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(54) **A VOLUTE CASING FOR A CENTRIFUGAL PUMP**

(57) The present invention relates to a volute casing for a centrifugal pump, the volute casing (44) having an axis A and a centreline C_L; a cutwater tongue (54); an outlet duct (50) with an outlet opening (52) having a centre, the outlet opening (52) being surrounded by a collar (56) with a collar surface (56'); and the centreline C_L of the volute casing (44) running via the axis of the volute casing (44) in a direction perpendicular to the collar surface (56'), wherein that the outlet duct (50) has a curved centreline C_{LOD}, a constant circular cross section and a constant cross sectional area for the entire length of the curved centreline C_{LOD}, and that the outlet opening (52) has a centreline C_{LO} running via the centre of the outlet opening (52) in a direction perpendicular to the collar surface (56'), the centreline C_{LO} of the outlet opening (52) being positioned at a distance D of from 0.25 to 0.8 times C from the centreline C_L of the volute casing (44) where C is the distance of the cutwater tongue from the axis of the volute casing (44).

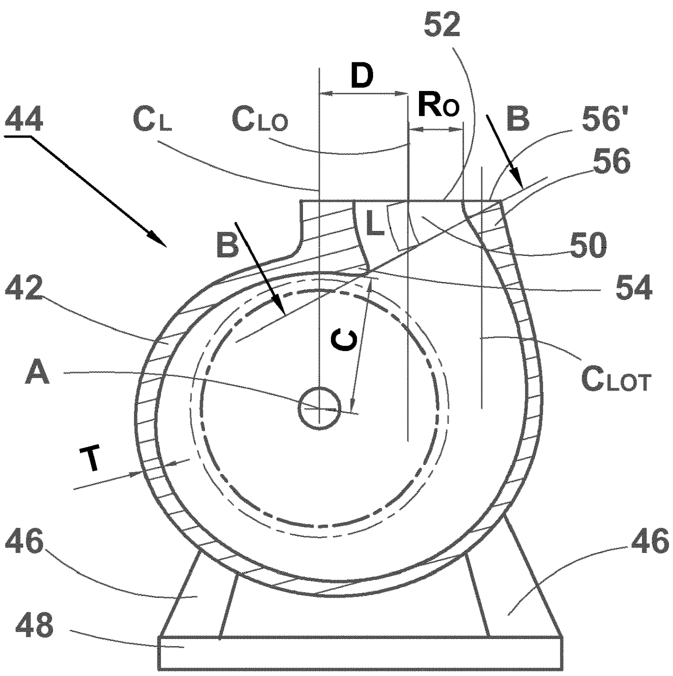

Fig. 3

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Description

Technical field

[0001] The present invention relates to a volute casing for a centrifugal pump. The volute casing of the invention is especially applicable in connection with centrifugal pumps where the efficiency of the pump plays a role in the pump design.

Background art

[0002] The present centrifugal pumps use, in principle, two types of volute casings in view of the positioning of the outlet opening. As a first example, industrial standards ISO2858 and EN733 concerning small centrifugal pumps suggest that the outlet duct and the outlet openings of the centrifugal pumps are positioned on the vertical centreline of the centrifugal pump, i.e. on the vertical line running via the axis of the pump and its rotor.

[0003] However, practice has shown that such an outlet duct and outlet opening result in a low efficiency for two separate reasons. Firstly, there is a substantially sharp bend in the outlet duct, i.e. a bend turning the flow of the medium abruptly from circumferential direction to radial direction, causing significant resistance to flow. And secondly, the outlet duct is relatively long, as it is common practice to arrange a widening part, i.e. a diffuser, to the outlet duct for matching the outlet duct to the following pipeline. Since the pump is normally made by casting the non-smooth cast inside surface of the outlet duct causes high friction losses between the flowing medium and the cast surface. In other words, the volute casing design downstream of the cut-water tongue adds flow resistance. In addition to the above mentioned effects on the power consumption, the outlet duct of the present centrifugal pump is much more expensive to manufacture than a corresponding length of pipe in the pipeline taking the medium further. Also the cast outlet duct is much heavier than a corresponding length of pipe in the pipeline. The pump outlet takes also due to its long outlet duct a considerable space in the direction of the outlet duct, i.e. normally in vertical direction. Thus, the additional weight and dimensions are clear drawbacks in all phases of taking the pump into use starting from the manufacture of the pump and ending to the installation thereof.

[0004] However, the positioning of the outlet of the centrifugal pump suggested by the standards have the advantage that the volute casing of the pump is self-deaerating, i.e. when the pump is filled with liquid almost all the gas/air is discharged from the volute casing to the outlet. Another advantage may be seen in the way the vertical forces acting on the centrifugal pump are affecting the construction of the centrifugal pump. In the construction of the standards the forces act along the centreline of the centrifugal pump in the middle between the legs of the centrifugal pump, whereby the centrifugal pump is stabile in relation to vertical forces. This means that the legs of the pump may be positioned rather close to each other, i.e. at a short distance from the centreline. This means, in practice, that the amount of material needed for the legs is small and that the base plate and the concrete foundation of the base plate and the pump may be designed small. As to the construction of the pump itself, due to the positioning and length of the outlet duct, it has to be supported often to the volute casing by means of one or more strengthening ribs, especially if friable material like for instance cast iron is used in the manufacture of the volute casing.

