

[0020] According to yet another aspect, the heat exchanger further comprises a bottom plate in which the gas inlet opening and the gas outlet opening are provided, and wherein the second end of the upstream conduit portion and the first end of the downstream conduit portion are secured to the bottom plate. The bottom plate may be reinforced or thickened, at least in areas proximate to the gas inlet opening and the gas outlet opening.

[0021] According to yet another aspect, the second end of the upstream conduit portion and the first end of the downstream conduit portion are aligned with one another along the overall gas flow direction.

[0022] According to yet another aspect, the second end of the upstream conduit portion and the first end of the downstream conduit portion are aligned with one another along a direction which is substantially perpendicular to the overall gas flow direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0024] Figure 1 is a top perspective view of a heat recovery device according to a first embodiment of the invention;

[0025] Figure 2 is an end elevation view of the heat recovery device of Figure 1, taken from the inlet end thereof;

[0026] Figure 3 is a top plan view of the heat recovery device of Figure 1, with the gas diverter valve in the bypass mode, and with the gas flow conduit sectioned in first plane PL1 of Figure 2;

[0027] Figure 4 is a top plan view of the heat recovery device of Figure 1, with the gas diverter valve in the heat exchange mode, and with the gas flow conduit sectioned in first plane PL1 of Figure 2;

[0028] Figure 5 is an isolated, top perspective view showing the gas flow conduit of the heat recovery device of Figure 1;

[0029] Figure 6 is a perspective view of the device of Figure 1, showing the opposite side of the device;

[0030] Figure 7 is a cross section along line 7-7' of Figure 1;

[0031] Figure 8 is a bottom perspective view of a heat recovery device according to a second embodiment;

[0032] Figure 9 is a top perspective view of the heat recovery device shown in Figure 8;

[0033] Figure 10 is a top plan view of a heat recovery device according to a third embodiment, partly in cross-section; and

[0034] Figure 11 is a top perspective view of the gas flow conduit of the heat recovery device of Figure 10.

DETAILED DESCRIPTION

[0035] A heat recovery device 10 according to a first embodiment is now described with reference to Figures 1-5. The heat recovery device 10 may be used as an EGHR device in a motor vehicle exhaust system, and is therefore sometimes referred to herein as EGHR device 10.

[0036] The device 10 comprises a gas diverter valve 12, a gas/liquid heat exchanger 14 and a gas flow conduit 16. The gas flow conduit 16 has an inlet 18 and an outlet 20. Where device 10 is an EGHR device, the device 10 will be installed in an exhaust gas conduit of a motor vehicle, downstream of the exhaust manifold and upstream of the tail pipe. Due to its compact size, the device 10 may be located in the engine compartment of the vehicle, close to the exhaust manifold. As used herein, the terms "upstream" and "downstream" are terms which are used to describe the locations of elements of the device 10, relative to the flow path of a gas flowing through the device 10.

[0037] An overall direction of gas flow through device 10 is defined between the inlet 18 and the outlet 20. In the present embodiment, the overall direction of gas flow is parallel to arrows A and B of Figure 1, which is the same as the direction of gas flow at the inlet 18 and outlet 20, respectively.

[0038] The heat exchanger 14 may be similar or identical to the heat exchanger described in commonly assigned U.S. Patent Application No. 13/599,399 for an invention entitled "Exhaust Gas Heat Recovery Device", filed on August 30, 2012, which is incorporated herein by reference in its entirety.

[0039] The heat exchanger 14 comprises a heat exchanger core 22 including a stack of core plates 24 defining a plurality of gas flow passages 26 and a plurality of liquid flow passages 28 arranged in alternating order. The gas flow passages 26 and the liquid flow passages 28 may be parallel to the flow of gas through the gas conduit 20. The gas flowing through the gas flow passages 26 may be a hot vehicle exhaust gas, and the liquid flowing through the liquid flow passages 28 may be a liquid coolant, such as a water/glycol engine coolant which may also circulate through other components of the vehicle's cooling system. The core plates 24 may comprise stainless steel or other heat resisting material, and may be joined by brazing with a suitable filler metal.

[0040] A plurality of manifolds extends through the core 22, and may be substantially perpendicular to the direction of gas flow through conduit 20. The heat exchanger 14 includes four such manifolds, namely a gas inlet manifold 30 and a gas outlet manifold 32 in flow communication with the gas flow passages 26; and a liquid inlet manifold 34 and a liquid outlet manifold 36 in flow communication with the liquid flow passages 28. The liquid manifolds 34, 36 are in flow communication with a pair of liquid fittings 6, 8.

[0041] The heat exchanger core 22 has a bottom plate 38 provided with a gas inlet opening 40 and a gas outlet opening 42. The openings 40, 42 extend through the bottom plate 38 and communicate with the gas inlet and outlet manifolds 30, 32, respectively. The heat exchanger 14 differs from that described in U.S. Patent Application No. 13/599,399 in that it does not include a thick mounting plate for mounting to the flange of a valve body. The attachment of a continuous mounting plate to the bottom plate 38 could constrain the flexibility of the heat exchanger 14 between the gas inlet and outlet openings 40, 42, and lead to high thermal stresses in the heat exchanger.

[0042] The structure of the heat exchanger 14 is not shown in detail in any of the drawings, except in the cross section of Figure 7. It will be appreciated that the heat exchanger may be "self-enclosing" as shown in Figure 7, i.e. it does not include an external housing. However, this is not essential, and the heat exchanger 14 may instead include an external housing enclosing a plurality of tubes or plates defining gas and/or liquid flow passages.

[0043] Between its inlet 18 and outlet 20, the gas flow conduit 16 is divided into a bypass branch conduit 46 and a heat exchange branch conduit 48. In this embodiment, the bypass branch conduit 46 extends along the overall gas flow direction. The bypass branch conduit 46 defines a bypass gas flow path along which the gas may flow without passing through the heat exchanger 14 under conditions where recovery of heat from the gas is not required, such as when the vehicle reaches its normal operating temperature.

[0044] The gas flow conduit 16 is divided into branch conduits 46, 48 at a divergent branch point 50 located upstream of the heat exchanger 14. In this embodiment the gas diverter valve 12 is located at the divergent branch point 50 to selectively block gas flow to either of the branch conduits 46, 48, depending on a position of the valve 12.

[0045] The branch conduits 46, 48 may converge downstream of heat exchanger 14, at a convergent branch point 52 located upstream of the outlet 20 of gas flow conduit 16.

[0046] The heat exchange branch conduit 48 comprises an upstream conduit portion 54 and a downstream conduit portion 56. The upstream conduit portion 50 has a first end 58 in flow communication with the gas flow conduit 16 at the divergent branch point 50, so as to receive the gas from the inlet 18, and a second end 60 in flow communication with the gas inlet opening 40 of heat exchanger 14.

[0047] The downstream conduit portion 56 has a first end 62 in flow communication with the gas outlet opening 42 of the heat exchanger 14, and a second end 64 which may be in flow communication with the gas flow conduit 16 at the convergent branch point 52.

[0048] It can be seen from the drawings that the direction of gas flow at the gas inlet opening 40 and gas outlet opening 42 of heat exchanger 14 is different from the overall gas flow direction through the gas flow conduit 16. In this regard, the direction of gas flow diverges from the overall gas flow direction as it flows through the heat exchange branch conduit 48 toward the heat exchanger 14. In the present embodiment, the direction of the gas flow as it enters the first end 58 of the upstream conduit portion 54 is substantially the same as the overall gas flow direction. The upstream conduit portion 54 is curved by about 90 degrees along its length, to cause the gas flow to undergo a change in direction of about 90 degrees relative to the overall gas flow direction, at the second end 60 of the upstream conduit portion 54 and the gas inlet opening 40 of the heat exchanger.

[0049] Also, it can be seen from Figure 7 that the direction of gas flow within the heat exchanger 14 is substantially U-shaped, flowing through the gas inlet and outlet manifolds 30, 32 in opposite directions which are at about 90 degrees to the overall gas flow direction, and flowing through the gas flow passages 26 in a direction which may be substantially parallel to the overall gas flow direction. This U-shaped flow path through heat exchanger 14 provides device 10 with a short module length in the gas flow direction, as in the T-shaped EGHR devices mentioned above.

