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(54) **Self-priming jet pump with flow control device**

Selbstansaugende Strahlpumpe mit Durchflusskontrollvorrichtung

Pompe à jet autoamorçante avec dispositif de contrôle de l'écoulement

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Description

[0001] The present invention concerns a self-priming single-impeller centrifugal pump with a built-in ejector, commonly called shallow-well jet pump, of the type including a diffuser with a return channel downstream the impeller, provided with a device for improving the working efficiency.

[0002] The development of shallow-well jet pumps tends to improve the self-priming capability and the operating performance, as well as reducing the pump dimensions and the working noise.

[0003] A solution increasingly used by now for obtaining simultaneously said features, otherwise hardly compatible, is that of eliminating the peripheral tangential component of the flow (or fluid flow) going out from the common diffuser around the impeller periphery, through a diffuser provided with a return channel. Said return channel conveys through guide vanes the fluid from the periphery on a central opening in the pressure chamber (in steady condition) or chamber of calm for the separation of the air from the water (during the self-priming phase). Consequently, said return channel reduces the rotation and the turbulence of the flow and the centrifugal effect which prevents the separation of the air from the liquid by holding it in the core of the rotating liquid.

[0004] Said diffuser with a return channel in a single-impeller shallow-well jet pump, which is a combination known from the patent EP 0361328 of the same inventor, presents some limits.

[0005] The outlet of the return channel, included in a circular crown around the final part of the ejector or suction duct of the impeller, limits the radial space usable to guide the flow from the peripheral tangential direction toward the axis. A part of the streamlines in the conveying channels come to the outlet through angles which are different from the radial direction, with a consequent residual rotatory component and a residual centrifugal effect in the pressure chamber slowing down the air separation from the liquid during the self-priming phase.

[0006] Sudden deviations of the flow direction in order to eliminate the residual rotation before the return channel outlet cause friction losses and worse operating performance, without improving the self-priming capability.

[0007] It has been observed that the reduction of the rotation is useful only if and even more if the flow velocity is decreased as well. If the residual rotation is reduced by increasing the flow velocity the air separation from the liquid is further slowed down.

[0008] The concentrated flow does not use all the surrounding liquid to decrease its own velocity and turbulence and causes the air entrainment together with the liquid. This slows down the air dispersion in the delivery and make its recirculation in the pump easier through the nozzle, the more said outlet of the return channel extends in the axial direction, parallel to the axis, by directing the flow adjacent to the ejector.

[0009] The device, known through the above-mentioned patent, of extending axially the guide vanes beyond said outlet of the return channel, or the more usual device of placing longitudinal baffle walls in the pressure chamber to decrease the fluid residual rotation, are not useful to reduce the flow velocity which causes the air entrainment together with the liquid.

[0010] The known devices used to make easier the inflow of the driving liquid in the ejector, as placing near the nozzle an anti-vortex device or deviating walls to reduce the air recirculation, or placing a duct drawing from below the most deaerated part of the liquid, are not useful to make the air dispersion in the delivery easier, because they do not reduce the fluid turbulence in the separation chamber placed upstream said devices near the nozzle.

[0011] Because of the above-mentioned limits the return channel can reduce just partially the rotation, the velocity and the turbulence of the flow and does not allow, by itself or coupled to other known elements, the elimination of the residual negative effects for the air separation from the liquid and for a fast pump self-priming with the highest suction lifts. Therefore it is necessary to have a pressure chamber with a liquid reserve suitable for restraining the air entrainment, slowing down the velocity and weaking the flow residual turbulence.

[0012] Said known embodiment has also the drawback of needing diffuser inlets with a configuration suitable for collecting, at the impeller outlet, as much air as it is separable from the liquid in the pressure chamber. In fact the possibility of a fast air separation from the liquid in the pressure chamber depends, as it will better explained later on, also on the way the air is collected upstream, at the impeller outlet.

[0013] Some embodiments of multistage jet pumps are known, as the one shown for instance in DE 2249883, in which return channels are present with the purpose of conveying the out flowing medium from an impeller to the inlet opening of the subsequent impeller and in which the fluid flows out from the last impeller with rotational motion.

[0014] Said rotational motion of the flow, in the pressure chamber communicating with the delivery port, slows down the air separation from the liquid.

[0015] Moreover, the embodiments with said return channels without any stationary bladed part around the periphery of each impeller are not suitable for collecting and deviating quickly into the return channels the gaseous portion of the fluid coming out from the first impeller and/or from the subsequent impellers.

[0016] The possibility of collecting faster the air at the impeller outlet is made conditional on the possibility of allowing the separation from the liquid of the greatest air amount coming in the pressure chamber, when the self-priming phase is extended through the highest suction lifts.

[0017] Said return channel can be coupled to an usual radial diffuser around the impeller periphery, producing the same result of reducing the rotation and the flow turbulence in the pressure chamber. The embodiments keeping said usual radial diffuser just adding said return channel, as the ones shown in EP 0401670 and US 5100289, avoid a greater planning and experimental care to combine at their best the diffuser and conveyer functions in a continuous vanes course, but they have further drawbacks.

[0018] A drawback consists in the considerable increase of the pump working noise, due to the interruption of the continuity in the vanes succession through the combination of two separate vaned portions, with a change of direction in the deviation from the centrifugal radial direction in the diffuser at the impeller outlet to the centripetal radial direction in the return channel. The consequent interruption in the guide of the direction and of the flow velocity causes a worse operating efficiency. Said interruption of the guide of the direction and of the flow velocity increases considerably the fluidborne noise during the self-priming process, increasing progressively said noise because of the increase in the amount of the solute air and of the separated air in bubbles, entrained by the liquid in the pump. The noise becomes more considerable if the pump casing is made with a thin sheet steel.

[0019] Another drawback is that the possibility of reducing the radial dimensions of the pump casing through the diffuser configurations, possible in the combination with the return channel, in a restricted diameter with an annular or tendentially radial centripetal course instead of radial centrifugal, is not used with an usual radial diffuser. The largest diameter of the pump implies disadvantages concerning the cost and the use of the pump in narrow spaces, but also increases the specific pressure on the diffuser and on the return channel walls, thus increasing the risk of permanent deformations in the case of a temperature rising and of a pressure increase because of a temporary and casual operation with closed connections, when said walls are made with plastic material. Using said usual radial diffuser the possibility of reducing the pump casing dimensions, thanks to the possibility of obtaining the self-priming with a smaller liquid reserve, through the reduced flow turbulence obtained with the return channel, is not exploited.

[0020] A further drawback is that a common radial diffuser around the impeller periphery makes easier the expulsion of the liquid in the delivery at the impeller start, because of its inlet angle configuration.

[0021] At the start the pump delivers temporarily the greatest operating flow rate with a zero suction lift, since all the chambers and the ducts included wherein are pre-filled with liquid, even, temporarily, the ones on the suction side of the impeller. The kinetic energy and the thrust of the liquid going out from the diffuser cause the expulsion and the dissipation from the delivery port of even a part of the liquid contained in the pressure chamber, that is a part of the driving liquid that must stay in the pump for the self-priming process while the air is dispersed in the delivery.

[0022] Said liquid expulsion at the start is greater in the pumps having a greater flow rate and larger passages in the ejector and in the impeller, anyhow needing a greater driving liquid reserve.

[0023] Said liquid expulsion at the start decreases the self-priming capability of the pump.

[0024] The air pocket, present in the pressure chamber after the start because of the dispersed liquid, prevents the following self-priming process. Said self-priming process is even more prevented if a rotation is imparted to said initial air pocket, fed by the air coming from the suction pipe, with the liquid reserve remained in the pressure chamber by a flow coming in said chamber with an excessive residual rotational component and velocity, holding the air through the residual centrifugal force of the liquid and because of the effect of the flow velocity entrainment.

[0025] A common radial diffuser around the periphery of the impeller collects quickly the air coming out of the impeller and makes it come out more quickly and in a larger amount from the return channel in the pressure chamber. It has been observed that said larger amount of coming air slows down its separation from the liquid in the pressure chamber and its dispersion in the delivery with pumps having a greater flow rate, with an higher flow velocity at the outlet of the return channel or with an insufficient liquid reserve, when the self-priming phase extends with suction lifts higher than the average. The progressive increase of the air amount in the separation chamber and recirculating in the pump through the nozzle and the increase of the liquid temperature because of the friction in the recirculation cause the saturation with a "flooding" effect that does not allow to carry on the process of air separation from the liquid as far as the highest suction lifts.

