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Strscheletzky

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[54] **SUCTION BEND FOR CENTRIFUGAL PUMPS**

[75] Inventor: **Michael Strscheletzky,** 799 Friedrichshafen, Germany

[73] Assignee: **J. M. Voith GmbH,** Heidenheim, Germany

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.**.....**138/39,** 415/183

[51] **Int. Cl.**.....**F15d 1/06**

[58] **Field of Search** 138/39; 137/1; 415/183, 186, 188

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Attorney—Walter Becker

[57] **ABSTRACT**

A suction bend, especially for centrifugal pumps, in which within the range or area where the substantially oppositely directed secondary flows impact upon each other, there is provided at least one rib which forms a boundary layer fence and extends primarily transverse to the flow lines of said flows.

16 Claims, 4 Drawing Figures

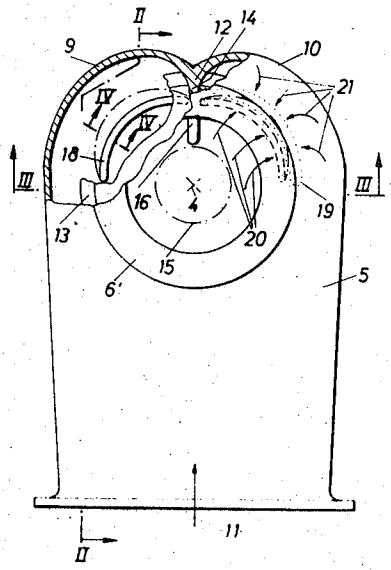


Fig. 1

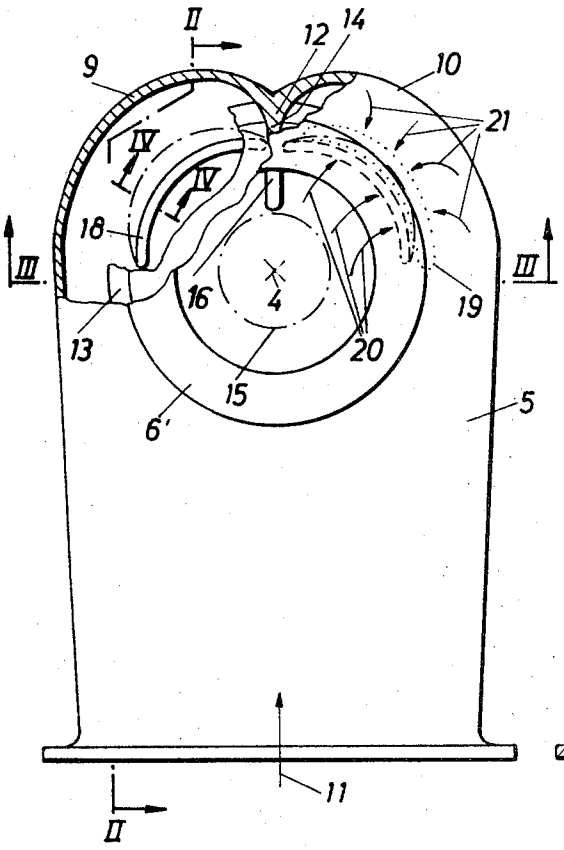


Fig. 2

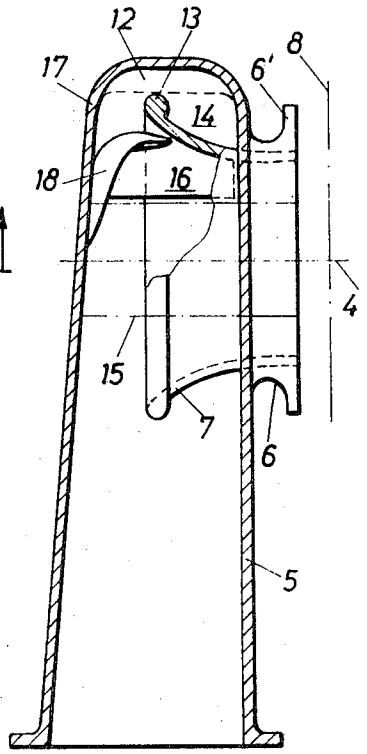


Fig. 3

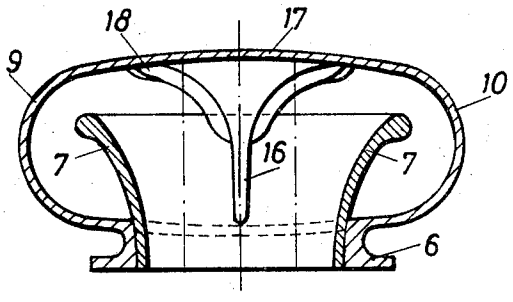
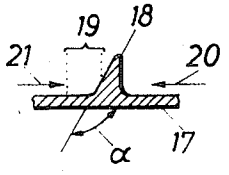


Fig. 4



SUCTION BEND FOR CENTRIFUGAL PUMPS

This application is a continuation of Ser. No. 797,491, filed Feb. 7, 1969.

