Aug. 11, 1942. H. E. LA BOUR 2,292,529

SELF-PRIMING CENTRIFUGAL PUMP

Filed Jan. 12, 1939 2 Sheets-Sheet 1

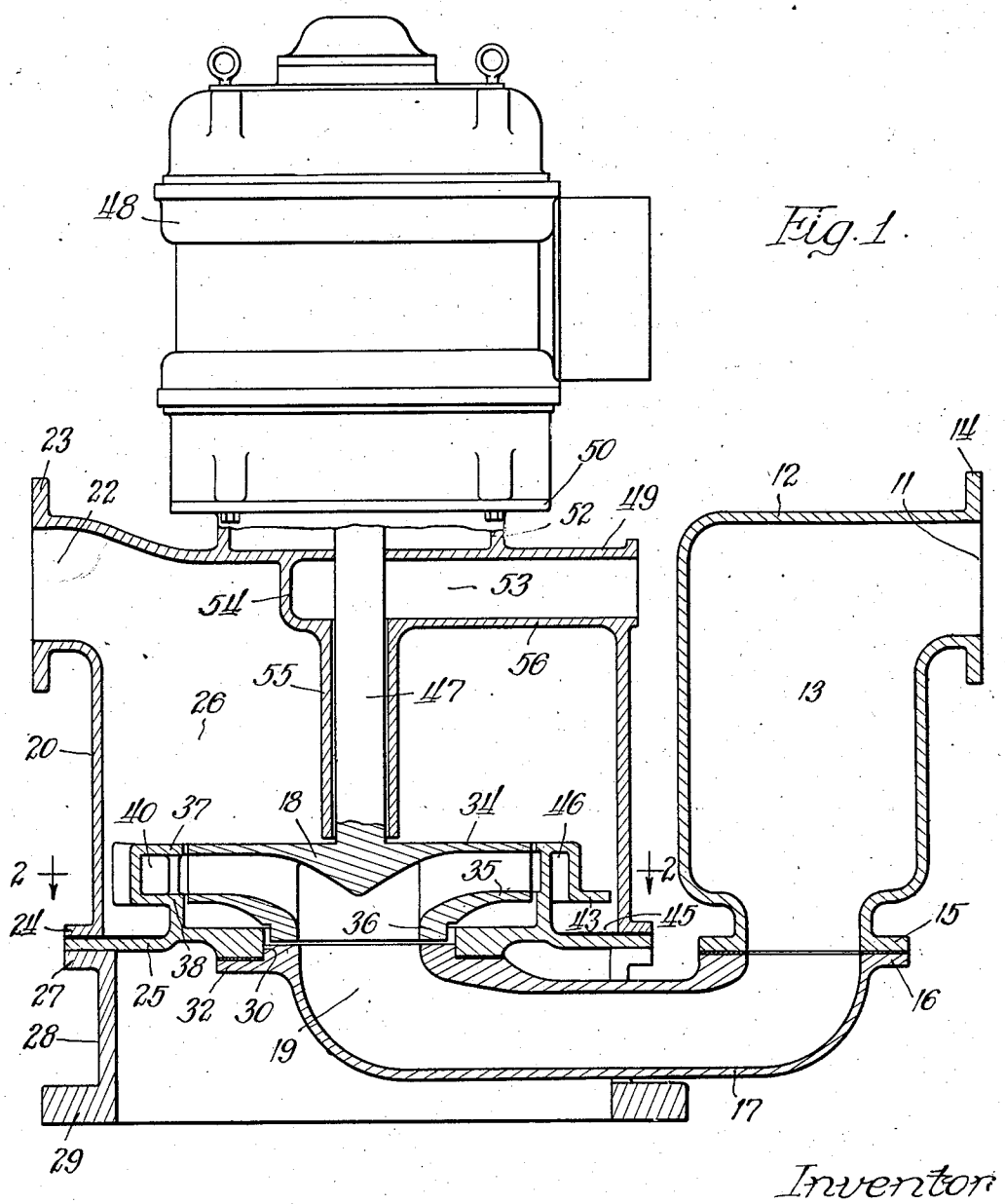


Fig. 1.

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Fig. 2.