[0026] Sometimes it is possible to obtain the self-priming through preliminary devices, as furnishing a high pipe on the delivery port before the outlet of the pipe itself, in order to restrain the liquid amount which otherwise would be dispersed in the delivery at the start and in order to avoid or reduce the initial air pocket in the pump. Sometimes it can be useful to close partially the gate valve in the delivery before any start. When even said devices are not sufficient to obtain the self-priming there is nothing left to do but to insert a foot valve to start the pump as a common centrifugal non-self-priming pump, with even the suction pipe pre-filled with liquid.

[0027] The present invention intends to overcome all the above-mentioned limits and the above-mentioned drawbacks of a diffuser with a return channel in a single-impeller shallow-well jet pump.

[0028] An aim of the present invention is that of improving further the pump self-priming capability with the highest suction lifts allowed by the atmospheric pressure through a further reduction of the velocity, of the residual rotation, and of the fluid turbulence in the pressure chamber.

[0029] Another aim is that of obtaining the self-priming with a pump casing of smaller dimensions containing a smaller liquid reserve and/or improving the self-priming capability without increasing the pump dimensions and the needed liquid reserve.

[0030] Another aim is that of reducing the operating noise during the self-priming phase and during the steady condition.

[0031] Another aim is that of improving the performance in steady condition with the highest suction lifts.

[0032] A further aim is that of reducing the pump cost.

[0033] The said aims and the advantages that will be clearer later on are achieved through the realization of a single-impeller centrifugal self-priming jet pump that, according to the main claim includes:

- a pump casing containing a pressure chamber communicating with a delivery port;
- a stationary suction duct connected with an impeller keyed on the driving shaft with horizontal axis of rotation;
- a diffuser provided with a return channel placed between two axially spaced walls with the interposition of at least a guide vane, one of said walls being adjacent to the suction side of said impeller with at least one inlet on the periphery and the other wall being provided with at least one outlet in the central part of said pressure chamber; characterized in that it is provided with at least a deflector, placed beyond said outlet of said return channel and around said stationary suction duct, suitable for distributing the fluid toward different directions in said pressure chamber, said at least one deflector having flow directing means.

[0034] Some embodiments of the pump of the invention are shown by way of examples but not restrictively in the enclosed drawings where:

- fig. 1 shows a partial longitudinal section of the pump of the invention;
- fig. 2 shows a front view of the pump of the invention according to the section A of fig. 1;
- figg. 3, 4, 5 and 6 show the details of different embodiments with respect to the realization of fig. 1;
- fig. 7 shows a partial longitudinal section of the pump of the invention in a different embodiment;
- fig. 8 shows a front view of the pump of the invention according to the section B of fig. 7;
- figg. 9, 10, 11, 13, 15 and 20 show partial longitudinal sections of the pump of the invention according to further different embodiments;
- fig. 12 shows a front view of the pump of the invention seen from C in fig. 11;
- fig. 14 shows a front view of the pump of the invention seen from D in fig. 13;
- figg. 16 and 17 show two different embodiments of the pump of the invention seen from F in fig. 15;
- figg. 18 and 19 show the details of front views of the pump of the invention seen from E in fig. 15, in the different embodiments shown, respectively, in figg. 16 and 17;
- figg. 21, 22 and 23 show the details of front views of the pump of the invention seen from G in fig, 20 according to three different embodiments.

[0035] The pump which is the object of the invention is shown in partial views in the drawings and is marked with 1, 100, 101, 102, 103, 104, 105, 106 as a whole. According to a preferred functional embodiment, shown in two realizations in figg. 1 and 7, said pump includes a pump casing 2, 20, in which there is the pressure chamber 3, 30 communicating with the delivery port 4, 40 placed on the upper part of said chamber; an ejector 5, 50 connected between the suction port (not visible in the drawings) of the pump and an impeller 6, 60 keyed on the driving shaft with horizontal axis of rotation 7, 70.

[0036] Said ejector 5 forms directly the stationary suction duct of the impeller 6 or it may be connected to said impeller 60 through a duct or connection 80 placed between said ejector 50 and said impeller 60, said ejector 5, 50 includes the respective feeding nozzle (not visible in the drawings) fed on its turn by the driving liquid in said pressure chamber 3, 30.

[0037] The placing of said ejector in the pump can be any: coaxial to the impeller axis of rotation, as shown in the drawings, or parallel or transversal with respect to said axis, said ejector being, with any different placing, anyhow connected, through a duct or connection, to the suction orifice of the impeller.

[0038] Downstream said impeller 6, 60 there is a diffuser with a return channel 9, 90 with at least an interposed guide vane 14, 140 conveying the fluid coming out of said impeller 6, 60 in the central part of said pressure chamber 3, 30. Said return channel 9, 90 substantially radial centripetal is placed between two walls axially spaced. One wall 10, 107 has at least one inlet on the periphery 11, 110. Said wall 10, 107 is placed adjacent to the suction side of said impeller 6, 60 and connected with said stationary suction duct 5, 50, 80 with the possible interposition of a seal means 18. 180. The other wall 12, 120, is inserted inside a peripheral cylindrical surface 200, 201 of said pump casing 2, 20, with at least an outlet 13, 130, placed 360° in a circular crown around said stationary suction duct 5, 50, 80 of said impeller 6, 60.

[0039] As it is shown in the figg. 2 and 8, when several guide vanes 14, 140 are interposed in said return channel 9, 90, they form conveying channels with outlets 13, 130, spaced by said guide vanes 14, 140.

[0040] Said diffuser with a return channel can have any combination of the two functions, diffuser and channel for the conveyance from the impeller periphery toward the axis, joined together or coupled, juxtaposed and subsequent so therefore they are distinguishable or combined so as to be not distinguishable, in a course with a continuous guide of the flow velocity and of the flow direction, also in the change of direction in the deviation from the centrifugal radial or tangential peripheral direction to the centripetal radial direction in the return channel.

[0041] Beyond said outlet 13, 130 of said return channel 9, 90, after having already obtained a first reduction of the velocity, rotation and flow turbulence, there is at least one deflector 15, 150, substantially annular so as to direct and distribute toward different directions, marked by the arrows 16-17, 160-170, diverging and converging, to the outside and the inside of said deflector 15, 150, the fluid coming from said return channel 9, 90. Said at least one deflector 15, 150 is placed in such a way as it prevents a concentrated flow and reduces further the velocity, the residual rotation and the residual turbulence of said fluid in said pressure chamber 3, 30, carrying on the guide of the flow without any additional loss, letting the air contained in the fluid follow the path of least resistance.

[0042] The invention uses in a jet pump the Principle of Least Resistance, considered in the technical literature of centrifugal pumps for the control of the fluid prerotation in the impeller approach. The present invention applies the principle of the path of least resistance downstream the impeller through a device, formed by at least one deflector, to carry on the control of the direction, of the velocity, of the residual rotation and turbulence of the flow (or fluid current) beyond the return channel in order to advance the start of the air separation from the liquid. Said device provides several outlets from the return channel at the inlet in the pressure chamber, distributing the flow toward different directions, avoiding a concentrated axial flow, in order to let the air follow the path of least resistance independently of the main liquid courses. Therefore a temporary separation or a partial separation of the air from the liquid is obtained, making easier a quicker definitive separation with the state of calm of the fluid obtained in said pressure chamber or separation chamber. As it is shown in figg. 1, 3, 4, 5 and 6, said at least one deflector 15, forming substantially an annular baffle, can have radial outlines with different shapes: truncated cone or bell-shaped, curved or flat.

[0043] Said at least one deflector 15, 150 can have frontal outlines substantially annular or can have a configuration with sectors which are substantially circular, equidistant or differently placed or spaced angularly and radially, equal or with a different width and/or with different shapes, frontally adjacent as shown in fig. 8 or separated one from the other and defined by substantially radial blades or walls 14, 19, as shown in fig. 2, or a configuration with lobes separated by septa connected to said guide blades.

[0044] Said at least one deflector with a substantially annular shape 15, 150 is placed with respect to said outlet 13, 130 from said return channel 9, 90 through flow directing means, consisting in a plurality of walls 14, 19 or guide blades 190, suitable to eliminate or reduce the residual rotation and the fluid turbulence coming out from said return channel 9, 90 at the inlet of said pressure chamber 3, 30.