[0050] At the gas outlet opening 42 of heat exchanger and the first end 62 of the downstream conduit portion 56 the gas flow direction is still at an angle of about 90 degrees relative to the overall gas flow direction. The downstream conduit portion 56 is curved by about 90 degrees along its length, to cause the gas flow to undergo a change in direction of about 90 degrees, such that the gas flow is substantially parallel to the overall gas flow direction by the time it reaches the second end 64 of the downstream conduit portion 56.

[0051] Thus, it can be seen that the upstream and downstream conduit portions 54, 56 form curved transitions to change the direction of the gas flow entering and exiting the heat exchanger 14. This permits the use of a compact heat exchanger with a U-shaped flow path, but also provides other advantages. It can be seen from the drawings, and particularly from Figures 3 to 5, that the second end 60 of the upstream conduit portion 54 and the first end 62 of the downstream conduit portion 56 are free from any connection to each other and are also free from any connection to other portions of the gas flow conduit 16. The upstream and downstream conduit portions 54, 56 are only connected to the remainder of the gas flow conduit 16 at their respective opposite ends 58, 64. Because the ends 60 and 62 of conduit portions 54, 56 are free from connection to the remainder of the gas flow conduit 16, and because the conduit portions 54, 56 are themselves curved, they are able to flex toward and away from each other (i.e. substantially in the overall gas flow direction) by a small amount, thereby relieving potential thermal stresses which may be brought about by thermal expansion and contraction of the heat exchanger 14 along the lengths of the plates 24.

[0052] It can be seen from the drawings that, with the exception of the divergent portions of the heat exchange branch conduit 48, the gas flow conduit

16 lies substantially in a single plane. In this regard, the inlet 18, outlet 20, bypass branch conduit 46, the divergent branch point 50 and the convergent branch point 52 are all substantially coplanar, such that a first plane PL1 (Figure 2) may pass through some or all of these components.

[0053] The divergent portions of the heat exchange branch conduit 48, on the other hand, and particularly the upstream and downstream conduit portions 54, 56, curve away from this first plane, and extend toward a second plane PL2 (Figure 2) which passes through the second end 60 of upstream conduit portion 54 and the first end 62 of the downstream conduit portion 56, and/or the points at which the conduit portions 54 and 56 are secured to the heat exchanger 14.

[0054] While the first and second planes need not be parallel to one another, the portions of the planes passing through portions of device 10 are spaced apart from one another. This spacing can be seen, for example, in Figure 2, and results in the heat exchanger 14 being spaced apart from portions of the gas flow conduit 16, except of course the heat exchange branch conduit 48. Thus, with the device 10 in bypass mode, the heat exchanger 14 is spaced from the flow of hot gas through the bypass branch conduit 46, reducing the amount of heat transferred from the exhaust gas to the coolant with the device 10 in bypass mode.

[0055] The gas diverter valve 12 includes a movable valve element 82 which is pivotably mounted in the gas flow conduit 16. The valve member 82 comprises a flapper which pivots about a pivot axis P extending through the flow duct at an angle of about 90 degrees to the direction of gas flow through the conduit 16. The valve member 82 may be mounted on a rod 84, and is rotated on rod 84 between the heat exchange position (Figure 4) and the bypass position (Figure 3).

[0056] In the embodiments shown in the drawings, the valve element 82 is mounted at the convergent branch point 50, which enables the valve element 82 to block the entrance to the bypass branch conduit 46 or the heat exchange branch circuit 48. While this arrangement provides the maximum benefit in terms of isolating the heat exchanger 14 from the flow of hot gas in the bypass mode, it will be appreciated that the valve element 82 may be mounted elsewhere in the gas flow conduit. For example, a similarly configured valve element 82 could be mounted at the convergent branch point 52 to alternately block the exits of the bypass branch conduit 46 and the heat exchange branch conduit 48. Alternatively, the valve element 82 could be a butterfly type valve element mounted in the bypass branch conduit, to alternately open and block the bypass gas flow through the bypass branch conduit 46. As another alternative, the valve element 82 could be a butterfly type valve element mounted in the heat exchange branch conduit 48, to alternately open and block the bypass gas flow through the heat exchange branch conduit 48.

[0057] The pivoting of valve member 82 about axis P may be controlled by any suitable means, including an electronic solenoid or an actuator driven by engine vacuum, or other suitable actuator or control system. The valve member 82 and may be of any suitable shape, so as to seal with the inner surface of the gas flow conduit 16 in the heat exchange position and the bypass position, and will depend at least partly on the shape of the flow duct 16. To maximize thermal isolation of the heat exchanger 14 in the bypass mode, the valve member 82 should substantially completely block gas flow to the heat exchange branch conduit 48 when in the bypass position. It may also be desired to seal with the inner surface of conduit 16 so that it will substantially completely block gas flow to the bypass branch conduit 48 when in the heat exchange position, although this is less critical.

[0058] Shown in the drawings is a bushing or "bearing block" 88 into which an end of the valve rod 84 extends and which may house valve bearings (not shown). Typically one end of the valve rod will be received in a bushing 88 which may be located within the flow duct 16, and an opposite end of the valve rod 84 will typically penetrate the duct wall and extend through a bushing or bearing block 88 mounting either inside or outside the duct wall. Also, the penetrating end of valve rod 84 will typically be attached to the valve actuation mechanism 86, schematically shown in Figure 5.

[0059] In operation of device 10, with the valve member 82 in the heat exchange position shown in Figure 4, the bypass branch conduit 46 is at least partly blocked by valve member 82 while the entrance to the heat exchange branch conduit 48 is substantially completely open, permitting flow through heat exchanger 14. The gas flow from the inlet 18 enters the heat exchange branch circuit 48 at divergent branch point 50 and enters the first end 58 of the upstream conduit portion 54. The gas then flows through the upstream conduit portion 54 to the second end 60 thereof, before entering the heat exchanger 14 through the gas inlet opening 40. Inside the heat exchanger 14, the gas flows into the gas inlet manifold 30, from where it enters the gas flow passages 26 to transfer heat to the liquid coolant flowing through liquid flow passages 28. The gas then flows out from the gas flow passages 26 and into the gas outlet manifold 32, from where it exits the heat exchanger 14 through the gas outlet opening 42. From the gas outlet opening 42 of heat exchanger 14, the gas enters the first end of the downstream conduit portion 56 and flows to the second end 64 thereof at the convergent branch point 52, from where it flows toward the outlet 20.

[0060] With the valve 12 in the bypass position of Figure 3, the gas flow from the inlet 18 enters the bypass branch circuit 46 at the divergent branch point 50. The gas then flows through the bypass branch circuit 46 to the convergent branch point 52, from where it flows toward the outlet 20.

[0061] The conduit portions 54, 56 of the heat exchange branch circuit 48 may be secured to the heat exchanger 14 by various means, one of which is shown in the cross-section of Figure 7. As shown, the second end 60 of upstream conduit portion 54 and the first end 62 of downstream conduit portion 56 may be provided with ridges 66 and 68, respectively, adjacent their ends, to act as stops against over-insertion into the heat exchanger 14 through the bottom plate 38. The ends 60, 62 may also be expanded by swaging to achieve a tight fit within the gas inlet and outlet openings 40, 42, followed by brazing. It will be appreciated that other arrangements exist for mounting the conduit portions 54, 56 to heat exchanger 14. It will also be appreciated that the bottom plate 38 may be reinforced and/or thickened, at least in the areas surrounding the gas inlet and outlet openings 40, 42, so as to provide a strong joint between the bottom plate 38 and the conduit portions 54, 56.

[0062] In device 10 the upstream and downstream conduit portions 54, 56 of the heat exchange branch circuit 48 are aligned with one another along the overall gas flow direction. Also, the heat exchange branch circuit 48 is parallel to the bypass branch circuit 46, at least in the plan view of Figures 3 and 4. However, the orientation of the components relative to one another is subject to change, depending at least partially on packaging requirements. Therefore, the orientation of components may vary from that of device 10, as will be discussed below with reference to Figures 8 to 10.