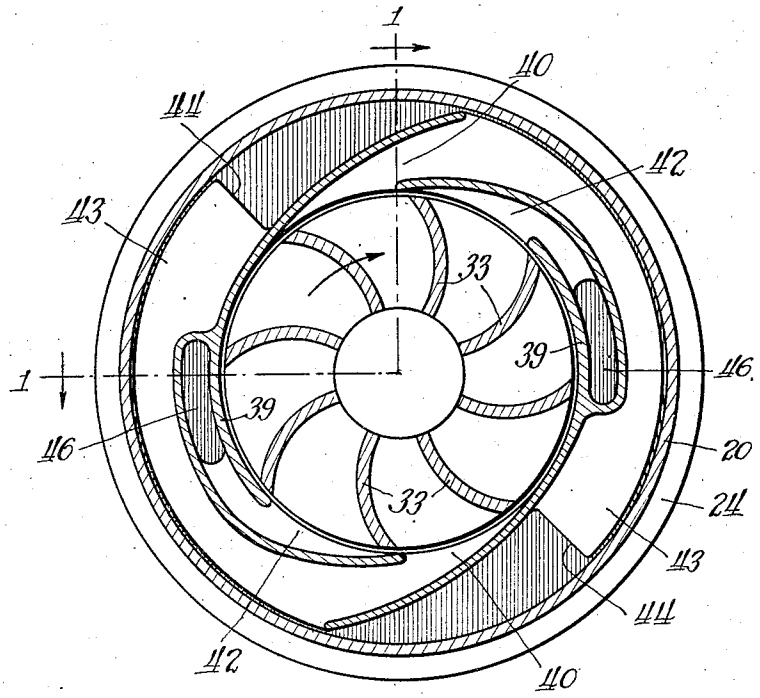
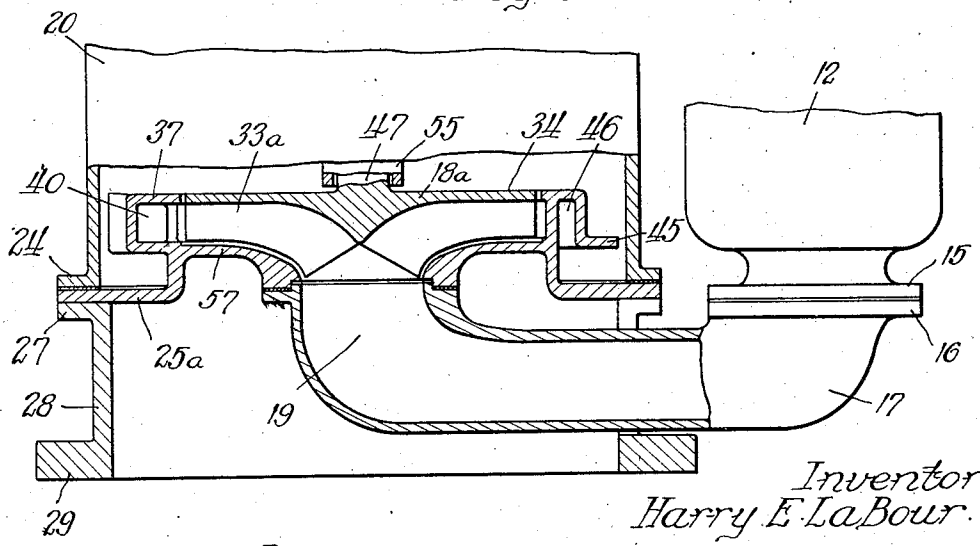


Fig. 3.



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2,292,529

SELF-PRIMING CENTRIFUGAL PUMP

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Application January 12, 1939, Serial No. 250,656

9 Claims. (Cl. 103—113)

The present invention relates to self-priming centrifugal pumps.

In the development of pumps of this class, one of the limiting factors, particularly where the pumps are employed for handling acids or other corrosive liquids, has been the shaft seal. As taught in my copending application, Serial Number 174,522, which has matured as U. S. Patent No. 2,250,714 of July 29, 1941, this limitation may be overcome by a vertical design of pump employing a liquid sealing sleeve.