[0045] In addition to said walls or guide blades 14, 19, 190 joined to said deflector 15, 150, for the reduction of the residual rotation and flow turbulence at the inlet of said pressure chamber 3, 30, a plurality of guide ribs 197, 198 substantially radial placed on said stationary suction duct 5, 50, 80, separated from said deflector 15, 150, can be coupled to said deflector 15, 150.

[0046] In the different embodiments shown in figg. 9, 10, 11, and 13, around the terminal part of said stationary suction duct 53, 54, 81, 82, 83, 84 connected to said impeller 61, 62, 63, 64 at least one deflector substantially circular 153, 157, 158, 159 can be placed. The configuration of said circular deflector 153, 157, 158, 159, forming substantially a circular baffle, is suitable for directing toward diverging or tendentially centrifugal directions the fluid coming out from said return channel 91, 92, 93, 94 to the inlet of said pressure chamber 31, 32, 33, 34.

[0047] Said substantially circular baffle 157, 158, 159 around said stationary suction duct 54, 81, 82, 84 can be coupled to at least one substantially concentric annular baffle 151, 152, 154 connected through the guide blades 191, 192, 194.

[0048] Therefore different directions of the fluid are obtained, marked by the arrows 161-171, 162-172, 164-174, at the outlet 131, 132, 134 of said return channel 91, 92, 94 at the inlet of said pressure chamber 31, 32, 34.

[0049] Around said substantially circular baffle 153, 157, 158, 159 a plurality of guide blades 191, 192, 194 or guide ribs 193 can be placed acting as flow directing means suitable for eliminating or reducing the residual rotation and the turbulence of said fluid.

[0050] In the embodiment shown in figg. 11 and 12, said substantially circular baffle 153, facing said outlet 133 of said return channel 93 and around the terminal part of said stationary suction duct 53, 83, avoids a concentrated axial flow and the consequent air entrainment with the liquid and deviates the flow from the direction toward the nozzle when it is placed in the central part of the pump, decreasing the air recirculation. The opening between said outlet 133 of said return channel 93 and the terminal part of said deflector 153 increases the outlet section of the return channel and decreases the entry velocity of the flow in said pressure chamber 33. Through the diverging or tendentially centrifugal directions 163, 173 of the fluid, the surrounding liquid is used to restrain the flow turbulence distributing it in the pressure chamber 33. In the change of direction of the fluid from the outlet 133 of said return channel 93 as far as the end of said deflector 153, the liquid tends to flow on said deflector 153 with the directions marked by the arrows 173. The air tends to take more internal directions, marked by the arrows 163, flowing on the liquid following the path of least resistance with a temporary or partial separation from the liquid, making the definitive separation easier with the fluid state of calm obtained in the pressure chamber 33.

[0051] For distributing the flow toward further different directions in said pressure chamber 33, the sectors of said deflector 153 between said guide ribs 193 can have inclinations and/or shapes different from one anothers.

[0052] In a different embodiment shown in the figg. 15, 16 and 18, said at least one deflector 155 is formed by walls with substantially constant and coincident outlines, independently of the possible different extents of said outlines, on parallel planes with respect to the shape divisional plane, placed preferably on said horizontal axis 75 and with orthogonal outlines perpendicular to said plane 75.

[0053] Said at least one deflector 155, facing said outlet 135 of said return channel 95 and around the terminal part of said stationary suction duct 55, 85 connected to said impeller 65, has inclined sides connected to the outside of said suction duct 55, 85 on septa 199 turned to the flow source, said at least one deflector 155 suitable to direct and distribute toward laterally opposed directions 165, 175 the fluid coming out from said return channel 95. Said septa 199, the possible guide ribs 195 as flow directing means and said deflector 155 are placed in such a way as to eliminate or reducing the residual rotation and the flow turbulence coming out from said return channel 95.

[0054] In addition to said main directions 165, 175, laterally opposed, said at least one deflector 155 let the flow be distributed through other ways along other directions, decreasing its velocity in said pressure chamber 35 and using the surrounding liquid to restrain the residual turbulence and reduce the air entrainment with the liquid, letting the air follow, after said return channel 95, the path of least resistance in order to come in said pressure chamber 35 with a temporary or partial separation from the liquid, making the definitive separation easier with the state of calm of the fluid obtained in said pressure chamber 35.

[0055] The frontal outline of said at least one deflector 155 can be polygonal, circular or mixtilinear.

[0056] The outlines of said at least one deflector 155 on parallel planes with respect to a plane on said horizontal axis 75, preferably constant to make the molding easier without any undercut and with an uniform thickness, can have different configurations. The general configuration can be, for example, the one having inclined, flat or concave walls joined toward the flow source on a plane which is perpendicular to said horizontal axis 75. Another general configuration can be the one having a convex deflector or a deflector with an asymmetric outline, or any other configuration suitable for directing and distributing the fluid coming out from said return channel 95 toward different directions and for eliminating or reducing the flow residual rotation, velocity and turbulence in the pressure chamber 35.

[0057] As it is shown in the figg. 15, 17 and 19, said deflector 155 can be coupled to other deflectors 215, preferably with a different width and height extent, respectively, parallelly and perpendicularly to said shape divisional plane, placed preferably on said horizontal axis 75. Said deflectors 215 placed laterally to said deflector 155 with said septa 199, as a sort of corolla on a stem, on the terminal part of said stationary suction duct 55, 85, partially connected through the guide ribs 195, are placed in such a way as to direct and distribute toward different directions 165, 167, 175, 177 the fluid coming out from said return channel 95 decreasing its velocity and in such a way as to eliminate or reduce the fluid residual rotation and turbulence in said pressure chamber 35.

[0058] In the different embodiments shown in figg. 20, 21, 22 several substantially annular concentric baffles 156, 315 connected through flow directing means, consisting in a plurality of substantially radial guide blades 196, form a so-called honeycomb flow straightener with different outlets 166, 176, 178 from said return channel 96 to the inlet of said pressure chamber 36.

[0059] Said coupled deflectors 155-215 can be at least partially frontally overlapping, or said deflectors 151-157, 152-158, 156-315 can be at least partially radially overlapped, or said deflectors 154-159 can be coupled without any frontal or radial overlap. The configurations of the coupled deflectors can be different according to the preferred molding possibilities. It is also possible to have a spiral and/or helicoidal development of one or more deflectors with the initial and terminal portions 156, 315 being asymmetric, with a shape, dimensions or positions which can be radially, angularly and axially different, as it is shown for example in fig 23.

[0060] Said flow directing means, consisting in said walls or substantially radial guide blades 19, 190, 191, 196, can be connected to the wall 12, 120, 121, 126 having said outlet 13, 130, 131, 136 of said return channel 9, 90, 91, 96. Therefore said at least one deflector 15, 150, 151, 156, 315, said flow directing means 19, 190, 191, 196 and said wall 12, 120, 121, 126 form a single piece. Therefore, said at least one deflector 15, 150, 151, 156, 157, 315 with said flow directing means 19, 190, 191, 196 or said vanes 14 can have also the function of reinforcing structurally the walls of said diffuser with return channel 9, 90, 91, 96 against the deformations due to temperature and pressure increases.

[0061] Said deflector 15 can be placed with respect to said outlet 13 through extensions of the said guide vanes 14 of said return channel 9 beyond said outlet 13. Therefore said deflector 15 and said guide vanes 14 form a single piece.

[0062] In order to reinforce further said wall 121, 126 with said guide blades 191, 196 and said deflectors 151, 156, 157, 315 it is possible to have a support on a shoulder 27, 227 around said stationary suction duct 51-81, 56-86.

[0063] As it is shown in fig. 10, the conveying channels 92 can be built through the zigzag course of one of the two walls 109, 122, axially spaced in correspondence with the channels 92 and connected between a conveying channel and the other, forming outlets 132 spaced 360° around said stationary suction duct 52, 82 by the guide blades 142 with the joints 147 between one channel and the other.

[0064] As it is shown in the figg. 10 and 11, said at least one deflector 152, 153, 158, the device characterizing the pump of the invention, can be a piece keyed around the terminal part of said stationary suction duct 52, 53, 82, 83, included between said wall 109, adjacent to the impeller 62, or between the collar front 127 or the central part of said wall 210 adjacent to the impeller 63 and a frontal shoulder 28,128 with possible locating elements 29, 129 for the positioning and for preventing angular shifts.

