Sept. 10, 1963 J. L. GATTO ETAL 3,103,177

SELF-PRIMING CENTRIFUGAL PUMP

Filed July 20, 1961 2 Sheets-Sheet 1

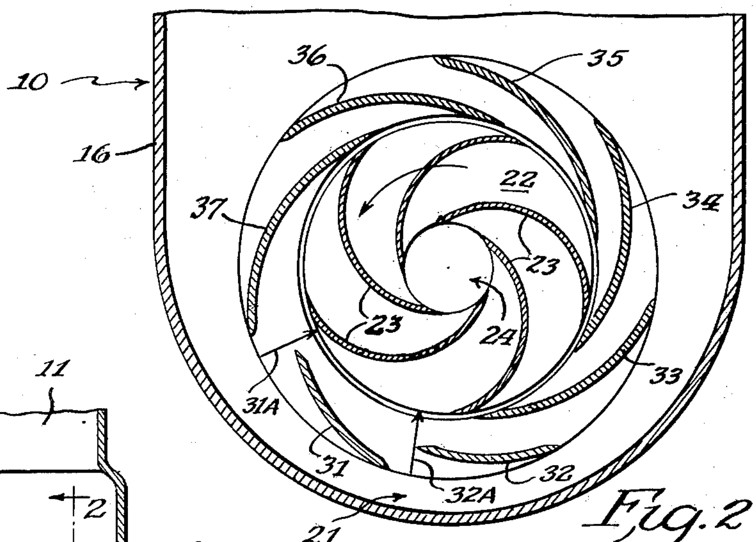

Fig. 2

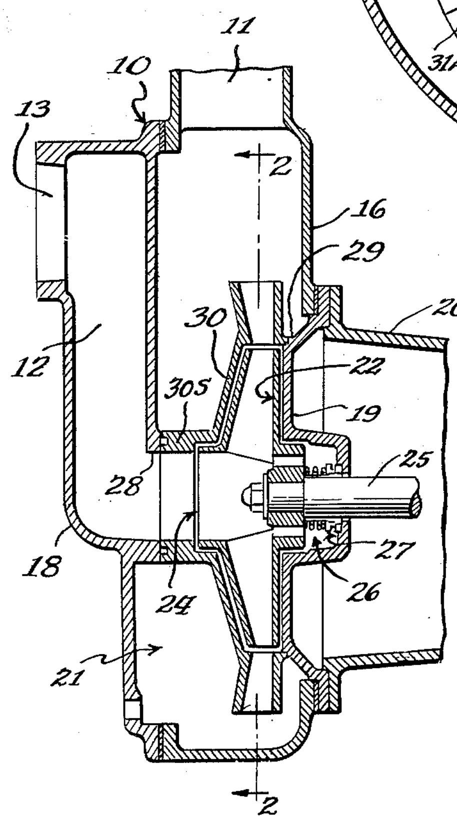

Fig. 1.

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Fig. 3.

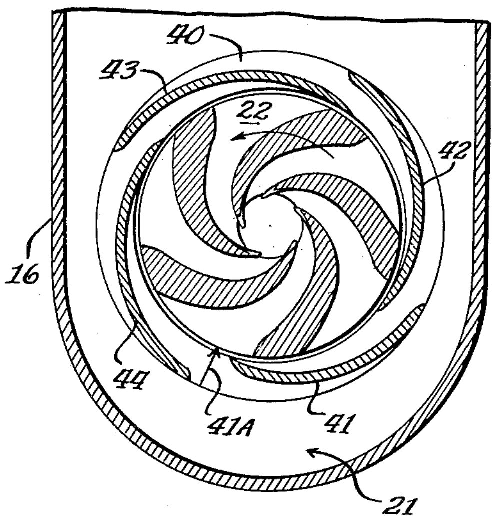


Fig. 3A.

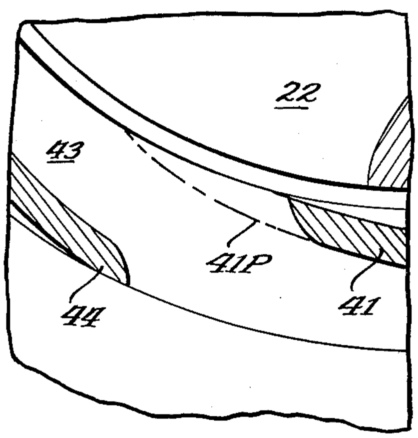


Fig. 4A.