The present invention aims to provide a pump of that general type, but of a different mode of applying the teaching. The prime object of the present invention is to provide a liquid sealed self-priming centrifugal pump of greater simplicity. While the present pump is designed for handling acids and corrosive liquids, i. e., to meet the severest requirements that a pump of this type generally meets, the invention is not limited to that service, and in fact lends itself to general use. Certain modifications for particular services will at once be apparent to those skilled in the art.

The present invention provides a compact vertical pump of low height. One of the particular advantages is the rapid priming by virtue of the throating arrangement and the relatively large and free separator capacity which this invention provides.

The pump of the present invention is simple to manufacture. There are few parts. They are rugged and may easily be cast and machined. This is of major importance where the material of the pump must be made of corrosion resisting metal such as high chrome alloys or the specific alloy of my prior Patent No. 2,103,855.

Further, the pump of the present invention is easily assembled and disassembled. This is of importance for servicing and particularly where a pump is installed as part of a production plant where ease of replacing a worn or corroded part is an important item.

The design here disclosed permits of simplification in providing a variety of impellers and casings, for the main castings may remain the same for a wide range of designs and capacities.

The pump of the present invention provides a high efficiency of liquid pumping by virtue of the unique throating and impeller as well as the freedom from gland friction and heating.

The pump of the present invention may be operated at markedly increased speeds without danger of destroying or injuring the packing and shaft. This increase in speed further increases promptness of priming and rate of delivery, the throating and impeller and separator arrangement permitting this to be achieved without loss of pumping efficiency.

The pump of the present invention further holds its delivery pressure over a wide range of deliveries which in many situations is a distinct advantage.

While I show herein a specific embodiment, it is to be understood that the invention is not to be limited to the specific form shown, as the form and the details may be varied.

Now in order to acquaint those skilled in the art with the manner of constructing and operating a device embodying my invention, I shall describe, in connection with the accompanying drawings, a specific form of the invention and the mode of operation thereof.

In the drawings:

Figure 1 is a vertical longitudinal section through a pump embodying the invention. The section of Figure 1 is taken on the line 1—1 of Figure 2.

Figure 2 is a horizontal cross section taken on the line 2—2 in Figure 1 looking in the direction of the arrows.

Figure 3 is a fragmentary sectional view, similar to the view of Figure 1 showing a semi-enclosed impeller.

Referring to the pump shown in Figures 1 and 2, the suction inlet 11 opens into a trap 12. This trap 12 is a hollow casting containing the base 13 forming an intake trap, that is, a trap for liquid on the intake side of the pump. The body 12 is provided with a vertical flange 14 by which the trap may be connected to a suction pipe in the well known manner. The body 12 at its lower end is provided with a clamping flange 15 by which it may be joined to the clamping flange 16 of a connection 17 of generally U-shape, which connection provides communication between the bottom of the intake trap base 13 and the interior of the impeller 18, which has its eye in communication with the inner end of the passageway 19 formed in the connection 17.

The main body of the pump in this case comprises an inverted bell-shaped casting 20 having an outlet or discharge connection 22 at its upper end. This outlet 22 has a clamping flange 23 at about the same level as the clamping flange 14 of the inlet 11. The outlet connection 22 is adapted to be connected to a discharge pipe for delivering liquid during pumping to a level above the level of the liquid supply from which the pump is adapted to raise liquid. The liquid sup-

ply is disposed at a lower level than the pump, so that it is necessary to exert a suction upon the suction pipe connected to the intake 11 in order to cause the liquid to rise from the lower level to enter the impeller 18 and to be discharged out of the discharge connection 22 to a suitable point of delivery.