[0065] As it is shown in figg. 13 and 15 said device can be coupled to said stationary suction duct 54, 55, 84, 85. Therefore said deflector 154, 155, 159, 215 and said stationary suction duct 54, 55, 84, 85 form a single piece.

[0066] The parts forming the diffuser with return channel and the above-described device can be built with the same material, formed by pieces joined through weldings or formed by parts connected with detachable systems or formed by parts of different or dissimilar materials, as metal and plastic or synthetic materials, connected through systems known to join or form pieces of dissimilar materials. Said parts can have a stable shape, built with rigid materials or parts of said device can be flexible, built with deformable elastic materials. Said parts can be realized through different structural shapes and different materials in order to obtain complementary functions, as improving the resistance against the deformations due to temperature and pressure increases, against the thrust of the flow coming out from the return channel, against corrosive liquids, against the wear due to abrasive parts, as improving the efficiency, keeping the adhesion of the return channel walls at the interposed vanes avoiding infiltrations when the vanes separate areas with a different pressure between one channel and the other.

[0067] The device described above coupled to a diffuser with a return channel improves the self-priming capability of a shallow-well jet pump with the highest suction lifts allowed by the atmospheric pressure.

[0068] The better self-priming capability is obtained through the reduction of the residual rotation, velocity and turbulence of the flow in the pressure chamber, avoiding the residual centrifugal effect restraining the air in the liquid, the entrainment effect of the air with the liquid due to the velocity of a concentrated flow and reducing the air recirculation through the nozzle.

[0069] The different outlets from the return channel in the pressure chamber or separation chamber, let the air contained in the fluid coming out from the return channel follow the path of least resistance independently of the liquid main courses. The result is, in the passages where the fluid looses its mixing state homogeneity, a temporary separation or a partial separation of the air from the liquid, making a quicker definitive air separation from the liquid easier, in the state of calm of the fluid obtained in the pressure chamber, since the air in the liquid tends to go upward and the aerated liquid tends to decant in this state of calm.

[0070] Since said device allows a quicker air separation from the liquid in the pressure chamber, making the air come out quicker from the pump and feeding the nozzle with a deaerated driving liquid, it allows also to have configurations of the diffuser inlets suitable for collecting quicker the air coming out from the impeller without restraining the greatest air amount coming in the separation chamber and without the recirculation of said air with the liquid when the self-priming phase extends with the highest suction lifts, in addition to configurations of the diffuser and of the return channel suitable to limit the liquid expulsion in the delivery at the start, with small radial dimensions and with a vanes course with a continuous guide of the direction and flow velocity.

[0071] Advantageously, the better self-priming capability allows the use of a source from extreme suction lifts and grants the self-priming regularity in fixed installations with normal suction lifts, even without the best plant conditions. Through the best self-priming capability the possibility of using a pump located above ground replacing a pump submersed in the liquid to be lifted eliminating any moving part in the well, even the foot valve with said pump located above ground, is increased. In order to avoid the pump emptying due to a siphon effect at every stop and to allow it to reprime automatically at every start, it is sufficient a non-return valve on the suction port of the pump.

[0072] According to tests results, with some of the shown embodiments it is possible to obtain a reduction of the self-priming phase time with the highest suction lifts of more than 1/3 with respect to the phase time in the same plant with the same pump with a return channel but without the device of the invention.

[0073] Advantageously, the quicker self-priming reduces the wait time of the continuous liquid flow in the delivery after the start and the permanence time of an air cushion on the contact faces of the mechanical seal on the shaft and this is a further grant against the danger of a failure of the mechanical seal due to lubrication or cooling lack.

[0074] Advantageously it is possible to obtain the self-priming with a smaller pump casing and, keeping the same dimensions, the self-priming capability is improved through a better use of the liquid reserve in the pump after the pre-filling, through the velocity, rotation, turbulence reduction and the distribution of the flow in the pressure chamber, in addition to the reduction of the dispersion of the liquid in the delivery at the start.

[0075] Advantageously, the device described above allows a functionally less noisy execution with a continuous guide and progressive decrease of the flow velocity and turbulence. This allows the use of the state of calm of the fluid in the pressure chamber in order to muffle the noise from the internal parts with a higher velocity and turbulence, even in a pump casing made with a thin sheet steel.

[0076] Said device allows to carry on beyond the return channel the reduction of the liquid velocity and turbulence without added losses, improving the operating performance through the nozzle feeding with a laminar driving liquid, increasing the flow rate and decreasing the head loss with the highest suction lifts, slowing down the beginning of cavitation which limit and reduce the highest possible flow rate when the suction lifts increase.

[0077] Advantageously, it can be obtained to reduce the pump cost using the possibility of obtaining the self-priming with a smaller liquid reserve, reducing the dimensions and the weight of the pump.

[0078] Further advantageously, the above-mentioned device can be used to reinforce structurally the walls of said diffuser with a return channel against deformations due to temperature and pressure increases.

[0079] All the possible embodiments, combining or separating the described functions, combining the embodiments shown in the drawings, changing the shape, the position or the quantity of the explained or described parts, removing shown elements or adding others or using the explained teachings with equivalent means producing substantially the same result of the expressed elements are to be intended as protected by the following claims.

Claims

1. Single-impeller centrifugal self-priming jet pump (1, 100, 101, 102, 103, 104, 105, 106) including:

    - a pump casing (2, 20) containing a pressure chamber (3, 30, 31, 32, 33, 34, 35, 36) communicating with a delivery port (4, 40);
    - a stationary suction duct (5, 50, 51, 52, 53, 54, 55, 56, 80, 81, 82, 83, 84, 85, 86) connected with an impeller (6, 60, 61, 62, 63, 64, 65) keyed on the driving shaft with horizontal axis of rotation (7, 70, 75);
    - a diffuser provided with a return channel (9, 90, 91, 92, 93, 94, 95, 96) placed between two axially spaced walls with the interposition of at least a guide vane (14, 140, 142), one of said walls (10, 107, 109, 210) being adjacent to the suction side of said impeller with at least one inlet on the periphery (11, 110) and the other wall (12, 120, 121, 122, 126) being provided with at least one outlet (13, 130, 131, 132, 133, 134, 135, 136) in the central part of said pressure chamber; **characterized in that** the pump is provided with at least a deflector (15, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 215, 315), placed beyond said outlet of said return channel and around said stationary suction duct, suitable for distributing the fluid toward diverging directions (16-17, 160-170, 161,171, 162-172, 163-173, 164-174, 165-175, 167-177, 166-176-178) in said pressure chamber, said at least a deflector having flow directing means (14, 19, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199).

2. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector (15, 150, 151, 152, 154, 156, 315) has a substantially annular shape.

3. Centrifugal pump according to claim 1) or 2) **characterized in that** said at least one deflector (153, 157, 158, 159) has a substantially circular shape.

4. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector (155, 215) is formed by walls having substantially coinciding outlines on planes parallel to a plane placed on said horizontal axis (75) and orthogonal outlines perpendicular to said plane (75), said at least one deflector being placed on said stationary suction duct (55) and being suitable for distributing the fluid coming out from said return channel (95) toward different directions (165-175, 167-177) in said pressure chamber (35).

5. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector (151, 152, 154, 155, 156) is coupled to at least one further deflector (157, 158, 159, 215, 315), said coupled deflectors (151, 152, 154, 155, 156, 157, 158, 159, 215, 315) being connected through said flow directing means (191, 192, 194, 195, 196, 199) and being suitable for distributing the fluid coming out from said return channel (91, 92, 94, 95, 96) toward different directions (161-171, 162-172, 164-174, 165-175, 167-177, 166-176-178) in said pressure chamber (31, 32, 34, 35, 36).

6. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector has portions (15, 150, 153, 155, 156, 215, 315) with inclinations, shapes and/or dimensions and/or positions different from one another radially and/or angularly and/or axially.

7. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector (15, 150) consists in substantially circular sectors frontally defined by substantially radial walls (14, 19, 190).

8. Centrifugal pump according to claim 1) **characterized in that** to said at least one deflector (15, 150) are coupled guide ribs (197, 198) separated from said at least one deflector.

