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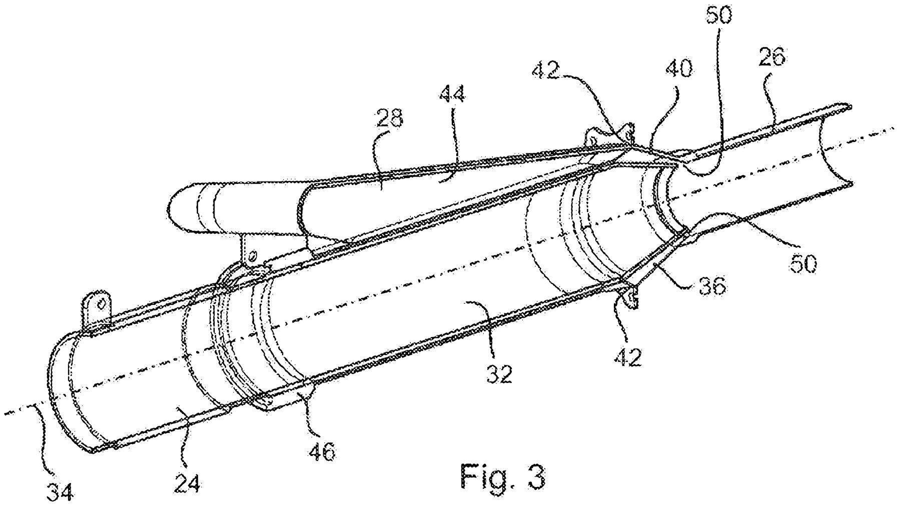

Fig. 3

(57) Abstract: A dredging tool (20) for underwater operation includes a suction pipe (24), an exhaust pipe (26) and a water inlet (44). The water inlet is arranged to form an annulus around the suction pipe to induce flow towards the exhaust pipe. The suction pipe is moveably relative to the exhaust pipe and water inlet to vary the size of the annulus.

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"DREDGING TOOL"

Field of the Invention

[0001] The present invention relates to dredging tools such as those used to clear matter away from underwater objects. It has been designed primarily for use in the off-shore oil-and-gas environment, but is considered to have the potential for wider application.

Background to the Invention

[0002] In underwater oil-and-gas settings, it is frequently necessary to access equipment such as pipes which have been on the ocean floor for some time. In order to access such equipment, it is often necessary to conduct a dredging operation to remove accumulated sand, sediment and biological matter from the equipment.

[0003] Typically, this dredging is done using vacuum dredging apparatus. Such apparatus uses a relatively high velocity water flow to induce a partial vacuum in a pipe. The material to be removed can be sucked into the pipe and expelled at a convenient location away from the equipment. Such apparatus is commonly described as employing a venturi effect.

[0004] Figure 1 shows a typical vacuum dredging apparatus 10 of the prior art. The apparatus includes a suction pipe 12, a water flow pipe 14 and an exhaust pipe 16. The water flow pipe 14 and the exhaust pipe 16 are generally aligned, so as to allow for the smooth flow of water from the water flow pipe 14 into the exhaust pipe 16. The water flow pipe 14 includes a water jet 15, which accelerates water as it enters the exhaust pipe 16. This acceleration causes a drop in water pressure, thus creating a partial vacuum in the suction pipe 12.

[0005] It will be appreciated that the only variable which can affect the operation of the prior art vacuum dredging apparatus 10 is the pressure at which water is supplied into the water flow pipe 14. This pressure is determined by the properties of a pump to which the water flow pipe 14 is connected. In many subsea operations (particularly operations performed by Remotely Operated Vehicles or ROVs) the pumps are hydraulic pumps which have a continuous output. There is therefore no means for adjusting or tuning the operation of the prior art vacuum dredging apparatus 10. Different makes and models of ROV have differences in hydraulic pressure and flow, meaning that the pump output will vary from one situation to another. Optimising the prior art vacuum dredging apparatus for a particular ROV and pump configuration is often not practical.

[0006] The applicant's research suggests that improvements in efficiency of a vacuum dredging apparatus can be made.