[0063] Figures 8 and 9 illustrate a heat recovery device 100 according to a second embodiment of the invention. The heat recovery device 100 of Figures 8 and 9 differs from heat recovery device 10 in the orientation of its components. All the elements of device 100 are also included in device 10 and have already been described above, and further description of these elements is unnecessary. The elements which are shared by heat recovery devices 10 and 100 are identified by like reference numerals in Figures 8 and 9.

[0064] In the heat recovery device 100 of Figures 8 and 9, the upstream and downstream conduit portions 54, 56 of the heat exchange branch circuit 48 are aligned with one another along a direction which is at about 90 degrees to the overall gas flow direction, and at about 90 degrees to the direction of gas flow through the bypass branch circuit 46. In addition, the direction of gas flow through the gas flow passages 26 is oriented at an angle of about 90 degrees to the overall gas flow direction. It will be appreciated that the orientation of the heat exchanger 14 at 90 degrees to the overall gas flow direction is not necessary in this embodiment. For example, the heat exchanger 14 may be oriented diagonally to the overall gas flow direction.

[0065] It can be seen that the device 100 according to the second embodiment considerably shortens the length of the downstream conduit portion 56 in the heat exchange branch circuit 48, effectively eliminating the portion of downstream conduit portion 56 which extends parallel to the bypass branch circuit 46, as the two branch circuits 46, 48 approach the convergent branch point 52. Thus, the device 100 may be more compact, lighter and use less material than the device 10 described above. It will be appreciated, however, that the overall configuration of the heat recovery devices described herein will depend at least partially on space restraints in the vehicles in which they are installed.

[0066] Figures 10 and 11 illustrate a heat recovery device 110 according to a third embodiment of the invention. The view of heat recovery device 110 in Figure 10 is similar to that shown in Figure 3; sectioned in a first horizontal plane, with the valve 12 in the bypass position, and showing the outline of heat exchanger 14 in dotted lines. Figure 11 shows the gas flow conduit 16 of heat recovery device 110 in isolation. The heat recovery device 110 differs from heat recovery devices 10 and 100 in the orientation of its components. All the elements of device 110 are also included in devices 10 and 100, and have already been described above, and further description of these elements is unnecessary. The elements which are shared by heat recovery devices 10 and 110 are identified by like reference numerals in Figure 10.

[0067] The heat recovery device 110 of Figures 10 and 11 achieves a similar benefit as the heat recovery device 100 described above, in that it substantially eliminates the portion of downstream conduit portion 56 which extends parallel to the bypass branch circuit 46. In heat recovery device 110, the rectangular openings at the second end 60 of upstream conduit portions 54 and the first end 62 of the downstream conduit portion 56 are aligned relative to one another (as shown by the dotted lines in Figure 11), but are rotated slightly (about an axis perpendicular to the plane of the paper in Figure 10) relative to the overall gas flow direction, and to the gas flow direction through the bypass branch circuit 46. This slight rotation minimizes the length of the downstream conduit portion 56 while maintaining alignment of the rectangular openings, to simplify the connection of the heat exchanger 14 to the conduit portions 54 and 56. As a result, the heat exchanger 14 and the gas flow passages 26 thereof are angled relative to the overall gas flow direction and to the direction of gas flow through the bypass branch conduit 46.

[0068] Although the invention has been described in connection with certain preferred embodiments, it is not limited thereto. Rather, the invention includes all embodiments which may fall within the scope of the following claims.

What is claimed is:

1. A heat recovery device, comprising:

a gas flow conduit having an inlet and an outlet, wherein an overall gas flow direction through the gas flow conduit is defined between the inlet and the outlet thereof;

a gas/liquid heat exchanger having a gas inlet opening and a gas outlet opening;

a gas diverter valve provided in the gas flow conduit, wherein the valve is movable between a bypass position and a heat exchange position;

wherein the gas flow conduit includes a divergent branch point at which the gas flow conduit is divided into a bypass branch conduit and a heat exchange branch conduit;

wherein the bypass branch conduit bypasses the heat exchanger, and the heat exchange branch conduit includes an upstream conduit portion and a downstream conduit portion;

wherein the upstream conduit portion has a first end in flow communication with said gas flow conduit at said divergent branch point, and a second end in flow communication with the gas inlet opening of the heat exchanger;

wherein the downstream conduit portion has a first end in flow communication with the gas outlet opening of the heat exchanger; and

wherein a gas flow direction into the gas inlet opening of the heat exchanger diverges in a direction away from the overall gas flow direction through the gas flow conduit.

2. The heat recovery device of claim 1, further comprising a convergent branch point at which the bypass branch conduit and the heat exchange branch conduit converge, the convergent branch point being located upstream of the outlet of the gas flow conduit.

3. The heat recovery device of claim 2, wherein the downstream conduit portion has a second end in flow communication with the gas flow conduit at the convergent branch point.

4. The heat recovery device of any one of claims 1 to 3, wherein a first plane passes through the inlet and outlet of the gas flow conduit, the first branch point and the bypass branch conduit.

5. The heat recovery device of claim 4, wherein a second plane passes through the second end of the upstream conduit portion and the first end of the downstream conduit portion, and wherein portions of the first and second planes passing through heat recovery device are spaced apart from one another.

6. The heat recovery device of claim 5, wherein the second end of the upstream conduit portion and the first end of the downstream conduit portion are secured to the heat exchanger at the respective gas inlet opening and gas outlet opening, in said second plane.

7. The heat recovery device of any one of claims 4 to 6, wherein the upstream conduit portion and the downstream conduit portion curve away from the first plane toward the second plane.

8. The heat recovery device of any one of claims 1 to 7, wherein the second end of the upstream conduit portion and the first end of the downstream conduit portion are free from connection to each other or to other portions of the gas flow conduit.

9. The heat recovery device of any one of claims 1 to 8, wherein the gas flow direction at the gas inlet opening of the heat exchanger is at an angle of about 90 degrees to the overall gas flow direction through the gas flow conduit.

10. The heat recovery device of any one of claims 1 to 9, wherein the gas flow direction at the gas outlet opening of the heat exchanger is at an angle of about 90 degrees to the overall gas flow direction through the gas flow conduit.

11. The heat recovery device of any one of claims 1 to 10, wherein the gas flow direction at the second end of the upstream conduit portion and the first end of the downstream conduit portion is at an angle of about 90 degrees to the overall gas flow direction through the gas flow conduit.

12. The heat recovery device of any one of claims 1 to 11, wherein the heat exchanger is constructed from a stack of plates defining alternating gas flow passages and liquid flow passages extending substantially parallel to the overall gas flow direction through the gas flow conduit.

13. The heat recovery device of any one of claims 1 to 12, wherein the heat exchanger further comprises a gas inlet manifold communicating with the gas inlet opening and a gas outlet manifold communicating with the gas outlet opening, and wherein a gas flow direction through each of the gas inlet manifold and the gas outlet manifold is at an angle to the overall gas flow direction through the gas flow conduit.

14. The heat recovery device of any one of claims 1 to 13, wherein the gas diverter valve is located at the divergent branch point.

15. The heat recovery device of claim 14, wherein,

with the gas diverter valve in the bypass position, gas flow to the heat exchange branch conduit is substantially completely blocked; and

with the gas diverter valve in the heat exchange position, gas flow to the bypass branch conduit is substantially completely blocked.

16. The heat recovery device of any one of claims 1 to 15, wherein the heat exchanger further comprises a bottom plate in which the gas inlet opening and the gas outlet opening are provided, and wherein the second end of the

upstream conduit portion and the first end of the downstream conduit portion are secured to the bottom plate.

17. The heat recovery device of claim 16, wherein the bottom plate is reinforced or thickened, at least in areas proximate to the gas inlet opening and the gas outlet opening.

18. The heat recovery device of any one of claims 1 to 17, wherein the second end of the upstream conduit portion and the first end of the downstream conduit portion are aligned with one another along the overall gas flow direction.

19. The heat recovery device of any one of claims 1 to 18, wherein the second end of the upstream conduit portion and the first end of the downstream conduit portion are aligned with one another along a direction which is substantially perpendicular to the overall gas flow direction.