9. Centrifugal pump according to claim 1) **characterized in that** said at least one guide vane (14) in said return channel (9) extends beyond the outlet (13) from said return channel (9) as far as connecting to said at least one deflector (15), said at least one deflector and said at least one guide vane forming a single piece.

10. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector (15, 150, 151, 156, 157, 315) is placed in its position by said flow directing means (14, 19, 190, 191, 196) connected to said wall (12, 120, 121, 126) having said outlet (13, 130, 131, 136) of said return channel (9, 90, 91, 96), said at least one deflector, said flow directing means and said wall forming a single piece.

11. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector (154, 155, 159, 215) forms a single piece with said stationary suction duct (54, 55, 84, 85).

12. Centrifugal pump according to claim 1) **characterized in that** said at least one deflector (152, 153, 158) consists in an element keyed around said stationary suction duct (53, 82).

Patentansprüche

1. Einstufige, selbstansaugende Kreiselpumpe mit Ejektor (1, 100, 101, 102, 103, 104, 105, 106), Folgendes umfassend:

- ein Pumpengehäuse (2, 20), das eine Druckkammer (3, 30, 31, 32, 33, 34, 35, 36) enthält, welche mit einer Austrittsöffnung (4, 40) kommuniziert;
- einen stätionären Saugkanal (5, 50, 51, 52, 53, 54, 55, 56, 80, 81, 82, 83, 84, 85, 86), der mit einem Laufrad (6, 60, 61, 62, 63, 64, 65) verbunden ist, das an der Antriebswelle mit waagerechter Drehachse (7, 70, 75) verkeilt ist;
- einen Diffusor mit Rückführkanal (9, 90, 91, 92, 93, 94, 05, 96), zwischen zwei axial mit Zwischenraum angeordneten Wänden positioniert, zwischen denen wenigstens eine Leitschaufel (14, 140, 142) eingefügt ist, wobei eine der Wände (10, 107, 109, 210) an die Saugseite des Laufrads angrenzt und wenigstens einen Einlass an der Außenseite (11, 110) aufweist und die andere Wand (12, 120, 121, 122, 126) wenigstens einen Auslass (13, 130, 131, 132, 133, 134, 135, 136) im zentralen Bereich der Druckkammer aufweist; **dadurch gekennzeichnet, dass** die Pumpe wenigstens einen Ablenker (15, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 215, 315) nach dem Auslass des Rückführkanals und um den stätionären Saugkanal herum aufweist, der geeignet ist, das Fluid in divergierende Richtungen (16-17, 160-170, 161-171, 162-172, 163-173, 164-174, 165-175, 167-177, 166-176-178) in der Druckkammer zu verteilen, wobei dieser wenigstens eine Ablenker Strömungsleitmittel (14, 19, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199) aufweist.

2. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (15, 150, 151, 152, 154, 156, 315) im Wesentlichen ringförmig ist.

3. Kreiselpumpe gemäß Patentanspruch 1) oder 2), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (153, 157, 158, 159) im Wesentlichen kreisförmig ist.

4. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (155, 215) aus Wänden gebildet ist, die im Wesentlichen übereinstimmende Umrisse auf Ebenen haben, welche parallel sind zu einer Ebene auf der waagerechten Achse (75) und orthogonalen Umrisse, die lotrecht zu dieser Ebene (75) stehen, wobei dieser wenigstens eine Ablenker auf den stätionären Saugkanal (55) positioniert ist und geeignet ist, das aus dem Rückführkanal (95) strömende Fluid in verschiedene Richtungen (165-175, 167-177) in der Druckkammer (35) zu leiten.

5. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (151, 152, 154, 155, 156) mit wenigstens einem weiteren Ablenker (157, 158, 159, 215, 315) gekuppelt ist, wobei diese miteinander gekuppelten Ablenker (151, 152, 154, 155, 156, 157, 158, 159, 215, 315) durch die Strömungsleitmittel (191, 192, 194, 195, 196, 199) verbunden sind und geeignet sind, das aus dem Rückführkanal (91, 92, 94, 95, 96) strömende Fluid in verschiedene Richtungen (161-171, 162-172, 164-174, 165-175, 167-177, 166-176-178) in der Druckkammer (31, 32, 34, 35, 36) zu leiten.

6. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker Abschnitte (15, 150, 153, 155, 156, 215, 315) aufweist, deren Neigungen, Formen und/oder Abmessungen und/oder Positionen sich radial und/ oder winklig und/oder axial voneinander unterscheiden.

7. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (15, 150) im Wesentlichen aus kreisförmigen Segmenten besteht, die frontal durch im Wesentlichen radiale Wände (14, 19, 190) definiert sind.

8. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** mit dem wenigstens einen Ablenker (15, 150) Leitrippen (197, 198) verbunden sind, die von diesem wenigstens einen Ablenker getrennt sind.

9. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** wenigstens eine Leitschaufel (14) in dem Rückführkanal (9) sich über den Auslass (13) hinaus aus dem Rückführkanal (9) so weit erstreckt, dass er mit dem wenigstens einen Ablenker (15) verbunden ist, wobei der wenigstens eine Ablenker mit dem wenigstens eine Leitschaufel ein einziges Stück bildet.

10. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (15, 150, 151, 156, 157, 315) durch die Strömungsleitmittel (14, 19, 190, 191, 196) in seine Position gehalten wird, wobei diese Strömungsleitmittel mit der Wand (12, 120, 121, 126) verbunden sind, die den Auslass (13, 130, 131, 136) des Rückführkanals (9, 90, 91, 96) aufweist, wobei der wenigstens eine Ablenker, die Strömungsleitmittel und die Wand ein einziges Stück bilden.

11. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (154, 155, 159, 215) mit dem stätionären Saugkanal (54, 55, 84, 85) ein einziges Stück bildet.

12. Kreiselpumpe gemäß Patentanspruch 1), **dadurch gekennzeichnet, dass** der wenigstens eine Ablenker (152, 153, 158) aus einem Element besteht, das um den stätionären Saugkanal (53, 82) herum verkeilt ist.

Revendications

1. Pompe centrifuge mono-étagée auto-amorçante à ejecteur (1, 100, 101, 102, 103, 104, 105, 106) comprenant:

- un corps de pompe (2, 20) contenant une chambre de pression (3, 30, 31, 32, 33, 34, 35, 36) communiquant avec un orifice de refoulement (4, 40);
- un conduit d'aspiration fixe (5, 50, 51, 52, 53, 54, 55, 56, 80, 81, 82, 83, 84, 85, 86) relié à une roue (6, 60, 61, 62, 63, 64, 65) assemblé sur l'arbre de transmission avec un axe horizontal de rotation (7, 70, 75);
- un diffuseur équipé d'un canal de retour (9, 90, 91, 92, 93, 94, 95, 96) positionné entre deux parois espacées d'une manière axiale avec l'interposition d'au moins une aube directrice (14, 140, 142), une desdites parois (10, 107, 109, 210) étant adjacente par rapport au côté d'aspiration de ladite roue avec au moins une entrée sur le côté extérieur (11, 110) et l'autre paroi (12, 120, 121, 122, 126) étant équipée d'au moins une sortie (13, 130, 131, 132, 133, 134, 135, 136) dans la partie centrale de ladite chambre de pression, **caractérisée en ce que** la pompe est équipée d'au moins un déflecteur (15, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 215, 315) positionné au-delà de ladite sortie dudit canal de retour et autour dudit conduit d'aspiration fixe, indiqué pour distribuer le fluide vers des directions divergentes (16-17, 160-170, 161-171, 162-172, 163-173, 164-174, 165-175, 167-177, 166-176-178) dans ladite chambre de pression, ledit au moins un déflecteur ayant des moyens de guidage de l'écoulement (14, 19, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199).

2. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ledit au moins un déflecteur (15, 150, 151, 152, 154, 156, 315) a une forme essentiellement annulaire.

3. Pompe centrifuge selon la revendication 1) ou 2) **caractérisée en ce que** ledit au moins un déflecteur (153, 157, 158, 159) a une forme essentiellement circulaire.

4. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ledit au moins un déflecteur (155, 215) se compose de parois ayant des profils essentiellement coïncidants sur des plans parallèles à un plan se trouvant sur ledit axe horizontal (75) et des profils orthogonaux perpendiculaires audit plan (75), ledit au moins un déflecteur étant placé sur ledit conduit d'aspiration fixe (55) et étant indiqué pour distribuer le fluide s'écoulant dudit canal de retour (95) vers des directions différentes (165-175, 167-177) dans ladite chambre de pression (35).