The present invention relates to a suction bend for centrifugal pumps. By means of such a bend, the suction conduit which leads at an angle, generally of 90°, to the axis of the rotor is deviated so as to be concentric to the rotor. In addition to the requirement that the field of velocity of the current should be as uniform as possible at the entry to the rotor, which is generally realized by a special shape of the walls of the bend and if necessary by profiling in a flow favorable manner the ribs dividing the flow in the suction bend into two or more partial flows, it is required that the flow prior to its entry into the rotor is free from concentrated turbulence because the bursting of such free vortices or vortices whirls onto the rotor blades interferes with the running quietness of the pump and also brings about more or less cavitation erosion of the blade surfaces.

It is known to reduce the formation of such whirls by axially extending the bend toward the rotor as far as possible and by selecting as large a bend radius as possible. With suction bends having a continuous or through shaft, and especially with large installations in which the axial extension of the bend is rather limited, these steps cannot be employed. In these conditions, the situation may become so critical that with large pump installations in which the bend has a rather limited axial extension, there is no and no guaranty can be assumed that cavitation erosion caused by such whirls or free vortices will be prevented and consequently there is no guaranty that the rotor will not be permanently destroyed.

It is, therefore, an object of the present invention to provide means by which even with large installations having a rather limited extension of the bend, a flow toward the rotor will be obtained which flow will be substantially free from such whirls or free vortices.

This object and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing, in which:

FIG. 1 diagrammatically illustrates partially in view and partially in section a bend as seen counter to the oncoming flow into the rotor.

FIG. 2 is a section partially broken open as taken along the line II—II of FIG. 1.

FIG. 3 is a section taken along the line III—III of FIG. 1.

FIG. 4 represents a section through a boundary layer fence, said section being taken along the line IV—IV of FIG. 1.

When solving the problem underlying the present invention, the inventor started with the finding that in the wall boundary layers of the suction bend, in a direction transverse to the main flow, there formed secondary flows which are caused by the fact that while in view of the strong curvature of the flow lines centrifugal forces occur in the main flow and bring about the pressure field thereof, such centrifugal forces hardly occur in the boundary layers decelerated by friction. The secondary flows in the boundary layers are, in the respective meridian section of the bend, directed from the outside to the inside. This means that the secondary flows primarily flow from that wall portion located at the outside arc to the wall portion on the inside arc where, while coming from opposite directions, they impact upon each other in an area the location and magnitude of which depend on the respective shape of the bend. Generally, the local velocities of these secondary flows differ as to magnitude and direction. In view of the said impact, free vortices or whirls form which then follow the flow lines of the main flow and by the same are conveyed to the rotor where they may cause the above mentioned disadvantageous cavitation.

Based on this finding, the present invention is characterized primarily in that in the range or impact of oppositely directed secondary flows ascertained by tests or calculation, and concerning the said impact of secondary flows which are directed substantially opposite to each other and which form in the boundary layers on the walls of the bend, there is arranged at least one rib which extends primarily transverse to the flow lines of one of said secondary flows, said rib being arranged in such a way as to form a so-called boundary layer fence. The range within which the secondary flows impact upon each other may in a simple manner be ascertained, for instance, in a model bend by measurements and observations by means of a thread held on a rod into the flow. When, as is mostly the case, secondary flows of different magnitude impact upon each other, preferably the boundary layer fence is arranged transverse to the stronger flow and within the latter shortly ahead of the range of impact. By means of said boundary layer fence, the secondary flows are cushioned to such an extent and deviated into the main flow that the formation of free whirls or vortices is greatly impeded or even prevented. Tests in which the flow behavior of suction bends provided with boundary layer fences according to the present invention were compared with the flow behavior of suction bends lacking such boundary layer fences but otherwise having the same shape, have shown surprising results. The threads arranged at the walls of the bend and by means of a rod held into the air flow created for test purposes have with the bends equipped with boundary layer fence shown a completely stable flow which had only a few or no whirls or vortices at all, whereas with bends lacking such boundary layer fences, clearly and unequivocally a strong formation of free vortices was encountered.