The hollow bell shaped body 20 has a clamping flange 24 at its lower end by which it is adapted to be connected, either directly or indirectly, to the margin of a closure plate 25, thereby defining within the member 20 a relatively large space 26 which is the separator or separating space for separating gas from liquid during the priming phase of operation. The closure plate 25 in this case in turn rests upon the flange 27 of a base member 28, this base member 28 being in turn provided with a flange 29 by which it may be secured to a suitable foundation or foundation plate. The base member 28 may be made of relatively inexpensive metal or material, particularly where the parts in contact with corrosive liquid are made of more expensive material, but where, for example, cast iron is used for the body of the separator and for the intake trap the fitting 17 and the base 28 may be made as one casting, or may otherwise be combined into a unitary part. Likewise the intake trap 12 and the connection 17 may, if desired, be constructed integral with each other. In fact, it is contemplated within the present invention that parts may be made integral or separate as suits the convenience of manufacture, or as may be dictated by the matter of corrosion resisting qualities or the like. The closure plate 25 has a central opening 30 into which there is piloted the adjacent end of the connection 17, a suitable bolting flange 32 being provided on the end of the connection 17 for sealing it to the closure plate 25. The closure plate 25 furthermore provides, preferably integral therewith, an impeller housing and throating arrangement shown more clearly in Figure 2. This housing cooperates with the impeller 18, shown in Figures 1 and 2, in which case the impeller is a closed impeller, that is, shrouded on opposite sides of the blades 33, 33, which blades may be of more or less conventional form or any desired form, curved blades being suitable or blades substantially straight throughout the major part of their length with curved ends being suitable for this purpose. The shrouding comprises the upper plate 34 and the lower plate 35 with the blades 33 between them. The lower plate 35 has at its central part a hub 36 which enters the opening 30 in the center of the plate, and provides a suitable running clearance between the impeller and the stationary parts adjacent thereto. Suitable labyrinth seals may be employed here, as is common in pump practice. At their outer peripheries the plates 34 and 35, which are circular, approach with a running fit corresponding parts of the housing and throating arrangement through which the impeller operates during priming to receive peripherally priming liquid and to discharge a mixture of gas and liquid for evacuating the intake passageway and trap space. To this end an upper circular flange 37 lies in the same plane as the upper plate 34 of the impeller and likewise the lower plate 35 lies in line with a similar wall 38. The impeller 18 may thus be introduced in the top or removed from the top of the housing and throating structure. By reference to Figure 2 it will be seen that the housing includes a cylindrical concentric wall 39 in advance of each main discharge throat 40, there being in the specific form herein shown two such main throats 40. Immediately posterior to the main throat 40 and considered in the direction of rotation of the impeller, which in Figure 2 is clockwise, there are the corresponding auxiliary or priming throats 42, 42. Between the outlets of these two throats of each pair there is a corresponding baffle wall or plate 43. The discharge of the main throat 40 is above the baffle wall 43, freely into the separator space 26, and the discharge of the auxiliary throat during liquid pumping is below the baffle plate 43. The baffle plates 43 terminate as indicated on Figure 2 at the margins 44 in advance of the wall of the main throat 40, whereby communication between the space 45 below the baffle wall 43 and the separating space 26 above the baffle wall 43 may be free and open. The purpose of opening the auxiliary throat 42 down to the space 45, as through the openings 46, 46 shown in Figure 2, is to keep the discharge of gas-laden liquid from the main throat 40 from the re-entry stream of gas freed liquid into the auxiliary throat 42 during priming.

The impeller 18 is carried on a shaft 47 which is supported in bearings in the electric or other motor 48 which is mounted upon the top plate 49 of the separator casting 20. The motor 48 is mounted directly upon the top wall 49 of the separator casting 20, and is secured thereto by suitable flange 50 which is part of an upstanding neck or collar 52 integral with the top wall 49. Any other suitable way of securing the driving motor to the rigid frame portion of the pump structure may be employed. The shaft 47 extends down through the top wall 49. Obviously, a slinger and pocket may be arranged above the wall, if desired. Immediately below the top wall 49 there is provided an open passageway 53 which communicates at its right hand end, as shown in Figure 1, with atmosphere or with a drain pipe leading either back to the low level source of liquid or to the sewer or other waste, as may be desired. At the left hand end of passageway 53 a closure wall 54 is provided. A shaft sealing sleeve 55 extends down from the wall of the passageway 53. Thus the shaft sealing sleeve 55, which embraces the shaft 47 but does not touch the same, is rigid with the walls of the passageway 53, and these in turn are rigid with the walls of the separator casting 20. A narrow annular passageway is provided between the sleeve 55 and the shaft 47 and through this annular space liquid will flow when the separator space 26 is put under fluid pressure. However, the clearance space is relatively long and relatively restricted, with the result that leakage along the shaft may occur, but the amount thereof is controlled by the shape and length of the annular passageway. Since the shaft 47 is inserted from the bottom as viewed in Figure 1, it is apparent that the motor and the separator housing may be assembled and the impeller and its shaft then inserted and fastened to the motor shaft. The motor shaft may be hollow to receive telescopically the upper end of the impeller shaft 47. A slinger ring or disc may obviously be located upon a shoulder disposed within the pocket provided by the passageway 53 and the end wall 54.