5. Pompe centrifuge selon la revendication 1) **caractérisée en ce qu'**au moins un déflecteur (151, 152, 154, 155, 156) est relié à au moins un déflecteur supplémentaire (157, 158, 159, 215, 315), lesdits déflecteurs couplés (151, 152, 154, 155, 156, 157, 158, 159, 215, 315) étant reliés par l'intermédiaire desdits moyens de guidage de l'écoulement (191, 192, 194, 195, 196, 199) et étant indiqués pour distribuer le fluide s'écoulant dudit canal de retour (91, 92, 94, 95, 96) vers des directions différentes (161-171, 162-172, 164-174, 165-175, 167-177, 166-176-178) dans la chambre de pression (31, 32, 34, 35, 36).

6. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ledit au moins un déflecteur présente des parties (15, 150, 153, 155, 156, 215, 315) avec inclinaisons, formes et/ou dimensions et/ou positions différentes l'une par rapport à l'autre d'une manière radiale et/ou angulaire et/ou axiale.

7. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ledit au moins un déflecteur (15, 150) se compose de secteurs essentiellement circulaires définis frontalement par des parois essentiellement radiales (14, 19, 190).

8. Pompe centrifuge selon la revendication 1) **caractérisé en ce qu**'audit au moins un déflecteur (15, 150) sont couplés des nervures de guidage (197, 198) séparées dudit au moins un déflecteur.

9. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ladite au moins une aube directrice (14) dans ledit canal de retour (9) s'étend au-delà de la sortie (13) dudit canal de retour (9) jusqu'à se relier audit au moins un déflecteur (15), ledit au moins un déflecteur et ladite au moins une aube directrice formant une pièce unique.

10. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ledit au moins un déflecteur (15, 150, 151, 156, 157, 315) est placé dans sa position par lesdits moyens de guidage de l'écoulement (14, 19, 190, 191, 196) reliés à ladite paroi (12, 120, 121, 126) ayant ladite sortie (13, 130, 131, 136) dudit canal de retour (9, 90, 91, 96), ledit au moins un déflecteur, lesdits moyens de guidage de l'écoulement et ladite paroi formant une pièce unique.

11. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ledit au moins un déflecteur (154, 155, 159, 215) forme une pièce unique avec ledit conduit d'aspiration fixe (54, 55, 84, 85).

12. Pompe centrifuge selon la revendication 1) **caractérisée en ce que** ledit au moins un déflecteur (152, 153, 158) est composé d'un élément assemblé autour dudit conduit d'aspiration fixe (53, 82).