Such boundary layer fences are known in connection with the design of airplanes where this term relates to sheet metal walls arranged on the top side of the wings transverse to the axis of the wings and on both sides approximately at the central area of a wing half. The said sheet metal walls serve for preventing the lateral moving-off and thereby premature separation of the boundary layer with back-swept wings of such airplanes which fly at speeds slightly less than sound velocity (Technische Hydro- and Aeromechanik, by W. Kaufmann, 2nd edition, 1958, page 271, 3rd paragraph).

With the present invention, however, the boundary layer fence does not serve for preventing the moving-off or separation of the boundary layer but is rather intended to cushion secondary flows within the boundary layer and to deviate said flows into the main flow. The location and shape of such a boundary layer fence depends to a major extent on the design of the suction bend which means on the curvature of its walls, the surface contour of its meridian sections, the shape of possible ribs which divide the flow in the suction bend, or on whether or not a shaft extends all the way through.

A highly advantageous cross-sectional shape of the rib serving as boundary layer fence is obtained when,

in conformity with a further development of the invention, that wall of the rib which faces the stronger secondary flow is substantially perpendicular to the wall of the bend and when that wall of the rib which faces the weaker flow will at that side against which the flow takes place form together with the wall of the bend an angle of from 120° to 150°. In this way, the stronger flow will be braked by the vertically arranged rib wall to a greater extent. The maximum height of the rib should preferably equal the ascertained local boundary layer thickness, but should not amount to more than from 5 to 10 percent of the local free distance from the oppositely located wall of the bend. The ribs which extend substantially over the entire range of the area where the two flows impact upon each other may be straight or may be curved in conformity with the differential direction of the flow lines. According to a preferred design, the ribs while becoming flatter on both ends gradually merge with the wall of the bend.

Referring now to the drawing in detail, the bend shown therein comprises a bend section **5** which is inclined by approximately 90° to the axis **4** of the rotor. The bend furthermore comprises a section **6** which is coaxial with the axis **4** of the rotor and merges with said section **5**. As will be seen from the drawing, the bend section **6** has a flange connection **6'** and includes a funnel **7** extending into the inclined bend section **5**, the funnel **7** providing an outlet opening or passage. The central plane of the rotor is indicated by the dot-dash line **8**. Those lateral walls **9** and **10** of the bend section **5** which are located within the area of the funnel **7** meet each other on that side of the funnel **7** which faces away from the inlet opening or passage, the axis of which is at 90° to the axis of the outlet opening in funnel **7**. The walls **9** and **10** at their junction form a spur **12** which extends to the bead-shaped reinforced marginal area **13** of the funnel **7** while extending in the form of a rib-shaped extension **14** to the outer funnel wall. Within the funnel **7**, a rib **16** extending into the vicinity of a longitudinal body such as a shaft protecting sleeve **15** (indicated only by a dot-dash line) and outside the funnel to the rear wall **17** of the bend forms an extension of the spur **12** or rib **14**. The longitudinal body **15**, such as the shaft body, with the outlet passage through funnel **7** forms an annular passage for flow of fluid to the rotor.

As will be seen from FIG. **3**, the rib **16** increases in thickness toward the rear wall **17** of the funnel to such an extent that the rib will have a substantially triangular cross-section. At each side of the rib **16** there is provided a curved rib-shaped boundary layer fence **18** which extends from the rear wall **17** of the bend to the rib **16**. The boundary layer fences **18** are respectively shortly ahead of the range **19** (indicated only by a dotted line on the right-hand side of FIG. **1**) in which when said boundary layer fence is lacking, two substantially oppositely directed secondary flows **20** and **21** would hit each other and, more specifically, within the stronger flow **20** of the said two flows.

As will be evident from the section shown in FIG. **4** through the boundary layer fence **18**, that wall of the boundary layer fence **18** which faces the stronger secondary flow **20** forms a right angle with the rear wall **17** of the bend, whereas that wall of the boundary layer fence which faces the weaker flow **21** forms with the bend wall an angle of approximately 150°.

It will be obvious that the boundary layer fences according to the invention may also be employed with bends of pumps which have no inlet funnel. In such an instance, however, due to the changed flow conditions, the boundary layer fences will have a location which is somewhat different from that of the embodiment illustrated in the drawing.

It is, of course, to be understood that the present invention is, by no means, limited to the particular showing in the drawing but also comprises modifications within the scope of the appended claims.