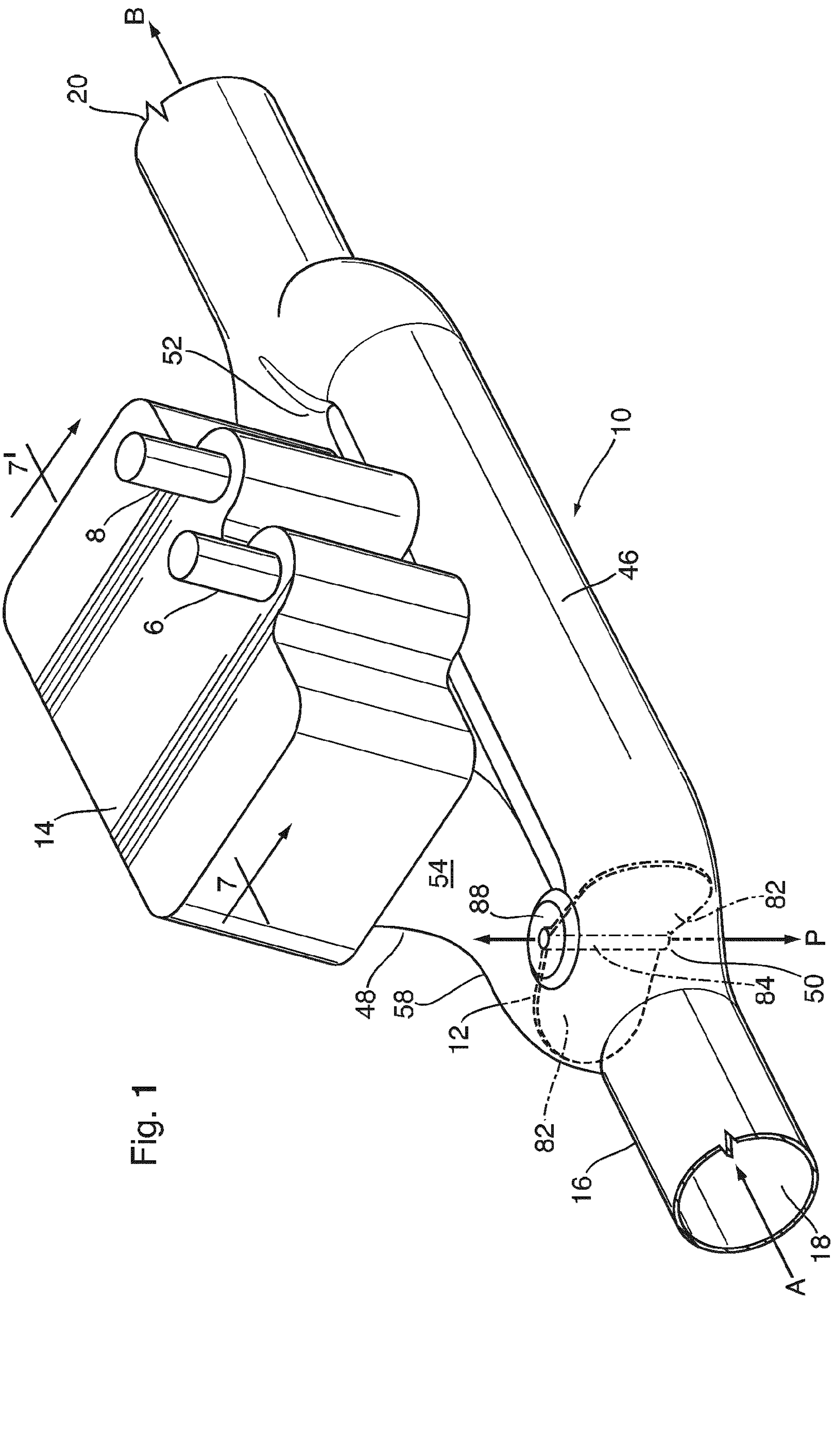


Fig. 1

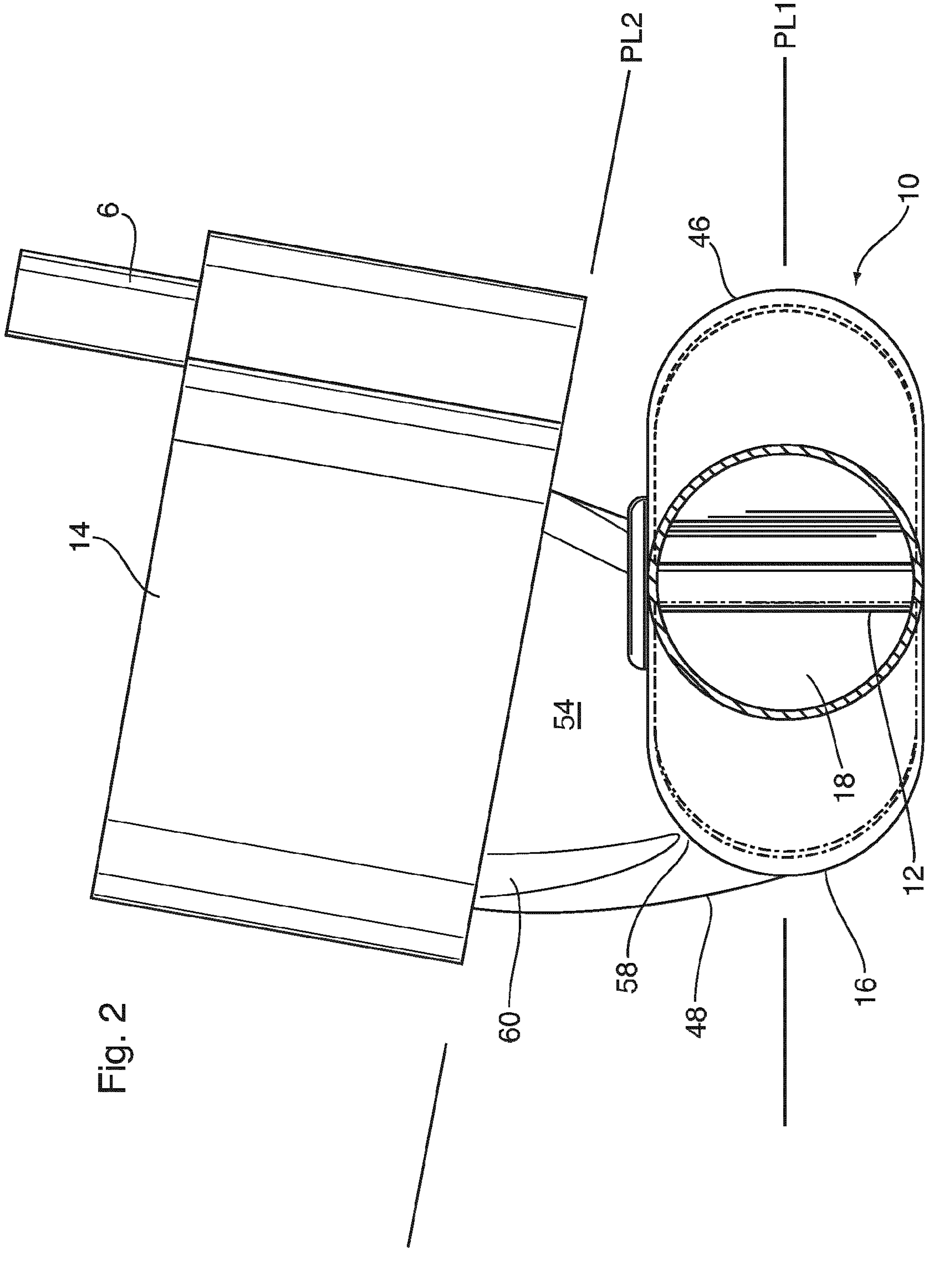


Fig. 2

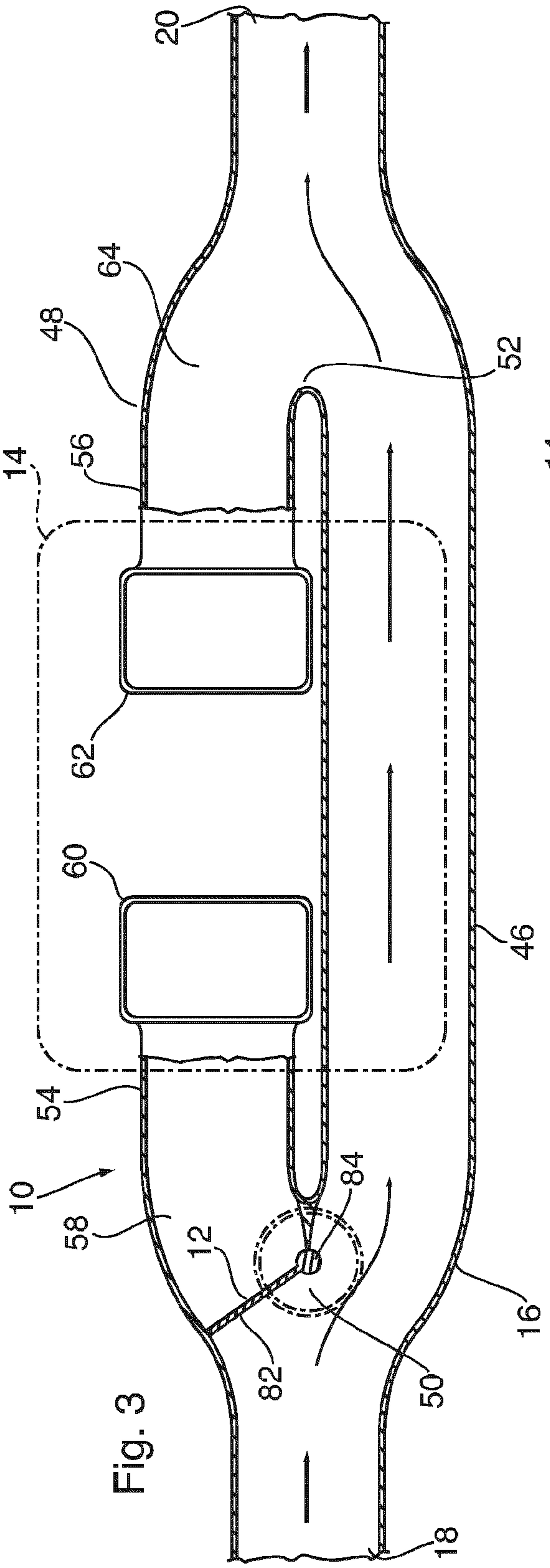


Fig. 3