Summary of the Invention

[0007] According to a first aspect of the present invention there is provided a dredging apparatus having a suction portion, an exhaust portion and a water inlet portion, the suction portion being fluidly connected to the exhaust portion, the water inlet portion being fluidly connected to the exhaust portion, the flow of water from the water inlet portion to the exhaust portion being arranged to generate a partial vacuum in the suction portion, wherein the suction portion has a maximum cross sectional area upstream from the exhaust portion, and the exhaust portion has a minimum cross sectional area downstream from the suction portion, and the maximum cross sectional area of the suction portion is greater than the minimum cross sectional area of the exhaust portion.

[0008] It is believed that such an arrangement promotes acceleration of fluid through the exhaust, and leads to a greater degree of suction in the suction portion than would otherwise be the case.

[0009] It is preferred that the suction portion has a reduced cross-sectional area portion downstream of the maximum cross-sectional area, and that the water inlet portion is arranged to join the suction portion at the reduced cross-sectional area portion of the suction portion. The reduced cross-sectional area portion of the suction portion may have a similar cross-sectional area to the minimum cross sectional area of the exhaust portion.

[0010] It is preferred that the minimum cross sectional area of the exhaust portion is less than 80% of the maximum cross sectional area of the suction portion. It is more preferred that the minimum cross sectional area of the exhaust portion is less than 65% of the maximum cross sectional area of the suction portion. It is most preferred that the minimum cross sectional area of the exhaust portion is less than 50% of the maximum cross sectional area of the suction portion.

[0011] According to a second aspect of the present invention there is provided a dredging apparatus having a suction portion, an exhaust portion and a water inlet portion, the suction portion being fluidly connected to the exhaust portion, the water inlet portion being fluidly connected to the exhaust portion, the flow of water from the water inlet portion to the exhaust portion being arranged to generate a partial vacuum in the suction portion, the water inlet portion having a cross sectional area which reduces to form a water jet as the water inlet portion joins the exhaust portion, the water jet having a cross sectional area, wherein the dredging apparatus includes means to vary the cross sectional area of the water jet.

[0012] Preferably, the suction portion and the exhaust portion are both generally cylindrical or frusto-conical, and the water inlet portion is arranged in an annulus around the suction portion, such that the water jet is annular. It is most preferred that the water inlet portion has a central axis which is substantially parallel to a central axis of the exhaust portion. This ensures that water introduced through the water inlet portion flows towards an outlet of the exhaust portion.

[0013] The water jet may have a frusto-conical outer wall having a first cone angle, and a frusto-conical inner wall having a second cone angle, the second cone angle being smaller than the first cone angle, such that axial movement of the inner wall relative to the outer wall changes the cross sectional area of the water jet.

[0014] It is preferred that the water inlet portion includes a cylindrical portion, an annular portion, and a transitional portion, wherein the cross sectional area of the water inlet portion remains substantially constant throughout the transitional portion from the cylindrical portion to the annular portion. This allows the velocity and pressure of water upstream of the water jet to remain substantially constant, and promotes laminar flow of the water along inner walls of the exhaust portion.

Brief Description of the Drawings

[0015] It will be convenient to further describe the invention with reference to preferred embodiments of the present invention. Other embodiments are possible, and consequently the particularity of the following discussion is not to be understood as superseding the generality of the preceding description of the invention. In the drawings:

[0016] Figure 1 is a schematic view of a prior art dredging apparatus, showing some internal features;

[0017] Figure 2 is a schematic view of a dredging apparatus in accordance with the present invention, shown connected to a pump;

[0018] Figure 3 is a cross section of the dredging apparatus of Figure 2, parallel to a longitudinal axis; and

[0019] Figures 4a to 4k are sequential cross sections along the dredging apparatus of Figure 2, perpendicular to the longitudinal axis.

Detailed Description of Preferred Embodiments

[0020] Referring to Figure 2, there can be seen a dredging apparatus 20 connected to a pump 22. The dredging apparatus 20 includes a suction portion 24, an exhaust portion 26 and a water inlet portion 28. The water inlet portion 28 is connected by a water flow pipe 30 to an outlet of the pump 22.

[0021] The suction portion 24 can be seen in greatest detail in Figure 3. The suction portion 24 includes a main body portion 32, which is generally cylindrical, and extends from a suction end of the dredging apparatus 20 towards the exhaust portion 26. The main body portion is centred about a longitudinal axis 34.