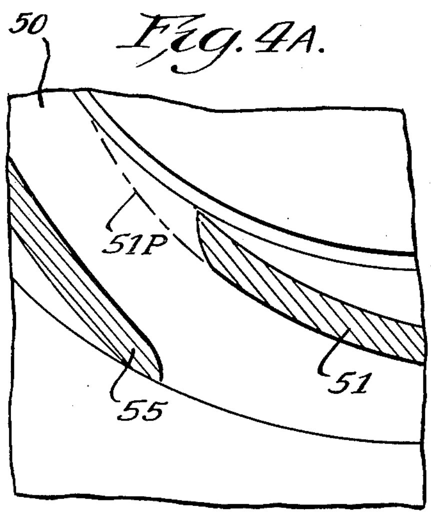
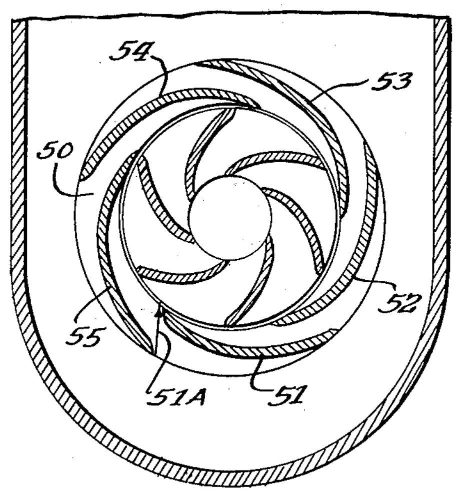


Fig. 4.



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SELF-PRIMING CENTRIFUGAL PUMP

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This invention relates to self-priming centrifugal pumps and more particularly is concerned with diffuser type self-priming centrifugal pumps.

Diffuser prime pumps such as are shown in Stratton Patent No. 2,281,175 and Marlow Patent No. 2,653,546 are well known and have served well over the years but at the present time numerous applications exist which require faster priming cycles that are not possible with existing pumps. For example, in the petroleum industry present day methods of handling petroleum require pumps having as rapid a priming time as possible. Similar trends exist in various sizes of contractors' pumps.

The principal object of the invention is the provision of a self-priming centrifugal pump that has a faster priming cycle and that eliminates recirculatory losses.

Another object of the invention is the provision of an improved diffuser prime centrifugal pump that eliminates recirculatory losses and that achieves a faster priming cycle both on static lift and against a positive discharge head.

Still another object of the invention is the provision of an improved self-priming centrifugal pump that eliminates prime holes and the accompanying problems of coring, machining and critical positioning of these holes.

A further object is the provision of an improved self-priming pump that creates increased priming turbulence at the impeller periphery and yet retains a relatively non-turbulent flow during pumping.

Briefly the invention contemplates the elimination of inner end portions of one or more discharge flow passage forming vanes adjacent the lower region of the impeller periphery to permit more direct entrance to the impeller periphery of only air-free liquid flowing reversely under the optimum pressure differential conditions existing at this location, to permit more efficient air-liquid mixing under the optimum turbulence conditions existing at the lower region of the impeller periphery, and finally to permit peeling and discharge of the entrained air into upwardly extending discharge flow passages in which case the momentum induced by the impeller rotation is reinforced by the inherent buoyancy of the air to achieve more rapid and efficient air separation and discharge.

A corollary of this is that long reverse flow paths may be maintained around the upper region of the impeller periphery and this better maintains the hydraulic seal between the air collecting in the pump tank during priming and the air at low pressure within the impeller and suction line and thus minimizes the likelihood of creating a vortex of air through the upper vane passages.

Where the invention is applied to pumps equipped with peeling vanes having a low vane angle, it is usually only necessary to eliminate the vane portion that is in close clearance with the impeller periphery, however, for pumps equipped with peeling vanes having a high vane angle, the elimination of the inner end of the vane leaves the resultant vane edge substantially removed from the impeller periphery and this clearance offers an additional advantage in that it accommodates more efficient mixing of air and liquid.