[0005] The second example of the volute casing construction is a traditional centrifugal pump having a tangential outlet, the efficiency ratio of which is 3 - 5 percentage units higher than the centrifugal pumps of the first example. The centrifugal pumps having a tangential outlet have a few disadvantages, like for instance the construction of a small centrifugal pump, which requires a very long outlet duct and which is difficult to manufacture due to the complicated construction of the cut-water tongue. Additionally, the pumps having tangential outlets are always equipped with a diffuser in the outlet duct, meaning that the outlet duct expands conically. This kind of a structure increases both the production costs and the weight of the pump significantly. Also, the friction losses are high due to a long cast outlet duct. And further, when such a pump is filled with liquid gas/air remains in the upper part of the volute casing and an additional degassing duct is required in the volute casing. A further downside is the vertical forces acting along the centreline of the outlet duct, but not centrally in relation to the pump itself, whereby the legs of the casing have to be brought outer. This results in price increase concerning both the centrifugal pump, the installation base plate and the concrete foundation for the base plate that have to extend farther than with the centrifugal pump in accordance with the above mentioned standards.

Brief summary of the Invention

[0006] Thus, an object of the present invention is to eliminate at least one of the above mentioned drawbacks or problems by means of a novel volute casing for a centrifugal pump.

[0007] Another object of the present invention is to develop a novel volute casing that maintains the efficiency of the centrifugal pump at a high level.

[0008] A further object of the present invention is to develop a novel volute casing that makes it possible to reduce the weight and dimensions of a centrifugal pump and thereby also the material costs in the production thereof.

[0009] A yet further object of the present invention is to develop a novel volute casing that makes it possible to reduce the size of the base plate and concrete foundation compared to prior art pumps capable of high efficiency.

[0010] The characterizing features of the centrifugal pump in accordance with the present invention by means of which at least one of the above discussed problems are solved and at least one of the above listed objects are reached become apparent from the appended claims.

[0011] The present invention brings about a number of advantages, like for instance

- The outlet duct is short, hydraulically optimal and cost-efficient to manufacture, as there is no need to manufacture either a long tangential outwardly widening outlet duct (diffuser), or an outlet duct having an extra bend and a diffuser for making the duct follow the vertical centreline of the volute casing.
- When the outlet flange is integrated into the volute casing as an outlet collar the outlet duct does not need any support and still the structure is extremely sturdy, material is saved, and the weight of the flow machine is reduced.
- The efficiency ratio of a centrifugal pump may be raised to correspond to that of the centrifugal pump with a tangential volute casing, i.e. 3 - 5 percentage units higher than that of a centrifugal pump with a radial outlet duct, i.e. centrifugal pumps in accordance with standards ISO2858 or EN733. In some cases the efficiency ratio may be raised even more.
- The volute casing of the centrifugal pump is self-deaerating, as the discharge outlet from the volute is located near the uppermost point of the volute casing. No need for an additional de-aerating duct.
- Forces acting on the pressure outlet of the centrifugal pump may be balanced by means of ordinary legs, whereby there is no need to increase the width of the installation base plate and the concrete foundation of the centrifugal pump like with centrifugal pumps with tangential outlet.
- The space between the flange at the end of the outlet duct and the volute casing, which, in ordinary centrifugal pumps constructed in accordance with standards ISO2858 or EN733, creates often a risk of breakage, is now minimized or totally avoided such that no strengthening ribs are needed.
- The outlet duct may be designed, without the dimensioning limitations based on the standards ISO2858 or EN733, hydraulically optimal and, additionally, the outlet may be integrated to the volute, whereby it is easier and more cost-effective to manufacture.
- The length of the outlet duct is minimized such that the weight and dimensions of the volute casing are minimized. Also due to the same reason the frictional losses are minimized, as it is, in view of friction, advantageous to extend the smooth-surfaced pipe of the pipeline as close to the impeller as practically possible.
- The volute casing in accordance with the present invention results in a higher efficiency ratio than the casings of prior art centrifugal pumps including the pumps constructed in accordance with standards ISO2858 and EN733.

[0012] As to the above listed advantages it should be understood that each embodiment of the invention may not lead to each and every advantage, but just a few of those.