I claim:

1. A suction bend for a centrifugal pump, comprising: wall means forming a conduit having an inlet opening and an outlet opening, said openings being spaced from each other and inclined to each other at an angle of substantially 90°, said conduit being adapted to receive a shaft on the axis of said outlet opening for supporting an impeller adjacent said outlet opening, a central guide fin in said conduit extending in the longitudinal central plane of said conduit from the portion of said wall means which is opposite the outlet opening and within that part of the bend between said wall means confining the space occupied by said shaft, said guide fin being concave on the opposite sides and merging with said wall means on opposite sides, at least one pair or rib means in said conduit serving as boundary layer fences and being arranged symmetrically to each other with respect to said longitudinal central plane of the suction bend and opposite said outlet opening, the contour of each of said rib means being arranged substantially parallel to adjacent lateral parts of said wall means spaced radially to said impeller shaft, the leading edge of each of said rib means being interposed between the lateral part of said wall means and said shaft, said wall means including guide surfaces deflecting the main flow toward said outlet opening so that secondary flows directed substantially oppositely to each other are formed in the boundary layer stream transversely to said main flow approaching said outlet opening, said rib means lying between said oppositely directed secondary flows and deflecting said secondary flows into said main flow to inhibit the formation of vortices in the flow through said outlet opening due to the oppositely flowing secondary flows.

2. A suction bend according to claim **1**, in which said oppositely directed boundary layer streams are of different strength, said rib means being transverse to the stronger one of said streams and being displaced from the plane where the said impact would occur upstream of the said stronger of said streams.

3. A suction bend according to claim **2**, in which said rib means on the side facing the said stronger of said streams is substantially perpendicular to the stream and on the opposite side makes an angle of from about 120° to 150° with the weaker stream, the sides of said rib means converging toward said outlet.

4. A suction bend according to claim **2**, in which said rib means in height is on the order of from about 5 percent to about 10 percent of the distance between the side of the conduit from which the rib means extends and the oppositely disposed side of the conduit, said rib means in height being approximately equal to the localized boundary stream thickness.

5. A suction bend according to claim **1**, in which said rib means is higher in about the middle of the length

thereof and decreases in height toward the opposite ends.

6. A suction bend according to claim 1, in which said conduit is substantially flat on the side having said outlet therein and on the other side which is opposed thereto, a funnel having a smaller end in said outlet and a large end in the conduit in spaced opposed relation to the said other side of the conduit and radially spaced from the closed end of said conduit and the laterally adjacent walls thereof, said guiding fin extending from the adjacent end of said conduit between the said sides thereof downwardly to said larger end of said funnel and into the upper portion of said funnel, said rib means comprising arcuate rib elements upstanding from said other side of the conduit and projecting toward the larger end of said funnel, each rib element extending from said wall member a circumferential distance of about 90° of said funnel.

7. A suction bend according to claim 6, in which each rib element has the greatest height at the end adjacent said wall member and diminishes in height in a direction away from said wall member.

8. A suction bend according to claim 6, in which said rib elements at the point of greatest height thereof are disposed radially inside the larger end of said funnel.

9. A suction bend comprising a conduit having an inlet passage leading from one end to a lateral discharge passage adjacent the other end having its axis at an angle to the axis of said inlet passage, the wall of said conduit adjacent the other end being curved to direct the main flow of fluid in said inlet passage laterally through said outlet passage, the flow of fluid in the boundary layers along the wall of said conduit forming secondary flows directed in opposite directions transverse to the main flow through said discharge passage, said secondary flows including a secondary flow from said curved wall directed inwardly toward said main flow through said discharge passage, and means in said conduit cooperating with the walls of said conduit to direct flow of fluid in said secondary flows through said discharge passage with the elimination of free vortices in the main flow through said discharge passage, comprising deflecting wall structure on the wall of said conduit between said curved wall and the axis of said discharge passage and extending outwardly from said wall in the direction of the axis of said discharge passage to form boundary layer fence means, said wall structure having two oppositely facing surfaces, one surface facing said curved wall and deflecting the secondary flow from said curved wall into said main flow, and the opposite surface facing the axis of said discharge passage and the main flow through said passage, and deflecting the oppositely directed secondary flow into said main flow, each of said surfaces being at an angle to the wall of said conduit on which said wall structure is fixed to deflect said secondary flows along said main flow.

10. A suction bend as claimed in claim 9, in which said curved wall on opposite sides of the axis of the discharge passage forms secondary streams directed from the sides of said conduit toward the axis of the main flow through said discharge passage, and said wall structure includes two walls fixed to the wall of said conduit on opposite sides of said axis of said main flow, each wall having one surface facing the curved wall on its side with the other surface facing said axis of said main flow.