In most pump arrangements to which the invention has been applied, the amount of vane eliminated is sufficient to create a direct reverse radial flow path for the return of air-free liquid though in some instances some vane overlap can be tolerated. In both instances, however, the path created for return liquid flow by elimination of the inner end of one or more of the lower vanes is substantially shorter than heretofore. In general, reverse flow paths range from 30 to 50% less than the unshortened paths for the particular pump arrangements that have been devised to date.

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Not only is the location of the eliminated vane portion important but the amount of vane removed varies not only with total vane length and number but also with impeller diameter, impeller radial clearance, impeller speed and vane height and angle. A definite trend indicates that the amount of vane or vanes cut back increases with increasing flow passage inlet area and with increasing total number of vanes.

On the particular pump arrangements for which data is presently available the amount of vane cut back, expressed as a percentage of the composite length of the total number of vanes, has ranged from 2.8% to 10.7%. The improvement in priming time has been on the order of 35% and in one situation involving a 20 foot suction lift, the improvement has been as much as 63%.

It has also been determined that additional important priming advantages can be obtained by matching the pump arrangement and vane removal configuration to the particular pumping application. Thus, a pump arrangement capable of providing very rapid priming on a 10 foot suction lift may offer no advantage on a 20 foot suction lift.

Other objects and advantages will become apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same:

FIG. 1 is a vertical sectional view along a center line of a pump having a seven vane diffuser;

FIG. 2 is a vertical sectional view taken substantially along the line 2—2 of FIG. 1 to illustrate the diffuser vane arrangement;

FIG. 3 is a vertical sectional view corresponding to that of FIG. 2 and illustrating the invention applied to a diffuser prime pump having four diffuser vanes;

FIG. 3A is an enlarged detailed sectional view better illustrating the nature of the vane modification of the pump of FIG. 3;

FIG. 4 is a vertical sectional view also corresponding to that of FIG. 2 and illustrating the invention applied to a diffuser prime pump having five diffuser vanes of low vane angle; and

FIG. 4A is an enlarged fragmentary view better illustrating the particular type of vane modification shown in the pump of FIG. 4.

Referring now to the drawings, one particular construction for a diffuser type self-priming centrifugal pump, as illustrated in FIGS. 1 and 2 for purposes of disclosure, includes a divided casing **10** having a discharge outlet **11** and a suction inlet passage **12** terminating at a suction inlet **13**. The pump casing **10** comprises a generally hollow main section **16**, both sides of which are open, and the top of which is provided with the discharge outlet **11**, a cover plate section **18** forming the suction side of the pump and secured across one of the open sides of the main section **16**, and a recessed closure flange **19** secured across the other open side of the main casing section **16** and sandwiched between a bearing flange **20** and the main section **16** to seal the pump. The casing provides an internal chamber **21** for holding a reserve of liquid.

A centrifugal impeller **22**, which is here shown as including a plurality of blades **23**, is rotatably mounted in the pump casing chamber for rotation in a counterclockwise direction as viewed in FIG. 2 and is formed at its axis with a suction eye **24** that communicates directly with the suction passage 12. A drive shaft 25 for the impeller projects through a seal well 26 provided by the closure flange 19 and a rotatable seal ring assembly 27 encircles the drive shaft and seals against the closure flange 19.

In the preferred form of the invention illustrated herein for purposes of disclosure a one piece diffuser disc, designated generally as 30 is located and held between oppositely facing annular shoulders 28 and 29, respectively, formed on the cover plate 18 and closure flange 19. The diffuser disc 30 is shown as including a tubular inlet stub 30S forming an extension of the inner end of the suction passage 12. The diffuser disc illustrated in FIG. 2 is equipped with a set of seven vanes, designated 31 through 37, each vane being shown spiraling forwardly and outwardly from adjacent the impeller periphery and in the direction of impeller rotation.

In the preferred arrangement illustrated herein, the diffuser vanes are equally spaced, the vane angles are equal and the vane trailing edges terminate at the same outer diameter. These features provide equally diverging discharge flow passages resulting in equal conversion from velocity head to pressure head in all passages and balanced radial pressure during pumping. While this uniformity is preferred, the invention is not limited to such a restricted configuration.

While some or all of the walls of the diffuser disc 30, as well as other parts of the multiple piece casing illustrated, could be cast integral, the separate arrangement of the present disclosure permits easy repair or replacement and also simplifies the coring problems involved in casting the various parts.