The inner wall of the sleeve 55 may be made of such configuration as to induce eddies in the liquid in the annular space to decrease the amount of leakage at this point and to increase the sealing effect. The sleeve may be provided with radially extending flanges for the purpose of pre-

venting excessive circular flow of liquid within the separating space 26. Alternatively, baffles may be provided on the inner faces of the separator wall 20 to prevent excessive swirling, or, alternatively, the shape of the separator 20, instead of being circular in cross section, may be in the form of a square or polygon, preferably with rounded corners, to reduce the swirl and to increase the volumetric content. The particular method of providing the intake trap space 13 may obviously be varied, as will at once be apparent to those skilled in the art.

An essential of the self-priming pump is to hold the charge of priming liquid above the impeller casing in the separator 20, so that the reentry of liquid to mix with gas and to be discharged as a mixture into the separator may be secured. In those forms of the pump where the liquid to be handled is not corrosive, the trap space may be greatly reduced in volume and a check valve introduced to limit back flow if desired. Where solids in the liquid to be pumped may be encountered, the impeller is preferably made of the semi-shrouded type as shown in Figure 3, and as will be described later. Also, if desired a guiding or spiral vane may be placed on the inside of the wall 20 to direct pebbles and the like upwardly and outwardly through the discharge connection 22.

The operation of the pump shown in Figures 1 and 2 is as follows:

Assuming that a charge of liquid is supplied to the separator and intake trap whereby the same stands at a substantial distance above the top wall 34 of the impeller 18 and below the bottom wall 56 of the passageway 53, and assuming that the suction connection 11 is connected by suitable suction pipe to a source of liquid at a level below that of the pump, and that the outlet 22 is connected to a suitable discharge pipe for discharging the liquid, the motor may now be started into operation. This motor may be an electric motor or a gasoline motor, or any other driving means, or even, alternatively, a pulley and belt may be employed, if desired. In the latter case, a shaft 47 is supported in suitable bearings so as to permit the employment of a belt. The liquid is drawn by action of the impeller from the intake trap and discharged into the separator. Immediately, air follows the liquid and since the air has not the same density as liquid, the pressure which can be created by action of the centrifugal effect of the impeller 18 upon the air is not sufficient to produce an adequate discharge pressure. As a result liquid tends to flow back through the throat, both the main throat and the auxiliary throat, and encounter the rapidly rotating periphery of the impeller 18, whereupon a medium denser than air, and lighter than liquid is created and is discharged out of the main discharge throat 40, liquid continuing to reenter through the throat 42, to maintain such a mixture of gas and liquid as will be discharged at the main throat 40 into the separating space 26.

By this continued re-circulation and discharge of a mixture of gas and liquid, the gas is being freed in the separating space 26 to a large extent. The denser liquid drops down at margins 44, 44 in the plate 43, 43 to the space 45 where such denser liquid may enter through the openings 46 and into the throats 42 into contact with the periphery of the impeller to maintain the same charged with sufficient liquid to create a mixture of gas and liquid. Thus, gas is carried out continuously until the pressure of gas in the intake connections, including the suction pipe, has been brought to the point where liquid is drawn over into the intake trap and is supplied to the eye of the impeller 18, whereupon the pumping of liquid alone continues so long as the supply is available at the suction pipe.

During the operation of priming, it is to be observed that the separator space 26 is not under suction, but is substantially at atmospheric pressure or the slight head of liquid which may be maintained by liquid standing within the separator space 26. Since the level of liquid in the separator space 26 is below that of the bottom wall 56 of the waste passageway 53, liquid will not flow out through the annular space between the sleeve 55 and the shaft 47. Neither will there be an inward flow, since there is no pressure difference to create the same.