[0022] The suction portion 24 has a frusto-conical exit portion 36, which extends from the main body portion 32 towards the exhaust portion 26. The exit portion 36 is centred about longitudinal axis 34, and has a diameter which decreases from a maximum, equal to the diameter of the main body portion 32, to a minimum diameter at its outer end which is approximately two thirds that of the main body portion 32. In the embodiment shown the exit portion 36 has a cone angle of about 40°. It is considered that a cone angle of between 20° and 60° would have a useful effect. It will be noted that the change in cross sectional area of the exit portion 36 is the square of the change of diameter, with the cross sectional area at the outer end of the exit portion 36 being about four ninths that of the main body portion 32.

[0023] The exhaust portion 26 is generally cylindrical, and is centred about the longitudinal axis 34. The exhaust portion 26 has a diameter approximately equal to the minimum diameter of the exit portion 36 of the suction portion 24.

[0024] The water inlet portion 28 includes a frusto-conical exit 40, which is formed to be contiguous with an inner edge of the exhaust portion 26. The exit 40 has a minimum diameter equal to that of the exhaust portion 26, and an increasing diameter away from the exhaust portion 26 (that is, towards the suction end of the dredging apparatus 20). The exit 40 is centred about the longitudinal axis 34, and has a cone angle of about 50° in this embodiment. In general, it is considered that a cone angle between 5° and 30° larger than that of the exit portion 36 is considered most useful.

[0025] The exit 40 of the water inlet portion 28 has a length slightly longer than the exit portion 36 of the suction portion 24. The combination of this increased length and the large cone angle means that the maximum diameter of the exit 40 is larger than the maximum diameter of the exit portion 36.

[0026] As will be described below, the exit 40 of the water inlet portion 28 locates generally around the exit portion 36 of the suction portion 24. The inner end 42 of the exit 40 (that is, at its maximum diameter), locates about the main body portion 32 of the suction portion 24. The cross sectional area of the water inlet portion at the inner end 42 is equal to the difference between the circular area of the inner end 42 and the circular cross-sectional area of the main body portion 32.

[0027] The water flow pipe 30 has a cross-sectional area approximately equal to the cross-sectional area of the water inlet portion 28 at the inner end 42. As will be appreciated, the difference is that the water flow pipe 30 has a circular cross-section of relatively small diameter, with the water inlet portion 28 at the inner end 42 having an annular cross-section with both outer and inner diameters being greater than the diameter of the water flow pipe 30.

[0028] The water inlet portion 28 includes a transitional region 44 which connects the water flow pipe 30 to the water exit 40 at the inner end 42. The transitional region 44 is shaped to gradually 'wrap around' the main body portion 32 of the suction portion 24. The transitional region 44 has a gradually increasing diameter, from the diameter of the water flow pipe 30 to the diameter of the water exit 40 at the inner end 42. A central axis of the transitional region 44 is arranged at an acute angle relative to the longitudinal axis 34, such that the axes intersect at the inner end 42 but are spaced apart near the suction end of the dredging apparatus 20. The main body portion 32 of the suction portion 24 thus increasingly 'cuts into' a nominal cross-sectional circle of the transitional region 44 as it approaches the inner end 42. The net result of this is that the cross-sectional area of the transitional region 44 is substantially constant.

[0029] This arrangement is shown by successive cross-sections shown in Figures 4a to 4k. Figure 4a shows the transitional region 44 with a diameter slightly greater than that of the water flow pipe 30, and with the main body portion 32 just impinging upon it. This progresses to Figures 4g and 4h, in which the transitional portion 44 virtually surrounds the main body portion 32, and finally to Figure 4i in which the inner end 42 of the water exit 40 surrounds the main body portion 32.

[0030] It will be appreciated that the cross-sectional area of water flowing from the pump 22 is therefore generally constant until it reaches the exit 40. The cross-sectional area then decreases along the exit 40, accelerating the water about an annulus into the exhaust portion 26.

[0031] The degree of acceleration of the water is dependent upon the size of the annulus at the outer end of the exit portion 36 of the suction portion 24. It will be appreciated that the diameters of both the outer end of the exit portion 36 and the outer end of the water exit 40 are both approximately equal to the diameter of the exhaust portion 26. The size of the annulus is therefore determined by the longitudinal distance between these outer ends.