Brief Description of Drawing

[0013] The volute casing for a centrifugal pump of the present invention is described more in detail below, with reference to the accompanying drawings, of which

Figure 1 illustrates schematically as a first example of a prior art centrifugal pump a radial cross section of a volute casing of a centrifugal pump,

Figure 2 illustrates schematically as a second example of a prior art centrifugal pump a radial cross section of a volute casing of another centrifugal pump,

Figure 3 illustrates schematically a radial cross section of a volute casing of a centrifugal pump in accordance with a preferred embodiment of the present invention, Figure 4 is used for defining the radial centreline plane of the volute casing, and

Figure 5 illustrates schematically, along the centreline plane of Figure 4, a radial cross section of a volute casing of a centrifugal pump in accordance with a preferred embodiment of the present invention.

Detailed Description of Drawings

[0014] Figure 1 illustrates as a first example of prior art centrifugal pumps a radial cross section of a volute casing 4 of a centrifugal pump constructed in accordance with industrial standards ISO2858 and EN733. The volute casing 4 is supported of its wall 2 by means of legs 6 to the installation base plate 8. The volute casing 4 comprises an outlet duct 10, an outlet opening 12 and a cutwater tongue 14. In the centrifugal pump of Figure 1 the outlet duct 10 and the outlet opening 12 are positioned on the vertical centreline C_L of the centrifugal pump, the centreline running via the axis of the volute casing and the rotor (shown by broken circle). In this document the centreline C_L of the centrifugal pump is considered to run via the axis of the volute casing in a direction perpendicular to the plane of the outlet opening or the outlet flange.

[0015] Since the vertical centreline C_{LOR} of the outlet opening 12 is on the vertical centreline C_L of the volute casing 4, the legs 6 may be arranged symmetrically to the vertical centreline C_L and substantially close to one another on the installation base plate 8. This reduces the material and manufacturing costs of the centrifugal pump - installation base plate combination. Naturally also the concrete foundation on which the installation base plate is located may be made small if the base plate is small.

[0016] However, practice has shown that the above discussed outlet duct 10 and outlet opening 12 result in a low efficiency, as there is an extra sharp bend 16 in the flow path from the volute to the outlet opening 12 causing resistance to flow. Furthermore, the volute casing design downstream of the cut-water tongue 14 adds flow resistance, too, as the outlet duct made by means of casting has a relatively rough inside surface and the outlet duct is relatively long (its length normally equalling to about a half of the average radius of the volute casing) and thus the friction losses against the cast duct surface are substantially high. The overall effect of the entire outlet duct is of the order of 3 - 5 percentage units' reduction in the efficiency ratio compared to pumps having a tangential outlet duct. In addition to the above mentioned effects, in reality, on the power consumption, the outlet duct 10 and outlet opening 12 of the present centrifugal pump are also expensive to manufacture, and take due to the substantially long outlet duct 10 a considerable space in the direction of the outlet duct, i.e. normally in vertical direction. Additionally, due to the construction and positioning of the outlet duct 10 it has to be supported by means of at least one strengthening rib 18 to the wall 2 of the volute casing 4, especially if friable material like for instance cast iron is used in the manufacture of the volute casing 4. Furthermore the long outlet duct, which is made to widen in the flow direction forms a considerable weight increase.

[0017] Figure 2 illustrates, as a second example of prior art centrifugal pumps, a radial cross section of a volute casing 24 of a centrifugal pump. The second example is a traditional centrifugal pump having a tangential outlet 30, whereby the vertical centreline C_{LOT} of the outlet duct 30 and the outlet opening 32 are relatively far from the vertical centreline C_L running via the axis of the volute casing 24. This kind of a construction means that the legs 26 of the centrifugal pump have to extend farther away from the vertical centreline C_L of the volute casing 24, at least so that the leg 26 situated on the same side of the volute 24 with the outlet duct 30 extends clearly outside the vertical centreline C_{LO} of the outlet duct 30. This results in price and weight increase concerning both the centrifugal pump, the installation base plate and the concrete foundation that have to extend farther than with the centrifugal pump in accordance with the standards mentioned in connection with Figure 1. The centrifugal pumps having a tangential outlet 30 have themselves a few disadvantages, like for instance the construction of a small centrifugal pump, which requires a very long (its length normally equalling to about a half of the average radius of the volute casing) conically expanding outlet duct 30 (diffuser), and which is difficult to manufacture due to the complicated construction of the cutwater tongue 34. Furthermore, the same friction-related problems that relate to the centrifugal pumps of the above mentioned standards concern also these pumps having a tangential outlet duct, i.e. the long cast surface causes high frictional losses. And still further, when such a pump is filled with liquid gas/air remains in the upper part of the volute casing whereby an additional degassing duct is required in the volute casing.

[0018] At least some of the above discussed problems or disadvantages may be obviated by trying to minimize the weight of the centrifugal pump, the dimensions of the centrifugal pump and the friction losses in the outlet duct. The above goals may be reached by designing the volute casing of a centrifugal pump to have as short outlet duct as possible. The length of the outlet duct may be measured from the cutwater tongue to the outlet flange. Minimizing the length of the outlet duct so that no additional flow losses are created requires that the outlet duct and the outlet opening of the centrifugal pump are located between the vertical centrelines discussed in connection with Figures 1 and 2, i.e. between the radial centreline C_{LOR} of the volute casing running via the axis of the volute casing and the centreline C_{LOT} of the tangential outlet duct. A further advantageous feature of the outlet duct of the present invention is such that the cross sectional flow area of the outlet duct remains substantially constant from the cutwater tongue area to the outlet collar. This feature minimizes the weight of the outlet duct as well as the cast surface area causing the frictional losses.