The principal purpose of the invention is to provide a pump construction capable of rapid priming and free of recirculatory losses. For this purpose, vanes 31 and 32 are substantially shorter than the remaining vanes in that they terminate well short of the impeller periphery to provide relatively short and direct reverse radial flow paths as indicated by the arrows 31A and 32A in FIG. 2. In the illustrated arrangement, the reverse flow paths 31A and 32A are approximately 50% shorter than the unshortened paths. It is the location and the extent of vane removal of these so-called cut-back vanes 31 and 32 that determines the speed and efficiency of priming. It may be observed that the vanes 31 and 32 are located in successive arrangements and have inner edges originating adjacent and alongside the lower downward sweep of the impeller periphery. For convenience of reference it may be explained that vanes 33 and 34 have inner edges located along the upward sweep of the impeller periphery and vanes 35, 36 and 37 have inner edges adjacent and along the top sweep of the impeller periphery.

It may be noted that the reverse flow paths indicated by the arrows 31A and 32A are located towards the bottom of the chamber 21 for the reserve of liquid and, therefore, substantially a maximum head of liquid acts to establish a near maximum pressure differential at these locations for encouraging a reverse radial flow of air free liquid from the chamber 21 to the impeller periphery. This greater pressure differential contributes to the creation of optimum turbulence conditions at this location and this encourages more efficient air and liquid mixing, a requirement for fast priming. Finally, the fact that air free liquid returns along the paths of the arrows 31A and 32A results in this liquid being carried along a substantial portion of the impeller periphery and becoming mixed with air during such movement with the resultant entrained bubbles then being peeled off, principally at the inner edges of vanes 33 and 34. The vanes 33 and 34 border upwardly extending discharge flow passages in which case the momentum induced by the impeller rotation is reinforced by the buoyancy of the air bubbles being peeled off to create a rapid and efficient air separation and discharge.

It may also be observed that the reverse liquid flow passages that exist between the vanes 35, 36 and 37, located across the top sweep of the impeller periphery, are all of substantially greater length and are all associated with inner vane edges that are substantially close to the impeller periphery so that the arrangement maintains a hydraulic seal between the high pressure air within the pump chamber 21 and the low pressure air within the impeller. The ability to maintain this hydraulic seal eliminates the likelihood of creating a vortex of air through the upper diffuser vane passages.

In the particular arrangement of FIGS. 1 and 2 wherein the diffuser is equipped with seven vanes, the total vane length that is eliminated, expressed as a percentage of the composite length of all of vanes 30 to 36 is about 10.7 percent. Because of this rather substantial figure and because of the relatively high vane angle, the inner edges of vanes 31 and 32 are substantially removed from the impeller periphery and the resultant clearance accommodates more efficient mixing of air and liquid.

During the priming cycle, a considerable differential in pressure exists between the liquid reserve in the pump casing chamber and the diffuser vane passages as compared with the suction eye of the impeller. This differential pressure causes the reserve of liquid to press against the blade tips of the rotating impeller and create an air-liquid mixture. Where the vanes along the lower downward sweep of the impeller periphery are foreshortened at their inner ends, substantially shorter reverse flow passages result and liquid is encouraged to return to the impeller periphery by reason of the greater pressure differential at this location. The greater the pressure differential, the more turbulence and the more air entrained in the liquid to be subsequently peeled off by the close fitted vanes 33 and 34. This action continues with air free liquid moving along the reverse flow paths 31A and 32A and mechanically mixing with air within the impeller to form a foamy mixture of air and liquid from which air bubbles are peeled off and discharged until all of the air is exhausted from the suction line and the pump is fully primed.

Not only is this pump arrangement capable of providing faster priming but it also retains a relatively non-turbulent discharge flow during normal pumping and, in general, is more efficient in normal pumping operation since it eliminates recirculatory losses.

In the case of the particular diffuser configuration illustrated in FIG. 2, it should be understood that, while somewhat less efficient, the vane 33 might have a portion of its inner end eliminated since it is rather closely adjacent the bottom of the impeller periphery such that it may be considered as being adjacent the lower downward sweep of the impeller. As the description proceeds in connection with FIGURES 3 and 4, it should become apparent that reasonable variations from the illustrated configurations are possible and are contemplated within the scope of this invention. In the care of vane 33, of FIG. 2, a vane at this location could more effectively be partially eliminated at its inner edge, if it were on a diffuser disc having substantially more than seven vanes.