[0032] The main body portion 32 of the suction portion 24 is held in position by means of a bushing 46 which is coupled to the water inlet portion 28 near the water flow pipe 30. The suction portion 24 is arranged for axial movement within the bushing 46. This means that the water inlet portion 28 and the exhaust portion 26 are in fixed relationship, with the suction portion 24 being able to move axially relative to the water inlet portion 28 and the exhaust portion 26. This axial movement has the effect of changing the gap 50 between the outer end of the exit portion 36 and the outer end of the water exit 40; that is, in changing the size of the water annulus (its cross-sectional area) and therefore the degree of acceleration.

[0033] In use, water is pumped from the pump 22 via the water flow pipe 30 into the water inlet portion 28. It proceeds through the transitional portion 44 at substantially constant pressure, and then is accelerated through the exit portion 40. It enters the exhaust portion 26 in an annulus having an outer diameter equal to the diameter of the exhaust portion 26, and thus establishes substantially laminar flow along the wall of the exhaust portion 26.

[0034] This acceleration of the water through the exit 40 creates a partial vacuum within the suction portion 24. Material adjacent the suction end of the dredging apparatus 20 is therefore pulled into and along the suction portion 24 of the dredging apparatus before being entrained in the water flow along the wall of the exhaust portion 26.

[0035] Rates of suction can be controlled or 'tuned' by longitudinal adjustment of the suction portion 24 within the bushing 46. Variable rates of suction can therefore be obtained even when using a constant pump output. It is considered that control of the system may be straightforward enough to enable ROV operation on the ocean floor.

[0036] Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention.

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Claims

1. A dredging apparatus having a suction portion, an exhaust portion and a water inlet portion, the suction portion being fluidly connected to the exhaust portion, the water inlet portion being fluidly connected to the exhaust portion, the flow of water from the water inlet portion to the exhaust portion being arranged to generate a partial vacuum in the suction portion, the water inlet portion having a cross-sectional area which reduces to form a water jet as the water inlet portion joins the exhaust portion, the water jet having a cross-sectional area, wherein the dredging apparatus includes means to selectively vary the cross-sectional area of the water jet.

2. A dredging apparatus as claimed in claim 1, wherein the suction portion and the exhaust portion are both generally cylindrical or frusto-conical, and the water inlet portion is arranged in an annulus around the suction portion, such that the water jet is annular.

3. A dredging apparatus as claimed in claim 2, wherein the water jet has a frusto-conical outer wall having a first cone angle, and a frusto-conical inner wall having a second cone angle, the second cone angle being smaller than the first cone angle, such that axial movement of the inner wall relative to the outer wall changes the cross sectional area of the water jet.

4. A dredging apparatus as claimed in claim 2 or claim 3, wherein the water inlet portion includes a cylindrical portion, an annular portion, and a transitional portion, and wherein the cross sectional area of the water inlet portion remains substantially constant throughout the transitional portion from the cylindrical portion to the annular portion.

5. A dredging apparatus as claimed in any preceding claim, wherein the suction portion has a maximum cross-sectional area upstream from the exhaust portion, and the exhaust portion has a minimum cross-sectional area downstream from the suction portion, and the maximum cross-sectional area of the suction portion is greater than the minimum cross-sectional area of the exhaust portion.

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6. A dredging apparatus as claimed in claim 5, wherein the suction portion has a reduced cross-sectional area portion downstream of the maximum cross-sectional area, and that the water inlet portion is arranged to join the suction portion at the reduced cross-sectional area portion of the suction portion.

7. A dredging apparatus as claimed in claim 6, wherein the reduced cross-sectional area portion of the suction portion has a similar cross-sectional area to the minimum cross sectional area of the exhaust portion.

8. A dredging apparatus as claimed in any one of claims 5 to 7, wherein the minimum cross sectional area of the exhaust portion is less than 80% of the maximum cross sectional area of the suction portion.

9. A dredging apparatus as claimed in claim 8, wherein the minimum cross sectional area of the exhaust portion is less than 65% of the maximum cross sectional area of the suction portion.

10. A dredging apparatus as claimed in claim 9, wherein the minimum cross sectional area of the exhaust portion is less than 50% of the maximum cross sectional area of the suction portion.

11. A dredging apparatus as claimed in any one of claims 5 to 10, wherein the suction portion includes a cylindrical portion whereby the maximum cross sectional area of the suction portion extends along at least 20% of the length of the suction portion.