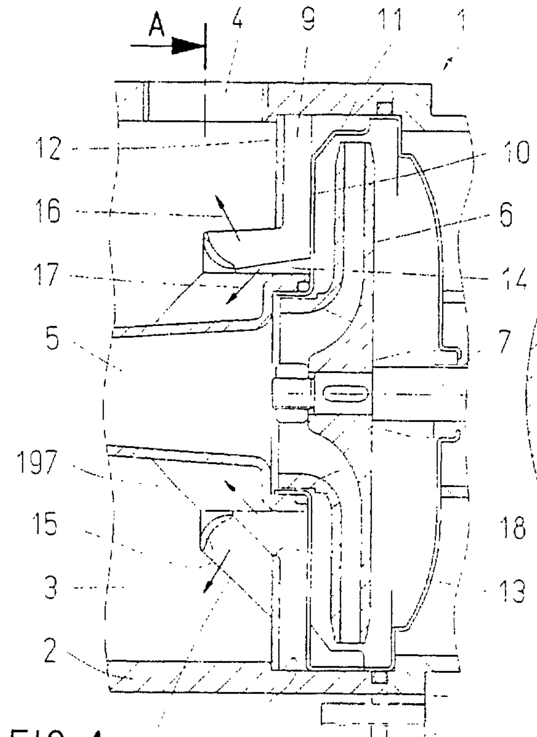

FIG. 1

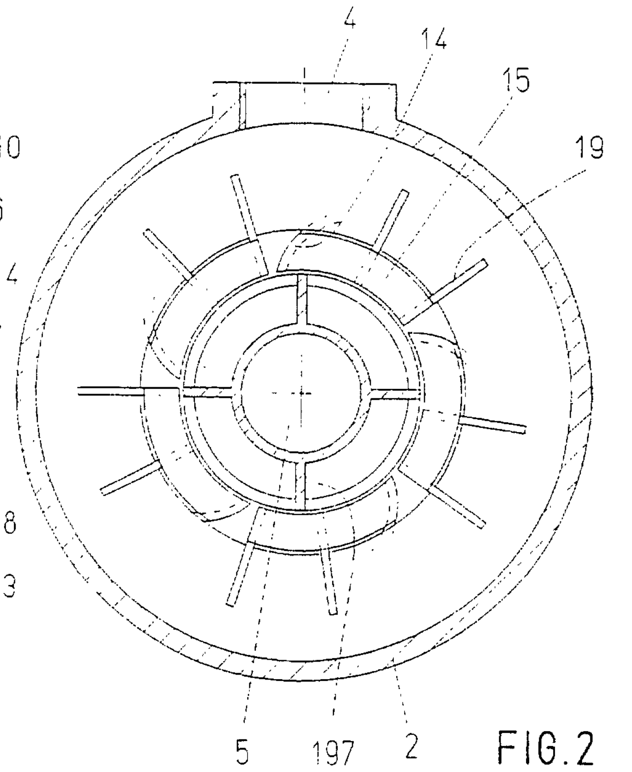

FIG. 2
A

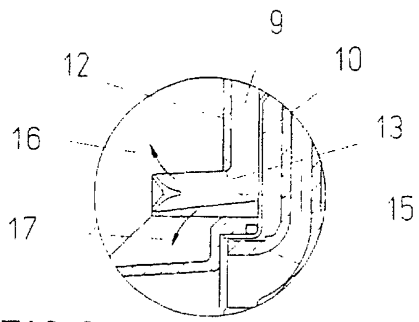

FIG. 3

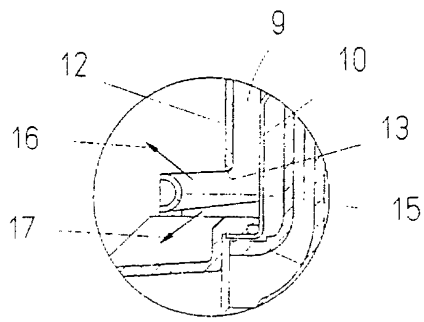

FIG. 4

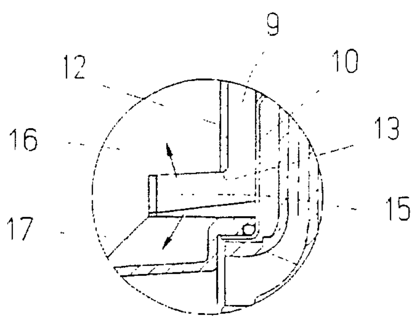

FIG. 5

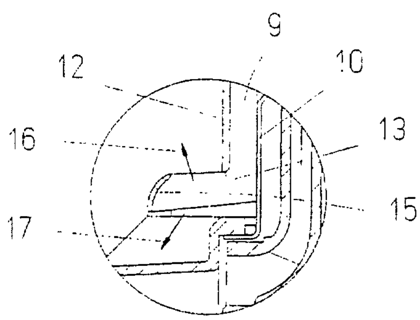

FIG. 6

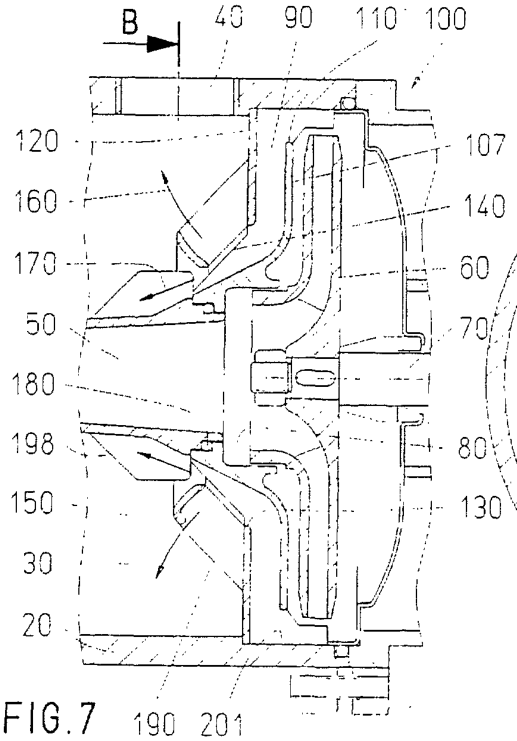

FIG.7

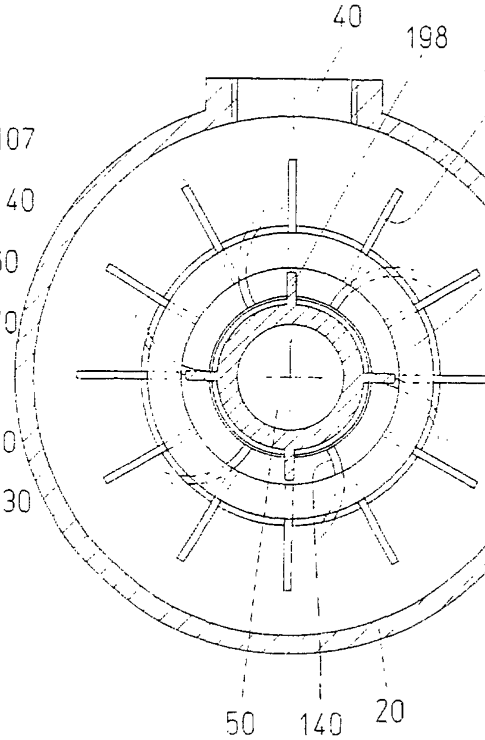

FIG.8
B

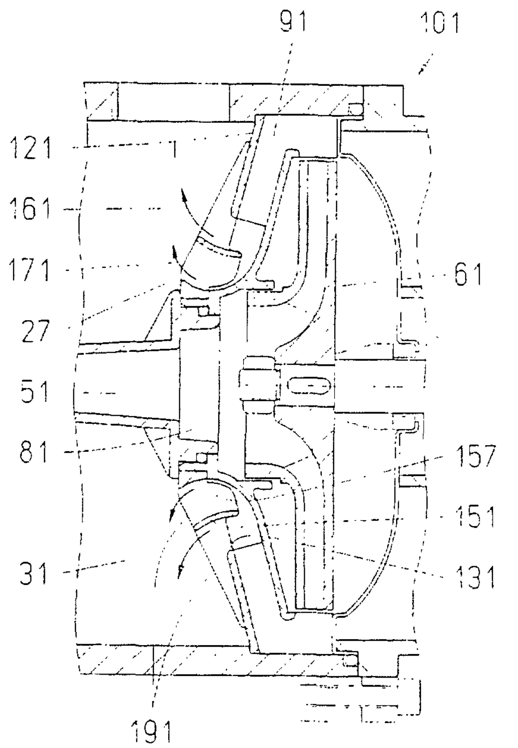

FIG.9

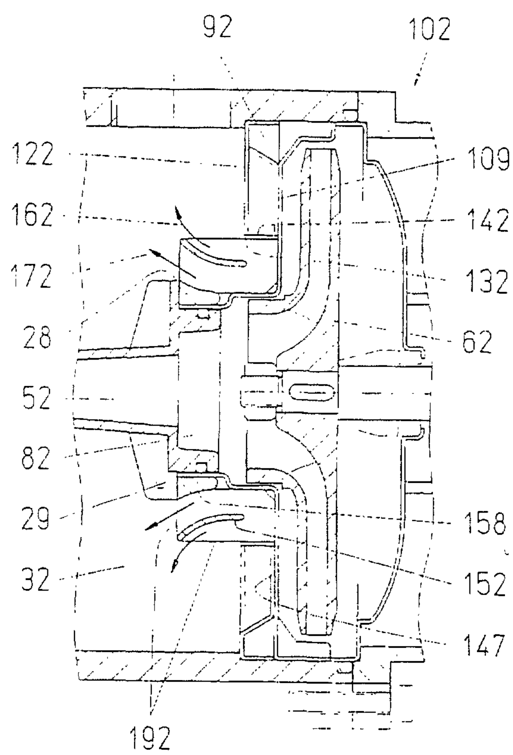

FIG.10

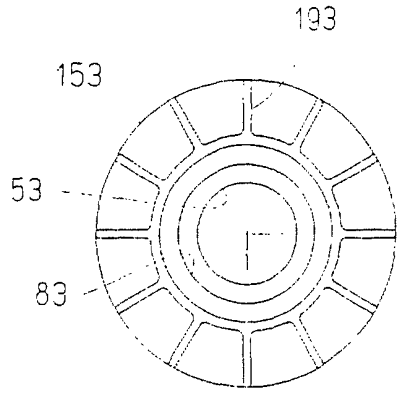

FIG. 12

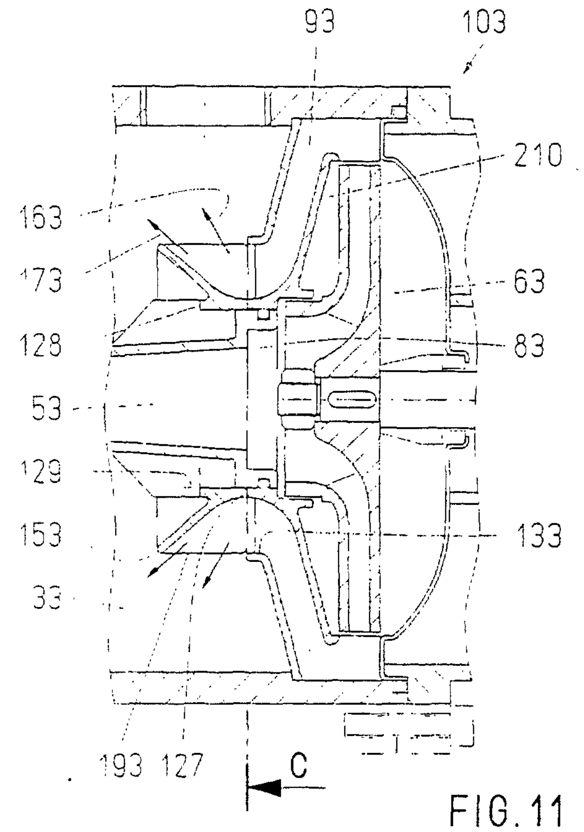