11. A suction bend as claimed in claim 17, in which said surface facing the curved wall forms a greater angle with said wall than the surface facing said axis of said main flow.

12. A suction bend comprising a conduit having an inlet passage leading from one end to a lateral discharge passage adjacent the other end having its axis at an angle to the axis of said inlet passage, the wall of said conduit adjacent the other end being curved to direct the main flow of fluid from said inlet passage through said discharge passage, a longitudinal body extending from adjacent said curved wall of said conduit axially through said discharge passage with its peripheral surface coaxial with said discharge passage to form an annular discharge passage, the flow of fluid in the boundary layers along the wall of said conduit forming oppositely directed secondary flows transverse to said main flow through said discharge passage, said secondary flows including a secondary flow deflected inwardly by said curved wall toward said main flow in said discharge passage, and means in said conduit cooperating with the walls of said conduit to direct flow of fluid in said secondary flows through said discharge passage with the elimination of free vortices in the main flow through said discharge passage, comprising deflecting wall structure on the wall of said conduit upstream of said curved wall between said curved wall and said longitudinal body, and extending outwardly from said wall in the direction of the axis of said discharge passage, to form boundary layer fence means, said wall structure having two oppositely facing surfaces, one surface facing said curved wall and deflecting the secondary flow from said curved wall into said main flow, and the opposite surface facing the said longitudinal body and the main flow through said discharge passage, and deflecting the oppositely directed secondary flow into said main flow, each of said surfaces being at an angle to the wall of said conduit or which said wall structure is fixed to deflect said secondary flows along said main flow.

13. A suction bend as claimed in claim 12, in which the wall structure constituting boundary layer fence means is formed by curved ribs fixed on the wall of said conduit spaced from the curved wall of said conduit and with a curvature corresponding to the curvature of said curved wall, said ribs lying transversely between the oppositely directed secondary flows.

14. A suction bend as claimed in claim 12, in which the axis of said discharge passage is substantially at 90° to the axis of said inlet passage, and in which said longitudinal body extends axially through said discharge passage to the wall of said inlet passage upstream from said curved wall of said conduit, said curved wall directing the secondary flow in the boundary layer stream toward said longitudinal body, and said wall structure constituting a boundary layer fence means is formed by curved ribs transverse to secondary flow on the wall of said conduit going between said longitudinal body and the curved wall of said conduit.

15. A suction bend for a centrifugal pump, comprising: wall means forming a conduit having an inlet opening and an outlet opening, said openings being spaced from each other and with their axes inclined to each other at an angle of substantially 90°, a shaft body on the axis of said outlet opening thus forming a substantially annular outlet opening, a central guide fin in said conduit extending in the longitudinal central plane of said conduit from the portion of said wall means which

is opposite the outlet opening and within that part of the bend within said wall means confining the space occupied by said shaft body, said guide fin being concave on the opposite sides and merging with said wall means on opposite sides, at least one pair of rib means in said conduit serving as boundary layer fences and arranged symmetrically to each other with respect to said longitudinal central plane of the suction bend and opposite said outlet opening, the contour of each of said rib means being arranged substantially parallel to adjacent lateral parts of said wall means spaced radially of said shaft body, said wall means including guide surfaces deflecting the main flow toward said outlet opening so that secondary flows directed substantially oppositely to each other are formed in the boundary layer stream transversely to said main flow approaching said outlet opening, said rib means lying between said oppositely directed secondary flows and deflecting said secondary flows into said main flow to inhibit the formation of vortices in the flow through said outlet opening due to the oppositely flowing secondary flows.

16. The method of delivering fluid to the rotor of a centrifugal pump through a suction bend comprising a conduit having an inlet opening and an outlet opening spaced from said inlet opening and with its axis on the same axis as said rotor and at an angle to the axis of said inlet opening, said method comprising deflecting the main flow of fluid from said inlet opening by surfaces on said conduit to direct the main flow of fluid through said outlet opening, thereby forming unfavorable oppositely approaching secondary fluid flows within the boundary layer stream transversely of and toward the axis of said main flow, and deflecting said secondary flows into the main flow directed through said outlet opening by oppositely facing surfaces on a deflecting wall structure forming boundary layer fence means arranged on the wall of said conduit transversely to said secondary flows and extending toward said outlet opening and positioned substantially within the region of collision of said oppositely approaching secondary fluid flows.

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