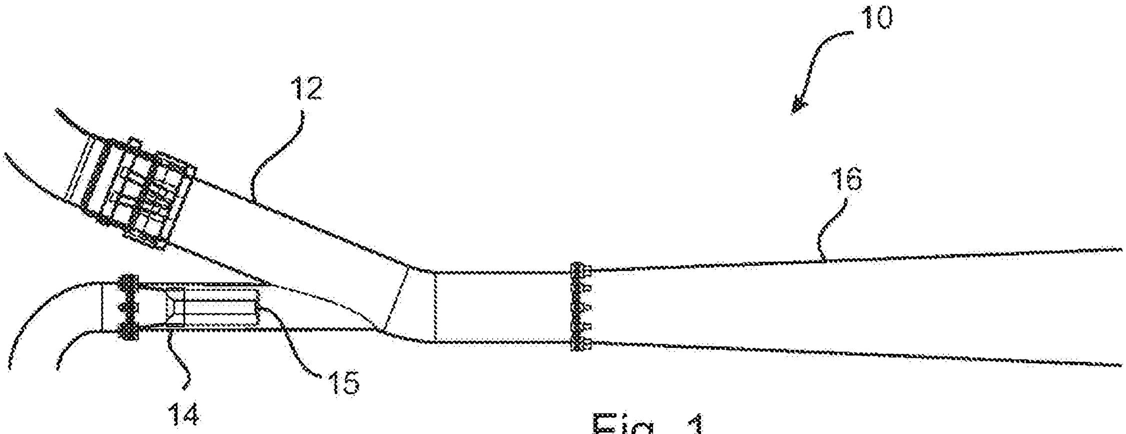

Fig. 1

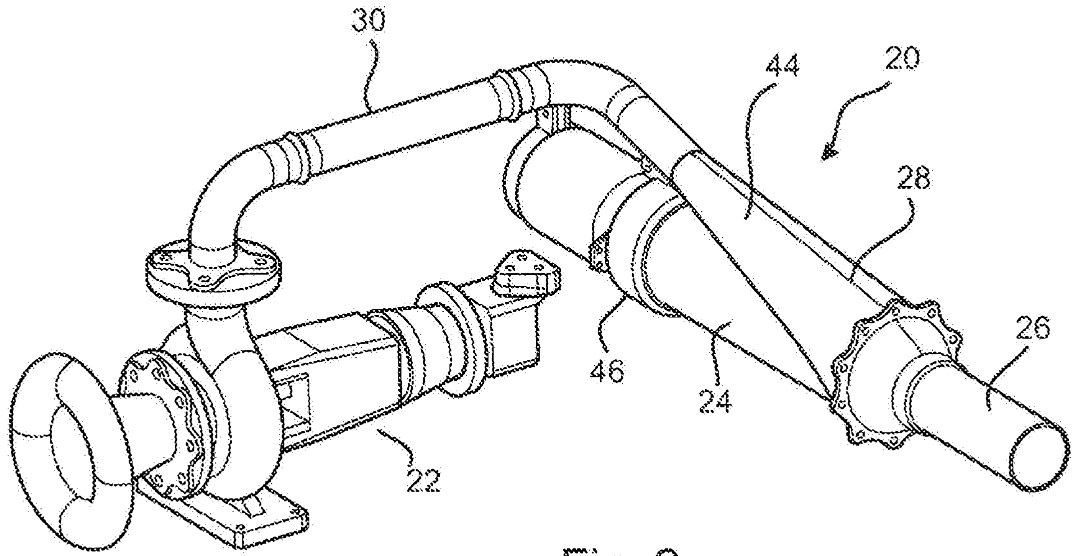

Fig. 2

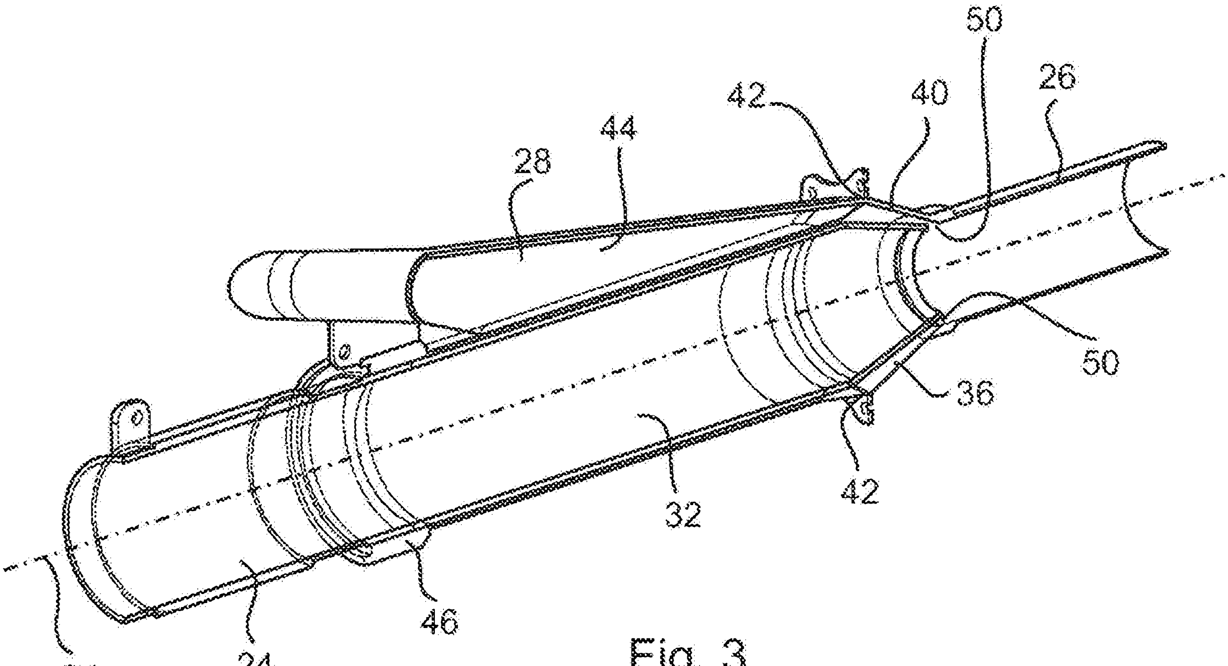

Fig. 3

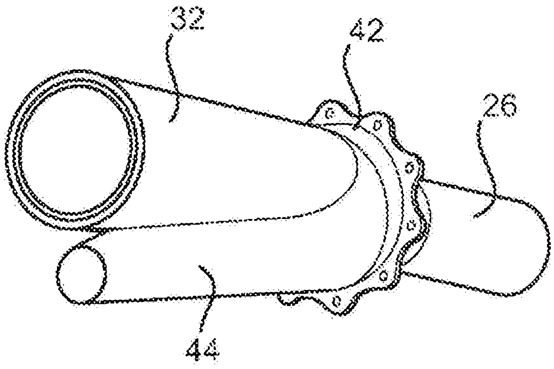

Fig. 4a

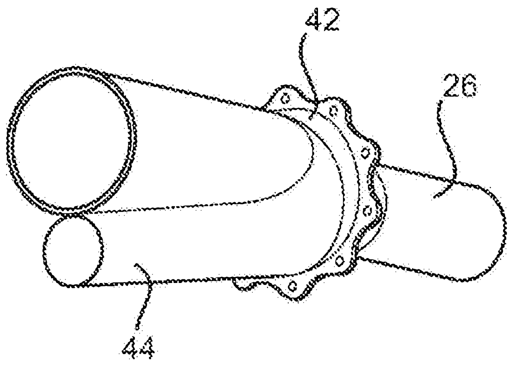