However, as soon as the impeller begins to pump liquid, as such, it fills the separator space 26 and begins to discharge liquid out of the discharge connection 22 at whatever head is required. Thereupon, the separator space 26 is put under pressure, and sealing liquid tends to flow through the annular space between the sleeve 55 and the shaft 47 into the waste passageway 53, where it may be drained back to the low level source, or it may be discharged to the sewer or other wastes. The sleeve 55 and the surface of the shaft 47, or either of them, may be provided with expedients for limiting the flow of liquid through the annular space.

The pump is peculiarly easy to construct and assemble and is simple to service. In order to remove the impeller, the discharge flange 23 may be unbolted, and likewise the flange 24 at the bottom of the separator body 20 may be unbolted, and thereupon the motor, impeller and discharge trap may be lifted as a unit. The impeller shaft 47 may then be released and the impeller removed, and/or replaced. Likewise, the closure plate 25 with the housing and throating arrangement is immediately accessible, and, if desired, may be serviced or replaced as desired.

By placing a drain cock in the bottom of the connection 17 the entire pump and all connections may be drained completely. Such a cock may be placed outside of the base member 29 at approximately the location of the reference numeral 17. This is important where acid is being handled, and where it is desirable to drain the pump completely before attempting to make repairs or to service the same.

The separator casting 20 and the plate 25 may be piloted together for greater convenience in inserting the impeller within the housing arrangement, as will be obvious to those skilled in the art.

In Figure 3 I have shown a semi-enclosed impeller 18*a* cooperating with a throating and housing arrangement on the closure plate 25*a*. The closure plate 25*a* has an annular wall 57 which lies closely adjacent the edges of the blade 33*a* with running clearance only. The impeller 18*a* thereby acts on the bottom side like an open impeller and on the top side like a closed impeller. Hence, on the open side there is no tendency for liquid to return and produce the local leakage, which is the case with a closed impeller.

Since in both forms of impellers the separator space 26 is at discharge pressure, the leakage between the top plate 34 and the cooperating flange 37 is unimportant during liquid pumping. As a matter of fact, the throating arrangement

is, during liquid pumping, mainly designed to give an orderly development of pressure, that is, conversion of flow into pressure, and hence the leakage through the gap at the periphery of the top plate 34 of the impeller is of no consequence.

The present invention relates to the self-priming type of pump wherein air evacuation is produced by entrainment of air from the suction side through recirculation of a body of trapped priming liquid which recirculation is reduced or stopped when liquid fills the pump.

According to the present invention, the suction side is sealed by submergence of the impeller and its housing in the body of liquid which is being recirculated. Hence, for the first time, so far as I am aware, no special sealing means on the suction side is required, yet the pump is tight against entry of air on the suction side during priming and liquid pumping without any rubbing parts or close clearances.

The present invention makes it possible to secure this advantage through the expedient of a combined standpipe and sealing sleeve around the impeller shaft on the discharge side of the impeller. This standpipe and sealing sleeve must perform certain functions to allow the pump to perform its necessary functions in the condition of standing idle, priming, and pumping liquid, as well as the transitions between such conditions. Among the useful effects of this standpipe and sleeve are the following:

1. When the pump is discharging liquid, the sleeve must provide a substantial restriction to outflow of liquid under pressure. For this purpose, it should comprise a gap of small radial extent, but extend axially along the shaft for a substantial distance, so as to act as an effective flow restriction.

2. The top of the sleeve preferably opens into a space where the velocity of flow of the liquid issuing along the shaft is reduced to a low value, and the pressure reduced to substantially atmospheric or other ambient pressures. This avoids forcing the pumped liquid which may be corrosive out over the pump body or into the bearings of the shaft or motor.

3. The opening of the sealing sleeve into said expansion space must not be substantially lower than the necessary level of liquid in the separator when the pump is priming. This opening should be at substantially the level of the discharge outlet, otherwise liquid would be needlessly lost at the seal, and the capacity of the separator would not be utilized.

4. When the pump is priming, or is pumping liquid, the sleeve performs the useful effect of keeping the shaft out of contact with the body of liquid in the separator. This avoids unnecessary whirling of the liquid, and prevents cavitation or the production of an air passage down through the center by whirl of the liquid.

From the above, it will be seen that I have provided a compact, efficient pump, suitable for various uses and particularly for handling corrosive liquid without the necessity for any rubbing parts.