[0019] Figure 3 illustrates a radial cross section of a volute casing 44 of a centrifugal pump in accordance with a preferred embodiment of the present invention. The exemplary centrifugal pump of Figure 3 comprises a volute casing 44 having a wall 42, an outlet duct 50, an outlet opening 52 and a cutwater tongue 54. The volute casing 44 is supported by means of legs 46 fastened to or being integral parts of the wall 42 of the volute casing 44 on an installation base plate 48. The volute casing 44 has a vertical centreline C_L, and the outlet opening 52 a vertical centreline C_{LO}. The centreline C_L of the centrifugal pump runs via the axis of the volute casing 44 in a direction perpendicular to the plane of the outlet opening 52 or the surface 56' of the outlet collar 56. In a similar manner the vertical centreline C_{LO} runs via the centre of the outlet opening 52 in a direction perpendicular to the plane of the outlet opening 52 or the surface 56' of the outlet collar 56. Figure 3 shows also by means of a line C_{LOT} running in a direction perpendicular to the plane of the outlet opening 52 or the surface 56' (against which the pipeline is attached) of the outlet collar 56 the position of a centreline of the outlet duct if the outlet were a tangential one in accordance with prior art (like shown in Fig. 2). The centreline C_{LO} of the outlet opening 52 of the volute casing of the present invention is within a distance D of between 0,25 * C and 0,8 * C, preferably between 0,4 * C and 0,75 * C from the centreline C_L of the volute casing 44, where C is the distance from the axis of the volute casing 44 to the tip of the cutwater tongue 54 of the volute casing.

[0020] With the above described construction it has been possible to shorten the outlet duct 50 significantly without a need to arrange a sharp bend in the outlet duct. In fact, it may be shortened such that the collar 56 at the end of the outlet duct 50 becomes a part integrated into the volute casing wall 42 as shown in Fig. 3. The length L of the outlet duct 50 measured along the centreline C_{LOD} (see Figure 5) of the outlet duct 50 is between 0,1 - 0,6 * C, preferably between 0,2 - 0,4 * C, where C is the distance from the axis A of the volute casing 44 to the tip of the cutwater tongue 54 of the volute casing 44. Another way of defining the length L of the outlet duct is to compare it with the wall thickness of the volute, whereby the length L equals to 1 to 5 times the wall thickness T of the volute casing. The cutwater tongue 54 may be very short in this construction, whereby there is no air pocket at the top part of the volute casing 44. The outlet duct 50 has, preferably, a substantially constant cross section for all of its length, i.e. from the level of the cutwater tongue 54 to the outlet opening 52, i.e. to the level of the collar surface 56'. The word 'substantially' is used here to take into account minor changes in the cross section due to constructional or manufacture-related issues.

[0021] However, it should be understood that, for keeping the flow resistance in the pump, and especially in the outlet duct, as small as possible, the cross sectional area of the outlet duct or pressure conduit should be substantially constant and have a cross sectional form of a circle, whereas the cross sectional shape of the volute casing in prior art pumps has usually an oval or, in most cases, a rectangular shape at the cutwater tongue area. Thus, in prior art pumps, the lengthy outlet duct is needed for converting the oval or rectangular cross sectional shape of the volute casing to a substantially round shape at the outlet opening.

[0022] Now, the present invention represents new thinking by introducing a volute casing whose cross section is formed such that the cross section of the inner wall of the volute casing is substantially circular at the area of the cutwater tongue.

[0023] Figure 4 shows, just for clarification, how the radial centreline plane of the volute casing 44 used in Figures 3 and 5 is defined. Thus, Figure 4 illustrates a cross section B - B of the volute casing of Figure 3. The radial centreline plane C_{LV} is running in a radial direction at right angles to the axis A (see Fig. 3) half-way between the axially outer extremities of the impeller 60 at the radially outer circumference C_{OI} of the impeller 60. In other words, if the impeller is provided with both working vanes 62 and rear vanes 64, the above mentioned outer extremities of the impeller 60 are the free tips 62' of the working vanes 62 and those 64' of the rear vanes 64 at the radially outer circumference C_{OI} of the vanes 62 and 64. If the impeller has only the working vanes and a shroud 66, the extremities are the free tips 62' of the working vanes 62 and the edge 66' of the shroud 66 facing away from the working vanes 62 at the radially outer circumference of the impeller 60. If it is a question of a closed impeller the extremities are the free tips of the front and rear pump out vanes at the radially outer circumference of the impeller. Etc.