Fig. 4b

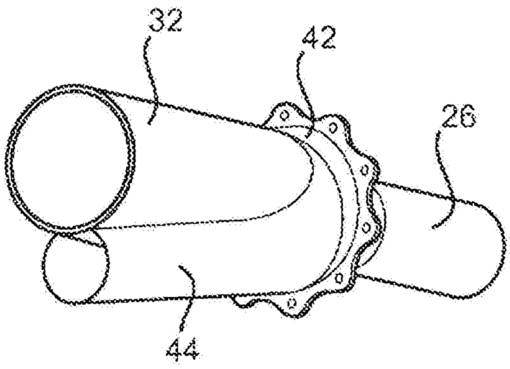

Fig. 4c

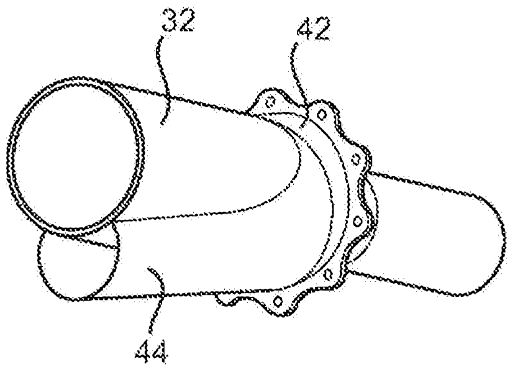

Fig. 4d

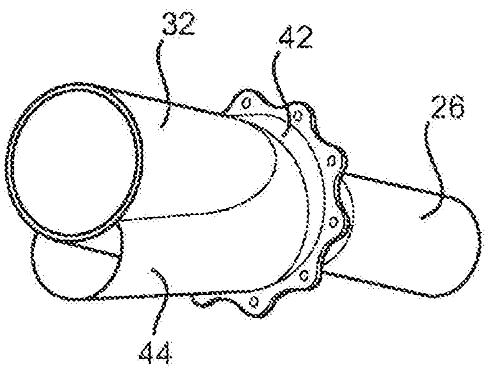

Fig. 4e

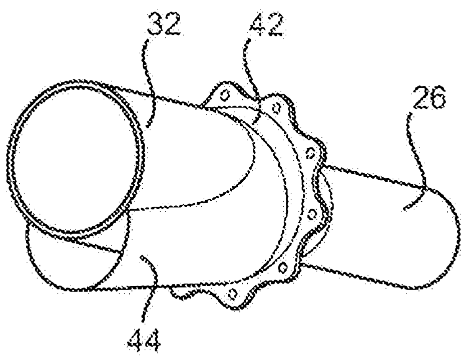

Fig. 4f