10
12
14
16
18
20
46
48
50
52
54
56
58
60
62
64
82
84

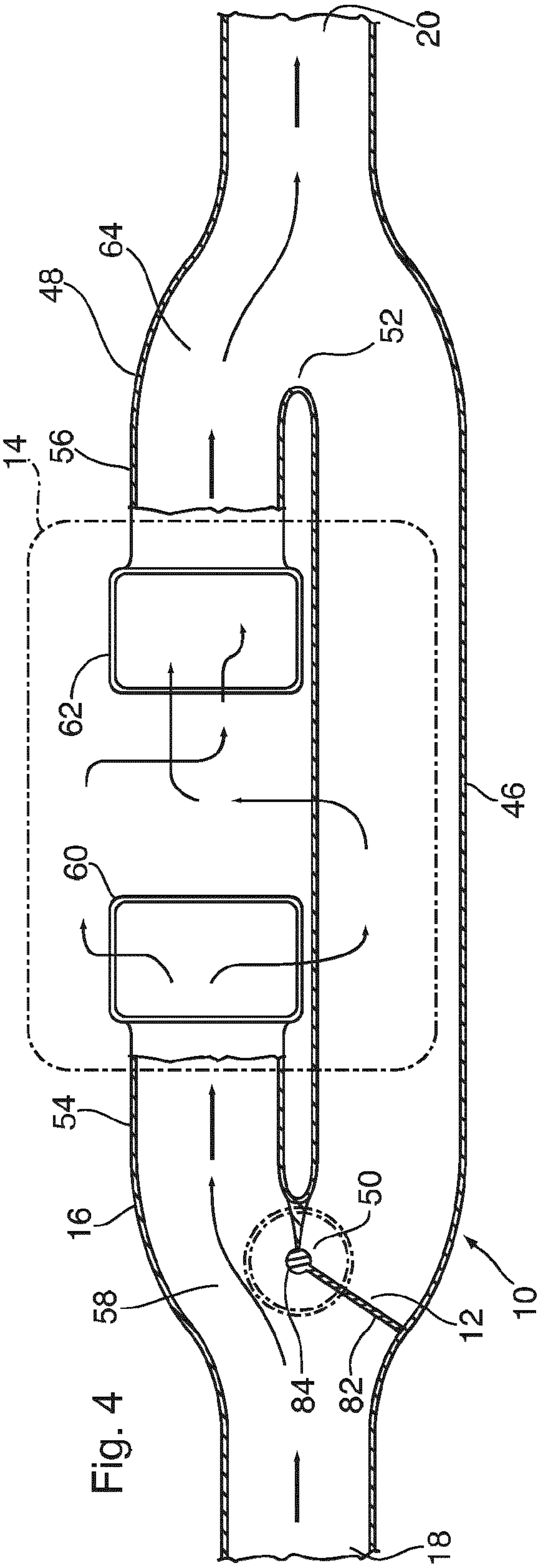


Fig. 4
10
12
14
16
18
20
46
48
50
52
54
56
58
60