[0024] Figure 5 illustrates schematically the design of the volute casing 44 of the present invention, i.e. especially the configuration of the pressure conduit or the outlet duct 50. Figure 5 illustrates a radial cross section of the volute casing 44, i.e. a cross section running along a radial centreline plane C_{LV} (see Fig. 4) of the volute casing 44. Since a goal of the present invention is to minimize flow losses of a centrifugal pump, a way to improve the pump performance is to provide the outlet duct 50 with a constant circular cross section from the level L_{CT} (at right angles to the centreline C_{LOD} of the outlet duct) of the cutwater tongue 54 to the plane L_{OO} of the outlet opening 52. One way to accomplish such is to arrange the centreline C_{LOD} of the outlet duct 50 to follow a circular curve whose centre C_P is on the plane L_{OO} of the outlet opening 52. The centre C_P is also located in the centreline plane C_{LV} of the volute casing 44.

[0025] As shown in Figure 5 the general longitudinal direction of the outlet duct 50 is at the plane L_{OO} of the outlet opening 52 at right angles to the plane L_{OO} of the outlet opening 52. For keeping the length (L in Figure 3) of the outlet duct 50 minimal, the outlet duct 50, when moving against the direction of the fluid flow towards the interior of the pump, starts turning to a side of the impeller 60 immediately below the plane L_{OO} of the outlet opening 52, yet maintaining its cross sectional shape and area up to the level L_{CT} defined by a line running from the tip of the cutwater tongue 54 to the centre C_P (of curvature of the centreline C_{LOD} of the outlet duct 50). The centreline C_{LOD} of the outlet duct 50 may be bent along any such curve that keeps the flow losses minimal. For instance, the curved centreline C_{LOD} may follow a circle, whereby the opposite surfaces 50_{SI} and 50_{SO} of the outlet duct 50 in the centreline plane C_{LV} (see Figure 3) are parts of a circle having a centre at C_P, too. Naturally, in view of minimizing the flow losses, the inner surface 70 of the wall 42 of the volute casing 44 joins tangentially in point S to the surface 50_{SO}. The radius R of the centreline C_{LOD} of the outlet duct (between the plane L_{OO} and the level L_{CT}) is preferably longer than the radius R_O of the outlet opening. In practice, R is from 1.2 to 3 times R_O, more preferably R is from 1.2 to 2.5 times R_O, most preferably R is from 1.25 to 2.0 times R_O.

[0026] The ellipses sketched in the outlet duct/volute casing represent the round or circular cross sectional area of the volute casing in different positions of the cross section. In other words, the two uppermost ellipses have the same cross sectional area, and the third one already somewhat smaller area due to the continuous convergence of the cross sectional area of the volute casing in the direction opposite to the flow direction in the volute casing 44 from the level L_{CT} of the cutwater tongue 54 up to below the cutwater tongue 54 where the cross sectional area it at its smallest. One option, while keeping in mind the desire of the present invention to have the cross section of the outlet duct circular at the level L_{CT}, to reduce the cross sectional area is to maintain the circular shape of the volute casing as far as possible keeping in mind, however, that the opening from the impeller cavity to the volute casing is an annular slot having a constant width W (see Figure 4), which is of the order of 1.05 - 1.1 * the axial dimension of the impeller at its radially outer circumference. Another option is to maintain the radius R_O (see Figure 4) of the outlet opening 52 as the radius of the inner surface 62 of the wall 42 of the volute casing 44 in a radial plane running along the axis of the volute casing for as wide sector of the inner surface as possible, keeping thus in mind, that the opening from the impeller cavity to the volute casing is an annular slot having a constant width W (see Figure 4), which is of the order of 1.05 - 1.1 * the axial dimension of the impeller at its radially outer circumference.

[0027] At this stage it is worthwhile understanding that the volute casing is preferably positioned such that the centreline of the outlet opening is opposite to the legs of the volute casing, whereby a natural way to install the volute casing, and the pump, is such that the centreline of the outlet opening is in vertical direction, the legs pointing down. However, it is also possible to manufacture the volute casing so that the outlet opening is arranged in any desired direction in relation to the legs of the volute casing, whereby in an installed pump the legs may be pointing down, and the outlet opening to the desired direction.

[0028] As may be seen from the above description it has been possible to develop a novel volute casing for a centrifugal pump the volute casing being very simple of its construction yet capable of performing its task as well as any other much more complicated volute casing. The volute casing of the present invention is less expensive and requires less space than the prior art volute casings, and the vertical forces acting on the volute casing may be taken care of by ordinary legs of the centrifugal pump. For the above reasons it is possible to use the same installation base plate and foundation for different centrifugal pumps. Additionally the efficiency ratio of the centrifugal pump is optimized with the design of the present invention.

[0029] While the present invention has been herein described by way of examples in connection with what are at present considered to be the most preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiment, but is intended to cover various combinations and/or modifications of its features and other applications within the scope of the invention as defined in the appended claims.