In FIG. 3 there is illustrated a pump equipped with a four vane diffuser 40 having vanes numbered 41 to 44. Here again the diffuser vanes preferably are equally spaced, have equal vane angles and have vane trailing edges terminating at the same diameter. It will be apparent that vane 41, which is located adjacent and alongside the lower downward sweep of the impeller periphery has its inner end terminated substantially short of the inner ends of the remaining vanes such that no overlap exists between the inner end of vane 41 and the outer end of the adjacent preceding vane 44. Thus, there is provided a direct short reverse radial flow path 41A for the return of air free liquid from the casing chamber to the impeller periphery. In the illustrated arrangement, the reverse flow path 41A is approximately 30% shorter than the unshortened paths.

Once again the location where the vane is eliminated is adjacent the bottom of the tank and is subjected to the greater head pressures existing at that point and once again the air bubbles that become entrained with the liquids returning along the path of the arrow 41A are peeled off at a vane 42 such that they are readily discharged through an upwardly extending discharge flow passage. Since the vanes 41 to 44 are arranged at a low vane angle, the resultant inner edge of vane 41 is rather close to the impeller periphery and this illustrates that in the present invention it is not an absolute requirement that the resultant vane edge be located substantially outwardly from this periphery as this is principally a function of the vane angle.

FIG. 3 is an enlarged view of the region from which the inner edge of vane 41 is eliminated, and phantom lines 41P illustrate the approximate amout of vane that is omitted.

Finally, there is illustrated in FIG. 4 another pump equipped with a five vane diffuser 50 having vanes numbered 51 to 55 wherein the vanes are equally spaced and are arranged at equal angles and have their trailing edges terminating at the same diameter. Once again the lower vane 51 has a portion of its inner end omitted as it is the vane which has its inner end originating along the lower downward sweep of the impeller periphery. FIG. 4A is an enlarged view better illustrating in phantom lines at 51P the approximate amount of vane that is omitted. It may be observed that some amount of vane overlap is tolerated in the arrangement of FIG. 4 such that the reverse liquid flow path indicated by arrow 51A is only approximately radial. One explanation for this difference between the arrangements of FIGS. 3 and 4 is that in FIG. 4 the impeller diameter is somewhat less than in FIG. 3 and, therefore, somewhat less vane removal is required for achieving the required improvements in priming efficiency. In any case it will be apparent that a sufficient amount of vane is omitted in FIG. 4 to shorten substantially the reverse flow path and also to make it approximately radial. In the illustrated arrangement of FIG. 4 the reverse flow path 51A is approximately 45% less than the unshortened paths.

It may also be noted that the slight amount of vane overlap illustrated in FIG. 4 can usually only be tolerated in pumps equipped with diffusers having a small number of vanes. For diffusers with large numbers of vanes, no vane overlap can ordinarily be tolerated and usually it is preferred that two or more successive vanes have portions eliminated at their inner ends.

It should be understood that the description of the preferred form of the invention is for the purpose of complying with Section 112, Title 35, of the U.S. Code and that the claims should be construed as broadly as prior art will permit.

What is claimed is:

1. In a self-priming pump of the type having a rotary impeller, means for supporting said impeller for rotating about a substantially horizontal axis, wall structure defining a main chamber for a reserve of liquid in which said impeller is rotatable and defining a suction inlet communicating centrally with said impeller and a discharge outlet leading from said chamber, and a plurality of vanes spaced about the periphery of said impeller, beginning at a point in close proximity with said impeller periphery and spiraling forwardly and outwardly therefrom to a point providing substantial peripheral overlap of the beginning point of the succeeding vane, the improvement wherein only each said vane that has its beginning point originating adjacent to the lower downward sweep of said impeller periphery has said beginning point located peripherally forward in relation to the proceding vane to provide therebetween substantially radial passages from said main chamber to said impeller periphery thereby providing short direct reverse flow paths for a substantial quantity of liquid contained in said main chamber to reach said impeller periphery thereby providing optimum conditions for rapid priming of said pump.