FIG. 11

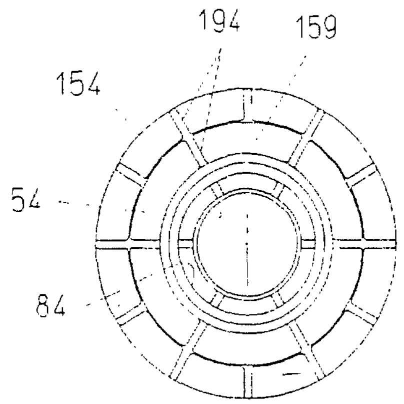

FIG. 14

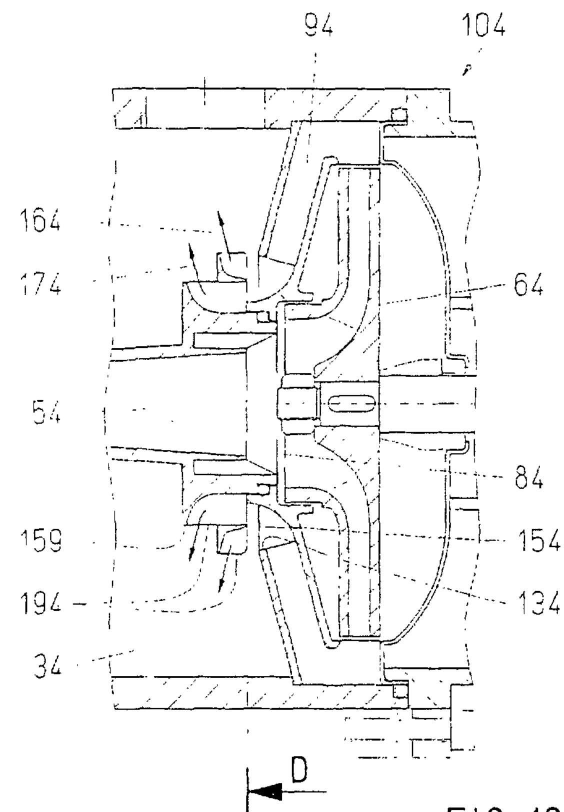

FIG. 13

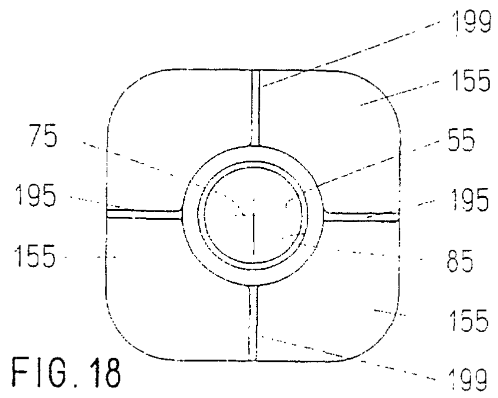

FIG. 18
E

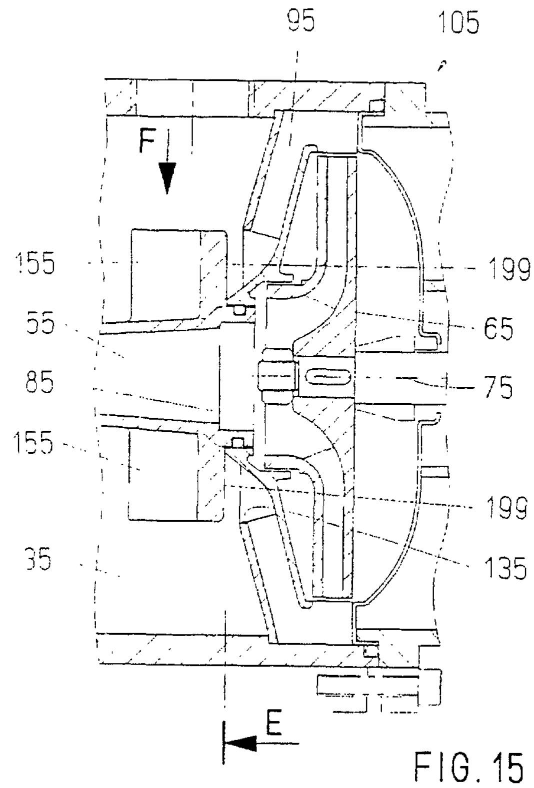

FIG. 15

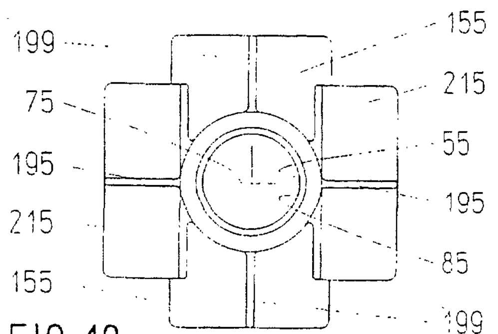

FIG. 19
E

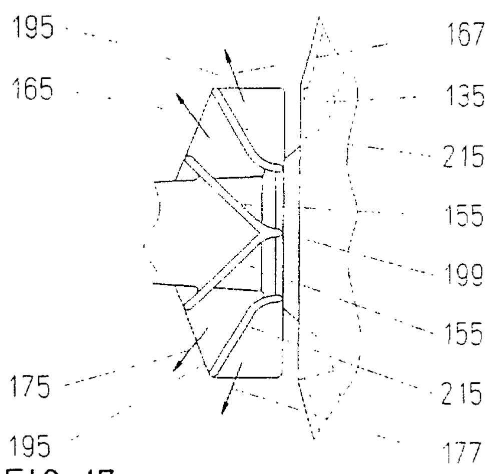

FIG. 17
F

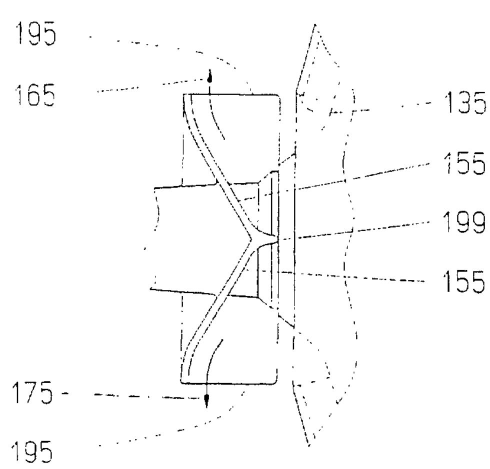

FIG. 16
F

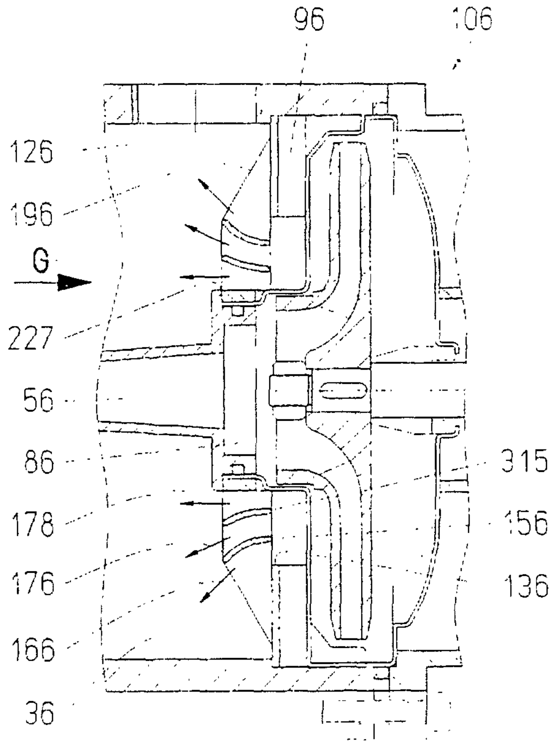

FIG.20

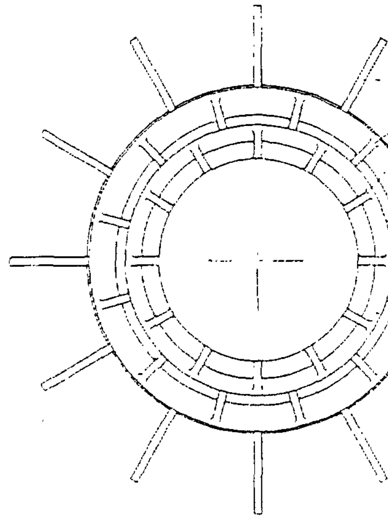

FIG.21
G

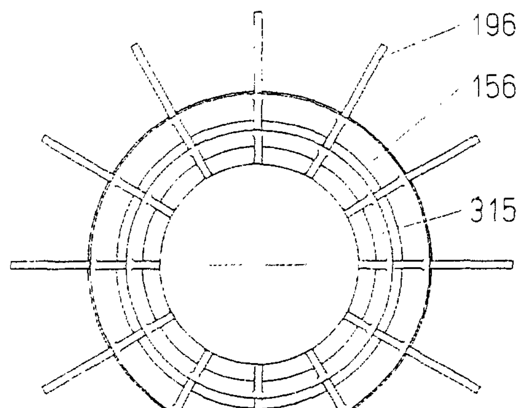

FIG.22
G

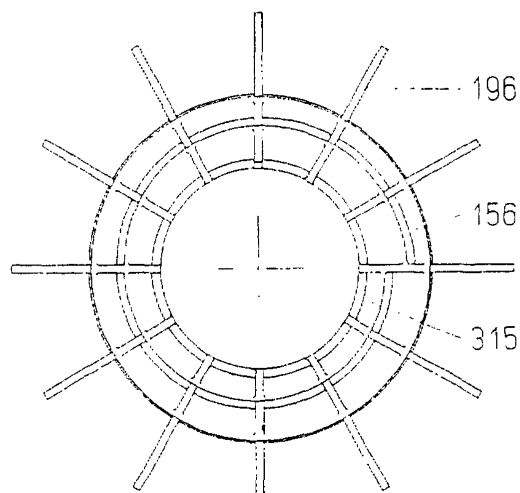

FIG.23
G