62
64
82
84

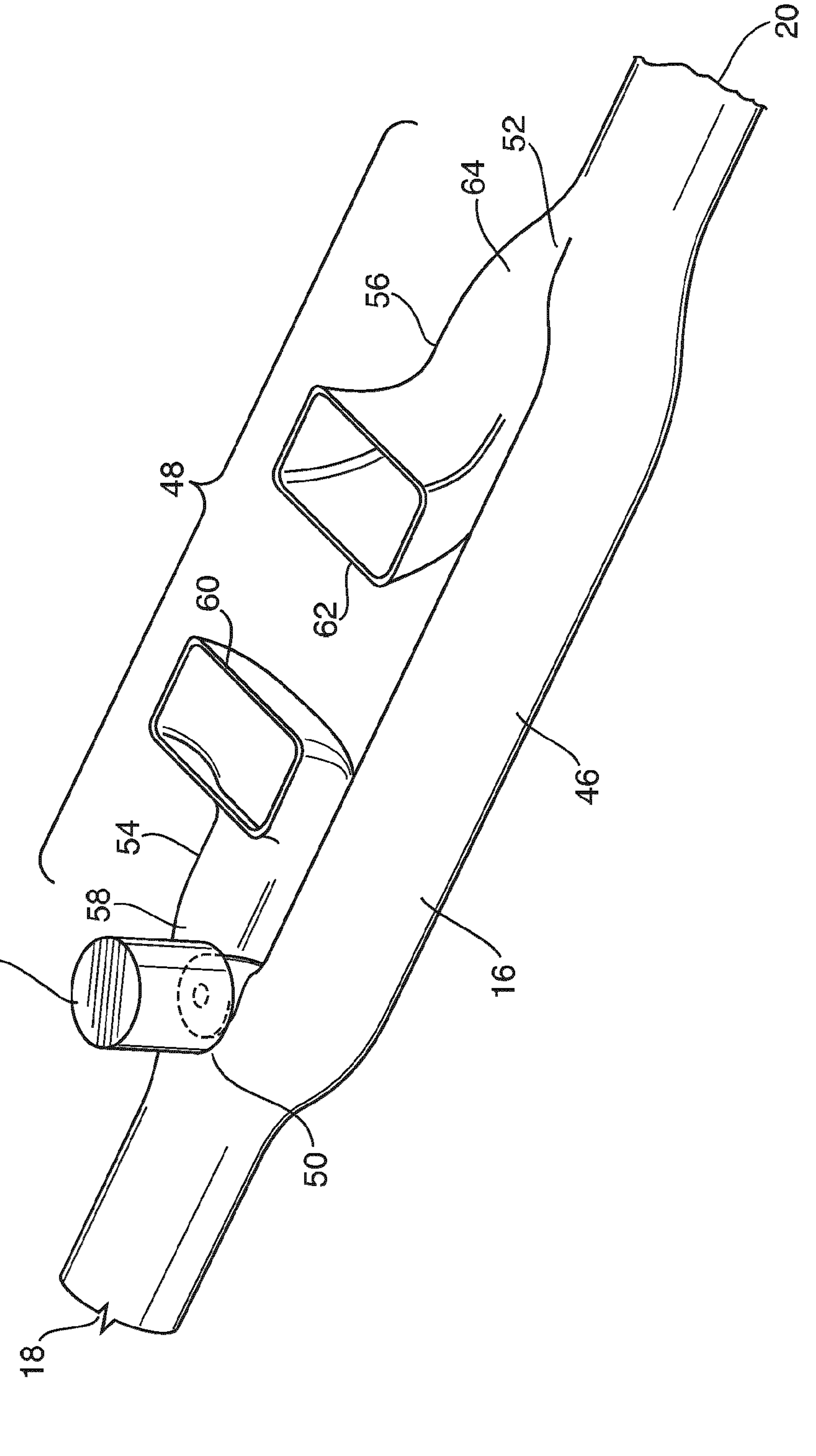


Fig. 5

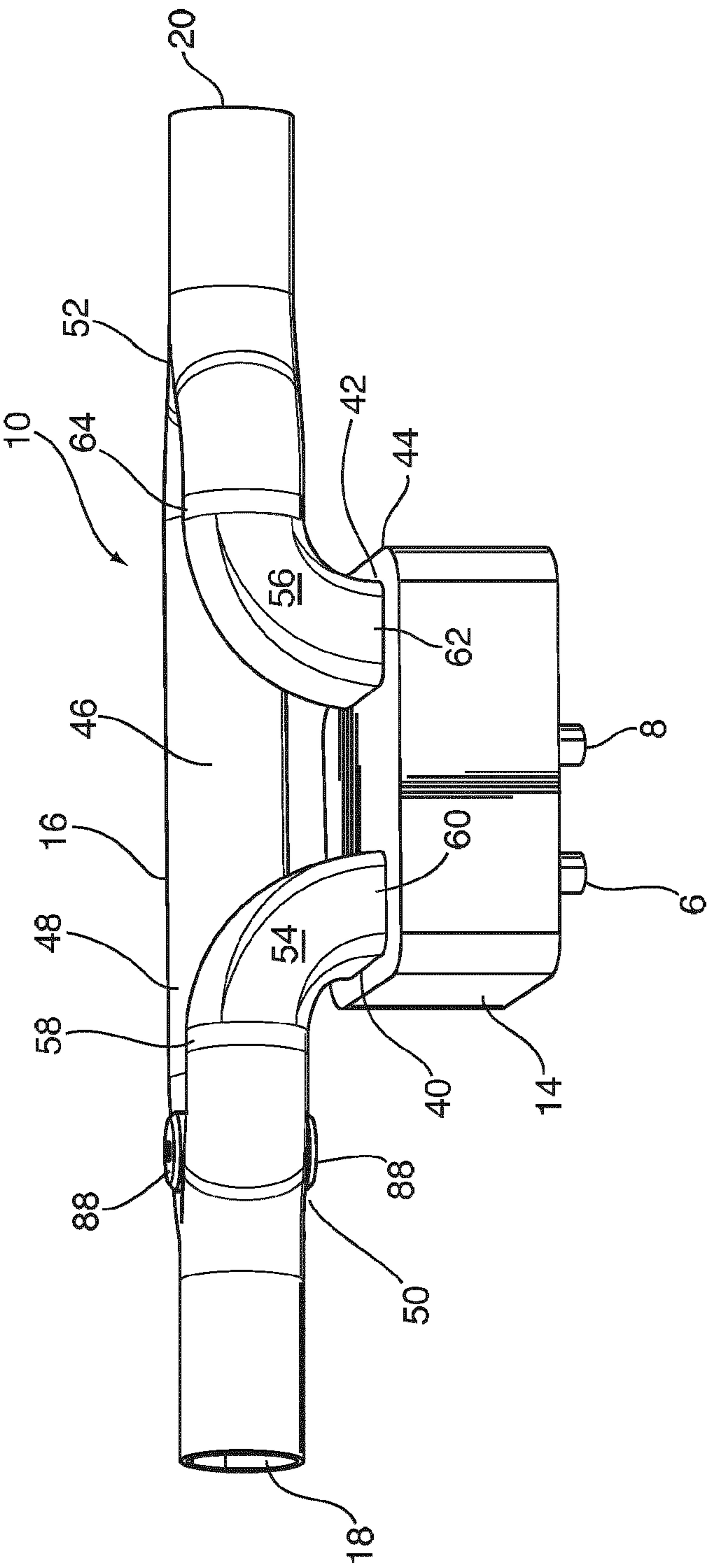
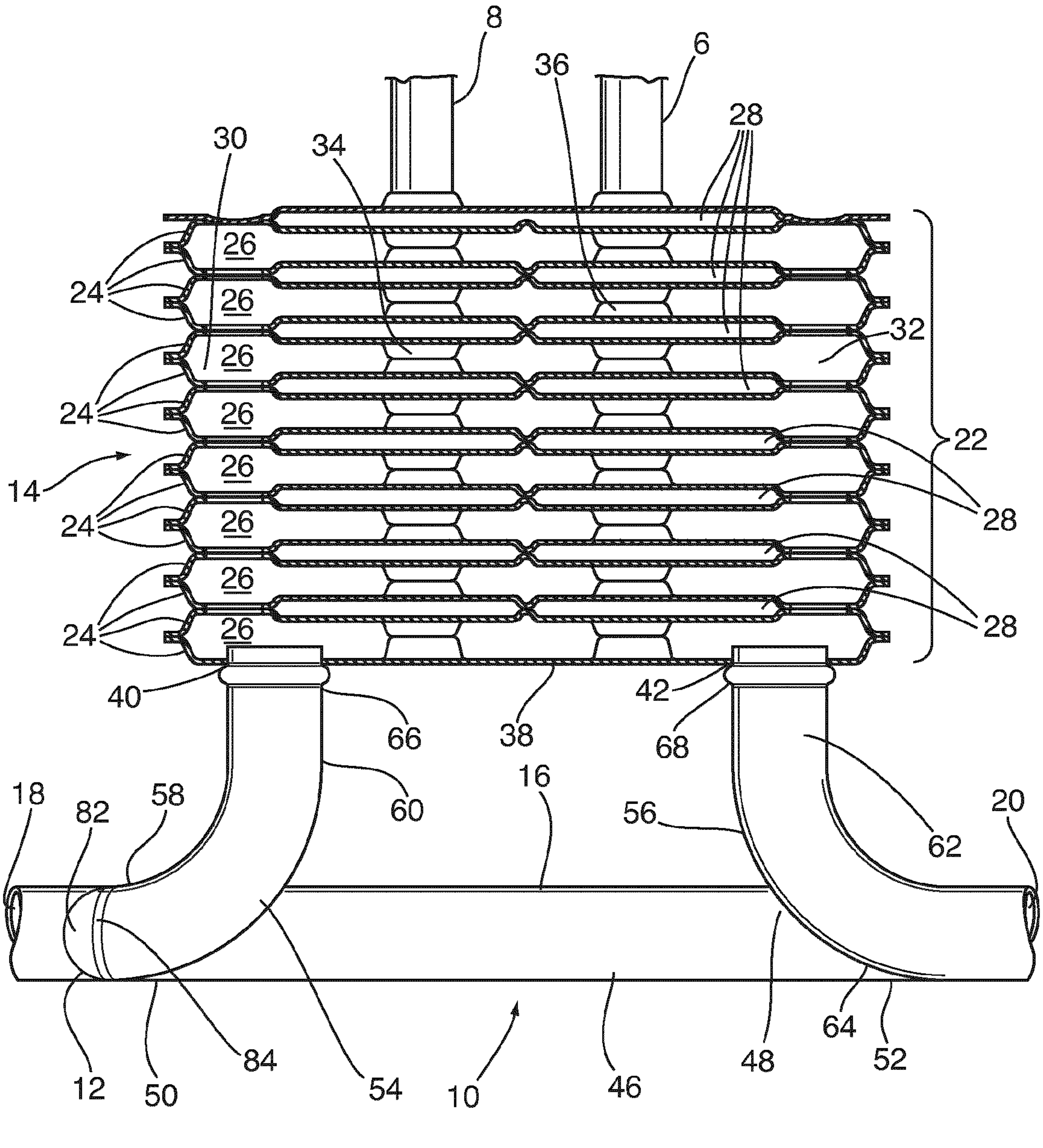