2. A self-priming pump capable of producing a priming cycle and a pumping cycle, comprising a casing for holding reserve liquid, said casing having a suction inlet, discharge outlet, a rotary impeller capable of producing an air-liquid mixture at its periphery, a stationary diffuser, said diffuser having more than two vanes, liquid passages between said vanes communicating to and from said impeller periphery and said reserve liquid in said casing, said vanes spaced 360° about said impeller, each beginning at a point in close proximity to said impeller periphery spiraling forwardly and outwardly therefrom to a point providing substantial peripheral overlap with the beginning point of the succeeding vanes; with each of said vanes that has its beginning point originating adjacent the lower downward and bottom sweep of said impeller periphery, having said beginning point widely spaced in relation to the preceding vane thereby opening a substantially radial low resistance passage to said impeller periphery from the deepest portion of said reserve liquid to return a susbtantial quantity of air-free reserve liquid for remixing with air at said impeller periphery; other said vanes having their beginning point originating across the upward and top sweep of said impeller periphery defining normal resistance passages concurrently discharging the air liquid mixture cut off at said vane beginning point while returning a limited quantity of said reserve liquid to said impeller periphery to accomplish said priming cycle; all of said passages cooperating to discharge liquid into said reserve liquid in said casing during said pumping cycle.

3. In a self-priming centrifugal pump, a rotary impeller, means for supporting said impeller for rotation about a substantially horizontal axis, wall structure defining a main chamber for a reserve of liquid in which said impeller is rotatable and defining a suction inlet communicating centrally with said impeller and a discharge outlet leading from said chamber, and a plurality of vanes spaced in distributed relation about the entire periphery of said impeller and spiraling forwardly and outwardly therefrom to define a plurality of discharge flow passages spaced about the periphery of said impeller and communicating between said main chamber and the periphery of said impeller, the improvement wherein each vane of said plurality of vanes has an inner edge originating adjacent the impeller periphery, with each vane of said plurality of vanes that has its inner edge originating adjacent the upward and top sweeps of the impeller periphery having a substantial inner end portion disposed in peripherally overlapping relation with an outer end portion of the immediately preceding one of said plurality of vanes to provide therebetween a reverse flow path leading generally spirally from said main chamber to said impeller periphery and with at least one of said plurality of vanes having its inner edge originating adjacent the lower downward sweep of the impeller periphery and having a substantial inner end portion disposed in peripherally offset relation with an outer end portion of the immediately preceding vane to provide therebetween a substantially direct reverse radial flow path leading from said main chamber to said impeller periphery.

4. In a pump arrangement in accordance with claim 3 and wherein a diffuser disc is fixed in said wall structure and integrally mounts said plurality of vanes.

5. In a pump arrangement in according with claim 3 wherein each of two successive vanes having inner edges originating adjacent the lower downward sweep of the impeller periphery has a substantial inner end portion disposed in peripherally offset relation with an outer end portion of the immediately preceding vane.

6. In a self-priming centrifugal pump, a rotary impeller, means for supporting said impeller for rotation about a substantially horizontal axis, wall structure defining a main chamber for a reverse of liquid in which said impeller is

rotatable and defining a suction inlet communicating centrally with said impeller and a discharge outlet leading from said chamber, and a plurality of vanes spaced in distributed relation about the entire periphery of said impeller and spiraling forwardly and outwardly therefrom to define a plurality of discharge flow passages spaced about the periphery of said impeller and communicating between said main chamber and the periphery of said impeller, the improvement wherein each vane of said plurality of vanes has an inner edge originating adjacent the impeller periphery, with each vane of said plurality of vanes that has its inner edge originating adjacent the upward and top sweeps of the impeller periphery having a substantial inner end portion disposed closely adjacent the impeller periphery and in peripherally overlapping relation with an outer end portion of the immediately preceding one of said plurality of vanes to provide therebetween a reverse flow path leading generally spirally from said main chamber to said impeller periphery and with at least one of said plurality of vanes having its inner edge originating adjacent the lower downward sweep of the impeller periphery and having a substantial inner end portion disposed in spaced relation to the impeller periphery and in peripherally offset relation with an outer end portion of the immediately preceding vane to provide therebetween a substantially direct reverse radial flow path leading from said main chamber to said impeller periphery.

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