Claims

1. A volute casing for a centrifugal pump, the volute casing (44) having an axis A and a centreline C_L; a cutwater tongue (54); an outlet duct (50) with an outlet opening (52) having a centre, the outlet opening (52) being surrounded by a collar (56) with a collar surface (56'); and the centreline C_L of the volute casing (44) running via the axis of the volute casing (44) in a direction perpendicular to the collar surface (56'), **characterized in that** the outlet duct (50) has a curved centreline C_{LOD}, a constant circular cross section and a constant cross sectional area for the entire length of the curved centreline C_{LOD}, and that the outlet opening (52) has a centreline C_{LO} running via the centre of the outlet opening (52) in a direction perpendicular to the collar surface (56'), the centreline C_{LO} of the outlet opening (52) being positioned at a distance D of from 0.25 to 0.8 times C from the centreline C_L of the volute casing (44) where C is the distance of the cutwater tongue from the axis of the volute casing (44).

2. The volute casing as recited in claim 1, **characterized in that** the outlet duct (50) has a longitudinal direction at the plane L_{OO} of the outlet opening (52), the direction being at right angles to the plane L_{OO} of the outlet opening (52).

3. The volute casing as recited in claim 1, **characterized in that** the outlet duct (50) has a length L from a level L_{CT} of the cutwater tongue (54) to a plane L_{OO} of the outlet opening (52), the length L being from 0.1 to 0.6 times C.

4. The volute casing as recited in claim 1, **characterized in that** the outlet duct (50) has a length L from a level L_{CT} of the cutwater tongue (54) to a plane L_{OO} of the outlet opening (52), the length L being from 1 to 5 times the wall thickness T.

5. The volute casing as recited in any one of the preceding claims, **characterized in that** the centreline C_{LO} of the outlet opening (52) is positioned at a distance D of from 0.4 to 0.75 times C from the centreline C_L of the volute casing (44).

6. The volute casing as recited in claim 3, **characterized in that** the outlet duct (50) has a length L from the level L_{CT} of the cutwater tongue (54) to the plane L_{OO} of the outlet opening (52), the length L being from 0.2 to 0.4 times C.

7. The volute casing as recited in any one of the preceding claims, **characterized in that** the centreline C_{LOD} of the outlet duct (50) has a radius R and the outlet opening has a radius R_O, the radius R being from 1.2 to 3 times R_O.

8. The volute casing as recited in any one of the preceding claims, **characterized in that** the centreline C_{LOD} of the outlet duct (50) has a radius R and the outlet opening has a radius R_O, the radius R being from 1.2 to 2.5 times R_O.

9. The volute casing as recited in any one of the preceding claims, **characterized in that** the centreline C_{LOD} of the outlet duct (50) has a radius R and the outlet opening has a radius R_O, the radius R being from 1.25 to 2.0 times R_O.

10. The volute casing as recited in any one of the preceding claims, **characterized in that** the collar (56) at the end of the outlet duct (50) is integrated into the volute casing (44).

11. The volute casing as recited in any one of the preceding claims, **characterized in that** the volute casing (44) has a pair of legs (46), which extend farther from the centreline C_L of the volute casing (44) than the centreline C_{LO} of the outlet opening (52).

12. The volute casing as recited in any one of claims 11, **characterized in that** the pair of legs (46) is positioned opposite to the outlet opening (52) in relation to the axis A of the volute casing (44).

13. A centrifugal pump having the volute casing of any one of the preceding claims.

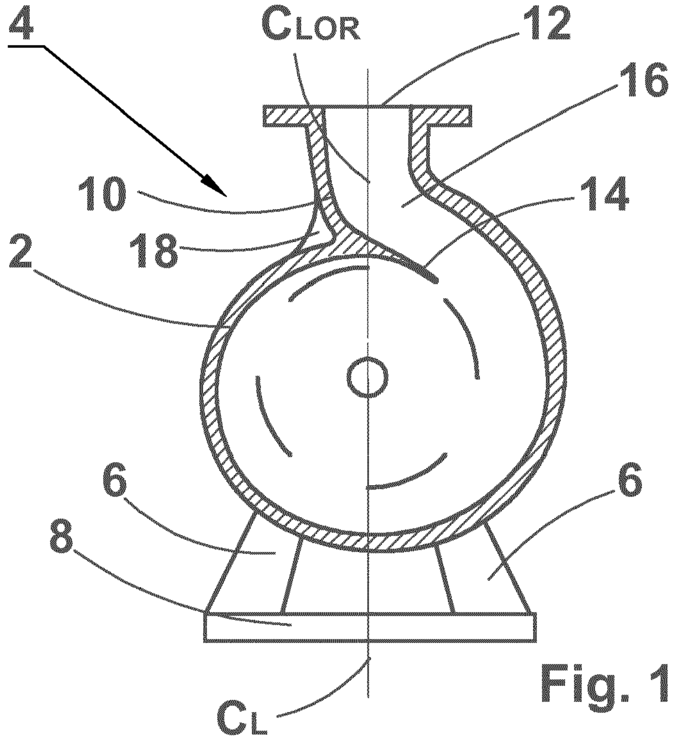

Fig. 1 (Prior art)