Fig. 6

Fig 7


8
6
36
28
30
34
26
24
32
22
14
28
40
42
38
66
68
18
82
58
60
16
56
62
20
12
50
84
54
10
46
48
64
52

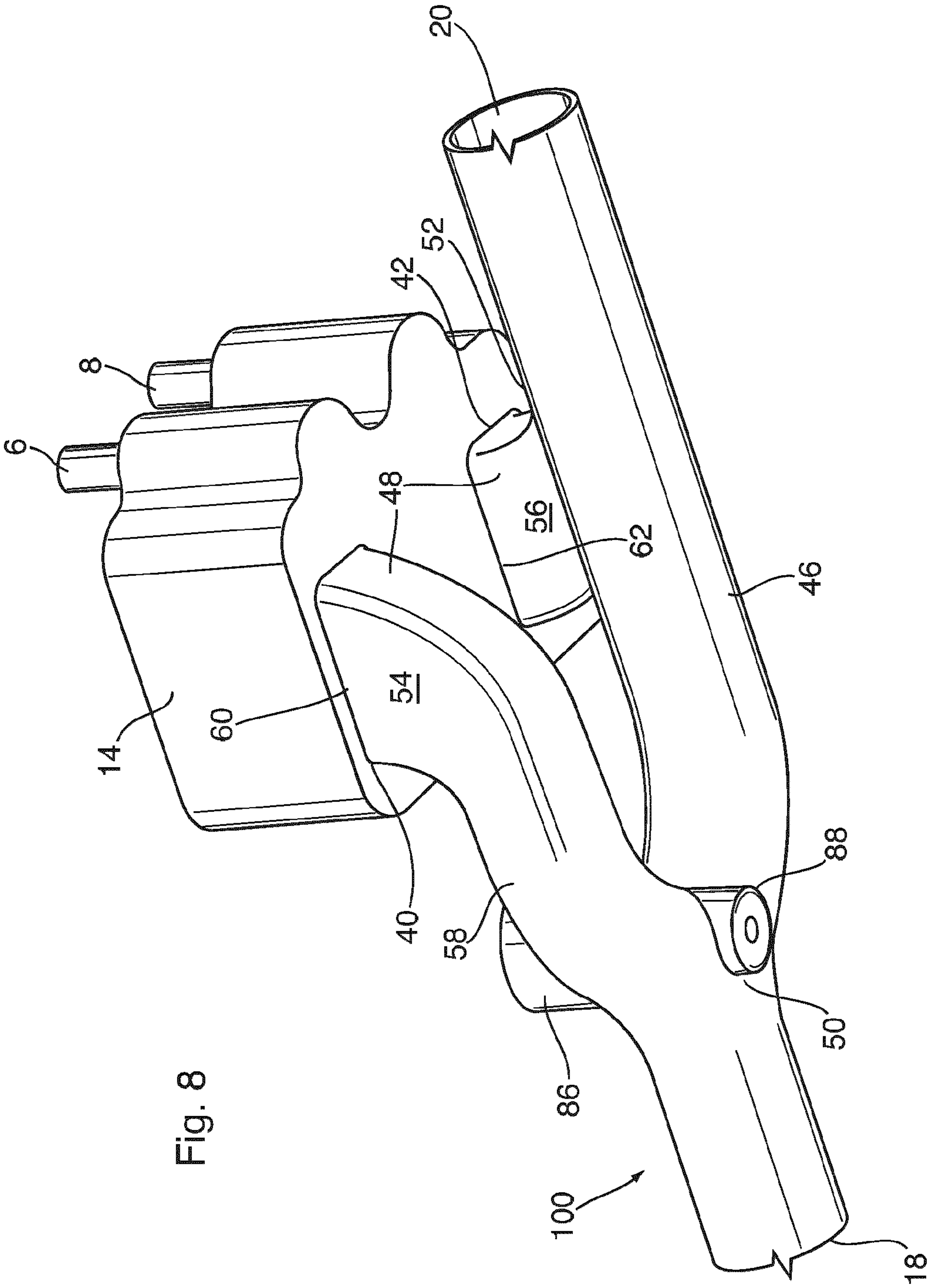
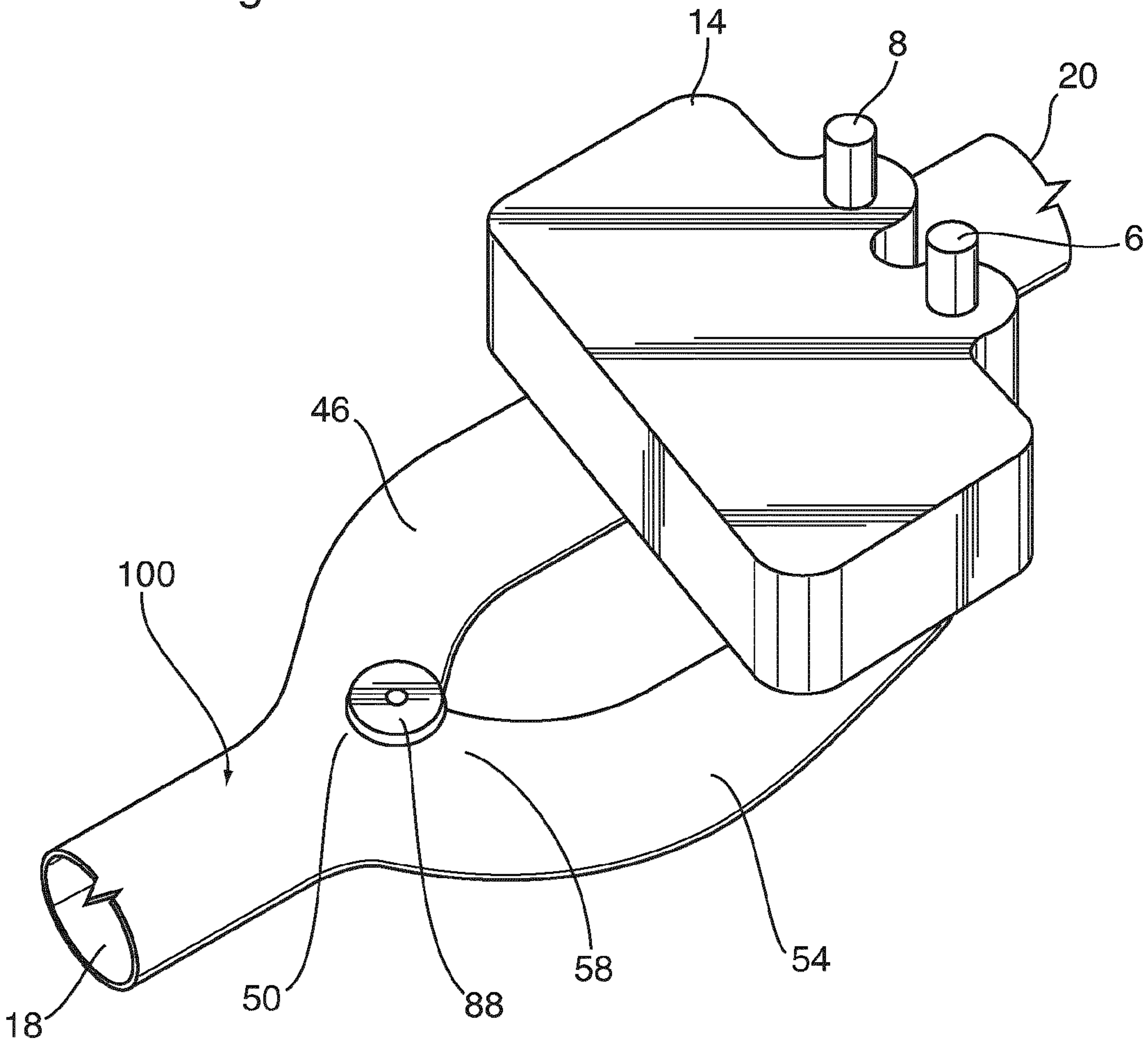