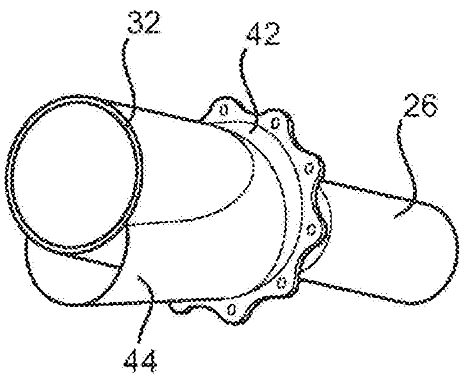

Fig. 4g

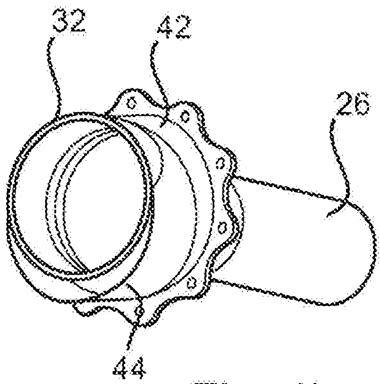

Fig. 4h

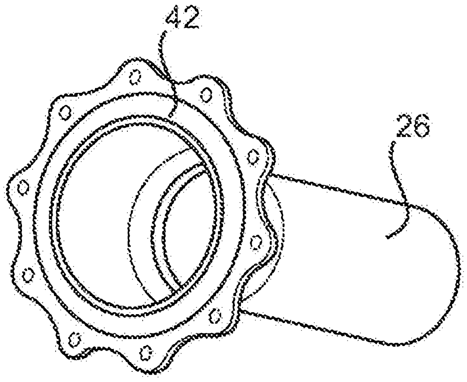

Fig. 4i

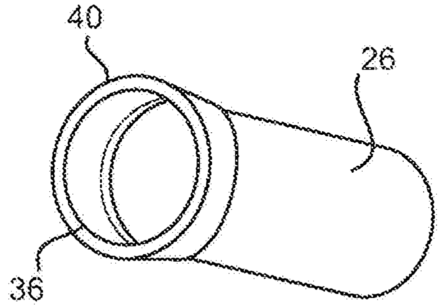

Fig. 4j

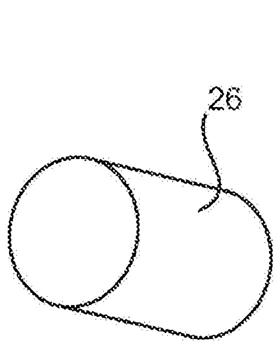

Fig. 4k