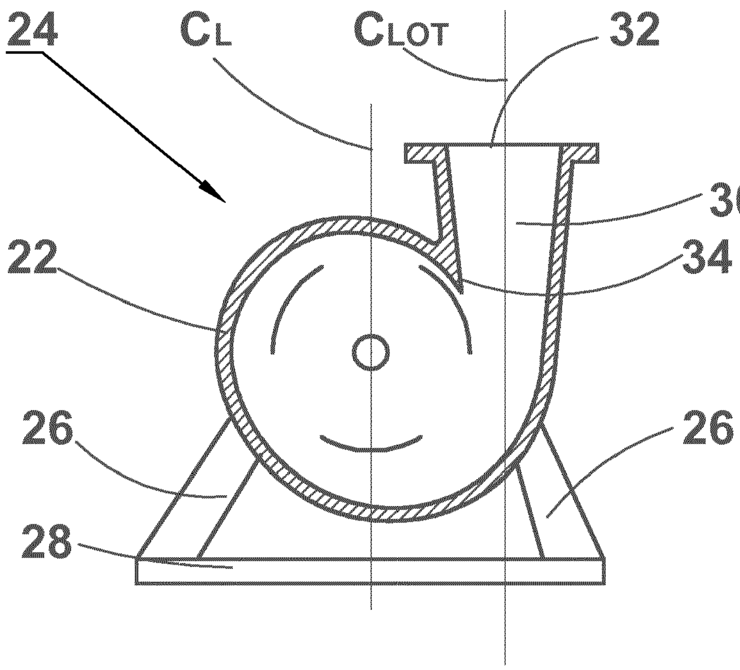

Fig. 2 (Prior art)

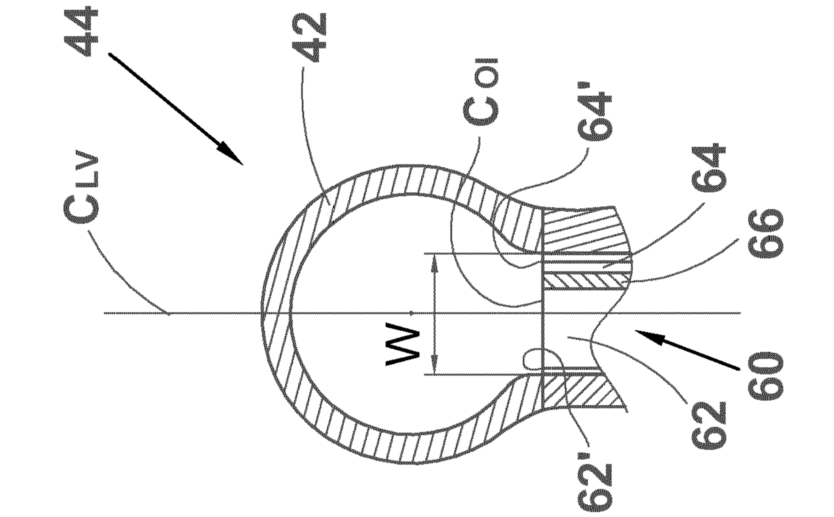
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Fig. 4 (B - B)

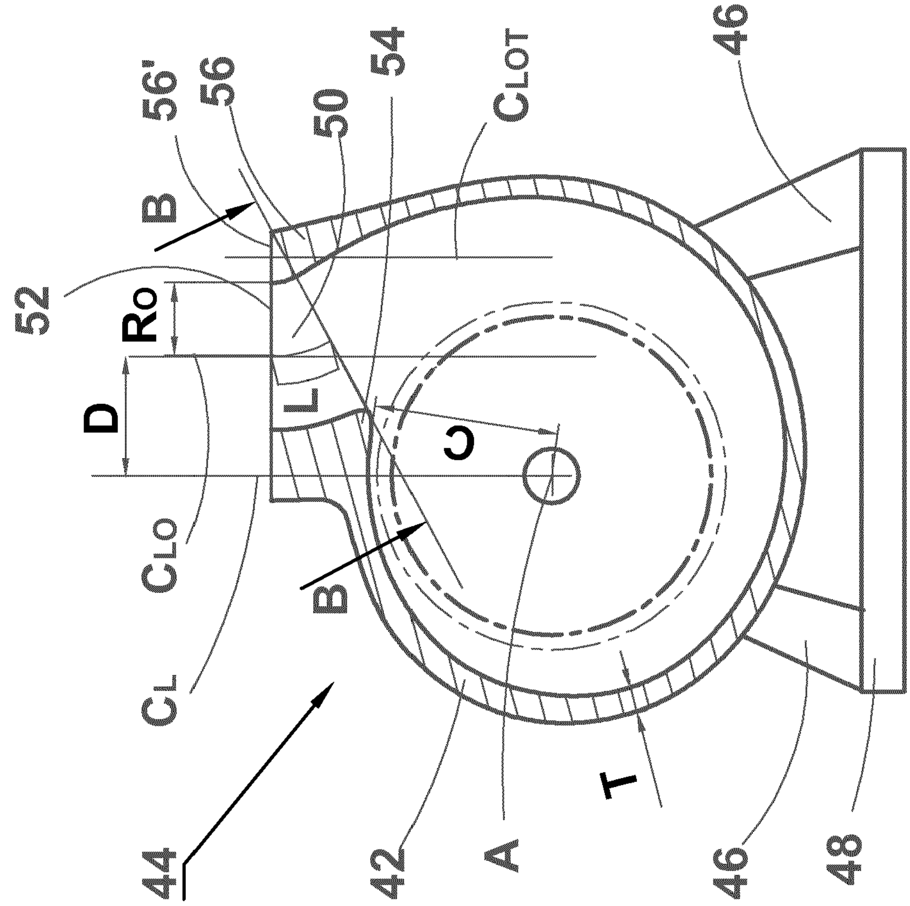
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Fig. 3