Fig. 8

Fig 9



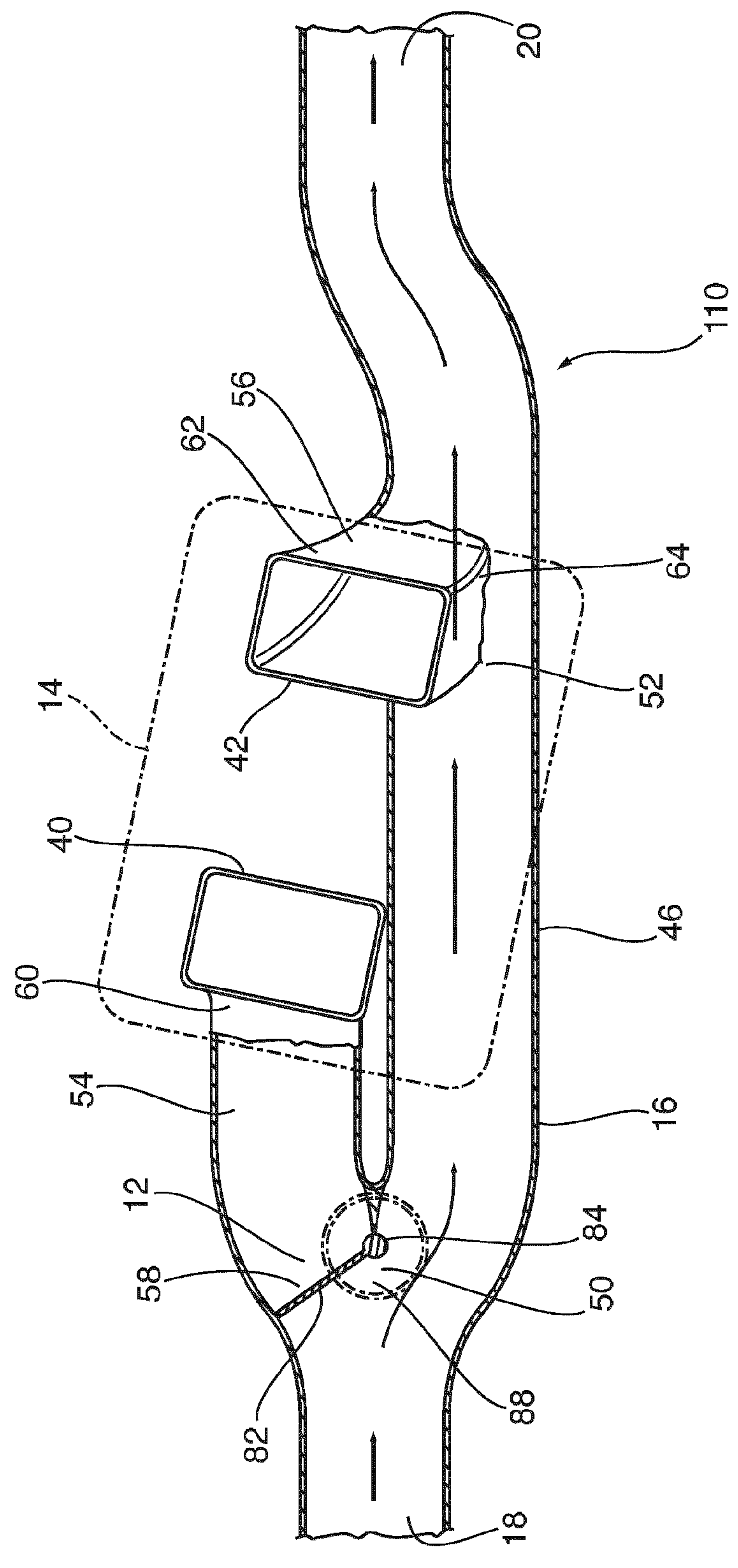


Fig. 10

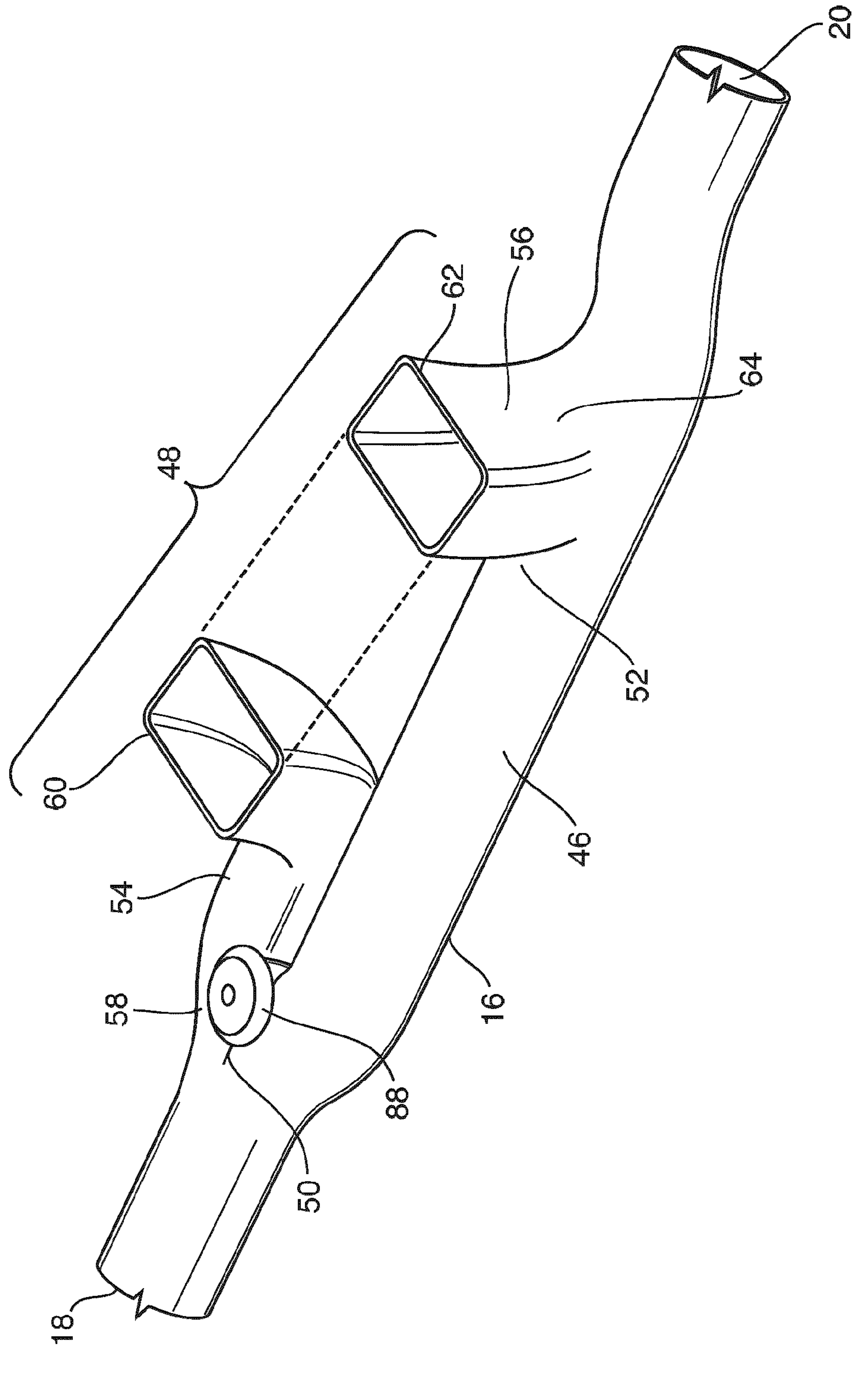


Fig.11

Fig. 1