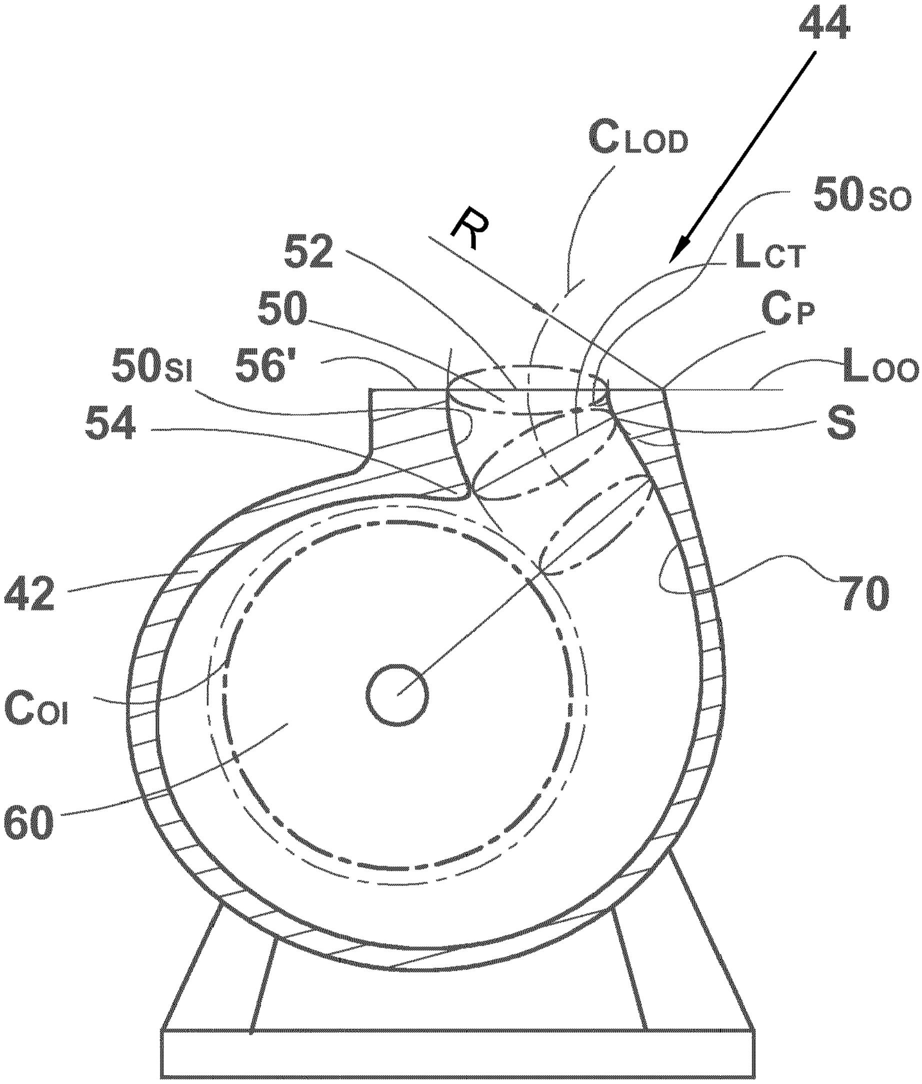

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 6930

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	US 5 084 236 A (MORRIS ALLEN L [US]) 28 January 1992 (1992-01-28) * column 4, lines 2-13 * * figures 3,4 *	1-6,10, 13	
A	EP 0 466 167 A2 (AHLSTROEM OY [FI]) 15 January 1992 (1992-01-15) * column 5, lines 22-41 * * figure 3 *	1,11,12	
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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	2 August 2016	Gombert, Ralf

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

& : member of the same patent family, corresponding document

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

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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