The unit is low in height. It has a low center of gravity. It is easy to pull apart for servicing, and it is simple in construction. It provides interchangeable throating, since the closure plate 25 and impellers may be changed to various forms without changing any of the main parts of the pump. The pump provides a high efficiency in both priming and particularly in liquid pumping, and provides, because of the multiple throat arrangement, a rapid evacuation of air and high rate of priming.

I do not intend to be limited to the details shown and described, except as they are recited as essentials in the following claims.

I claim:

1. In a self-priming centrifugal pump, the combination of a horizontally disposed plate having a central inlet opening for a suction connection, walls defining an open topped housing for a vertical impeller mounted on the plate, said housing having a circular wall providing a circular opening at its top, said housing comprising a plurality of pairs of throats opening tangentially from the inside of the circular wall, each pair comprising a main discharge throat and an auxiliary throat which serves to permit reentry into the impeller housing of priming liquid during priming, each pair of throats having a baffle wall between their outer ends for deflecting the discharge of a mixture of gas and liquid from the main throat above the reentry flow of liquid back through the auxiliary throat during priming, a vertical impeller having a disc on its top side cooperating with said housing to close said opening with mechanical clearance between them, a separator and discharge chamber of inverted cup shape joined to the margins of the said plate, and a driving shaft for the impeller extending through the top wall of said chamber.

2. In a centrifugal self-priming pump of the vertical type, the combination of a hollow separator body of inverted cup shape, a closure member having its margins adapted to be clamped to the open lower end of the said body and having a downwardly facing central opening, a base supporting said member, a hollow U-shaped suction connection having one leg connected with said opening and a suction trap connected to the other leg, an impeller housing mounted on the top side of said closure, said housing being throated to permit peripheral reentry of priming liquid from the separator to the impeller during priming, an impeller disposed in and cooperating with said housing, and a vertical impeller shaft extending through the top wall of the separator body.

3. The combination of claim 2 wherein the housing comprises a plurality of pairs of substantially tangential discharge passageways, each pair comprising a main passageway and an auxiliary passageway, a circular concentric wall in advance of each main passageway, which circular concentric wall is swept by the impeller, and means for segregating the discharge of the main passageways from the reentry flow of liquid to the auxiliary passageways during priming.

4. The combination of claim 2, wherein the impeller is formed with open blades on its bottom side and with a circular disc shrouding on the top side and the impeller housing has a circular opening at its top which embraces the shrouding disk with mechanical clearance to close the top of the housing.

5. In a vertical centrifugal self-priming pump having a hollow casing comprising means to trap a priming charge of liquid for cooperation with the impeller in the continuous removal of air from the inlet side of the pump by the entrainment of said air in priming liquid and discharge of the mixture from the impeller, said means comprising a separator and an inlet trap, an impeller shrouded on at least its upper side disposed between the inlet trap and the separator,

a vertical impeller shaft, and a cooperating impeller housing with an opening at its top side of substantially the same diameter as the impeller shrouding, said opening being substantially closed by said shrouding.

6. In a vertical self-priming centrifugal pump, an impeller housing having a central inlet opening downwardly and having discharge and reentry means for the circulation of priming liquid to remove air from the inlet during priming, an impeller in the housing, a vertical impeller shaft, a trapped inlet connection communicating with said inlet opening, a closed separator having a top outlet and being joined to said impeller housing and adapted to trap and retain a body of priming liquid which seals the impeller housing against the entry of air during priming, the separator at its lower end communicating with said discharge and reentry means.

7. In a vertical self-priming centrifugal pump, the combination of an impeller housing, a cooperating impeller therein, a vertical shaft for said impeller, said housing having a central inlet which opens downwardly and having peripherally disposed discharge and reentry means for the circulation of priming liquid through the housing to remove air from the inlet side of the pump by entrainment during priming, a trapped inlet connection communicating with said inlet opening, a closed separator having a top outlet for gas and liquid, said separator having sidewalls spaced from the sides of the impeller housing to provide an approximately annular space in communication with the discharge means of the impeller housing and having a bottom wall which forms a closure with the inlet side of the impeller housing, said separator being adapted to trap and retain a body of priming liquid which seals the impeller housing against the entry of air from the discharge side, and serves as the air entraining and removing medium during priming.

8. A vertical self-priming centrifugal pump comprising an impeller housing having a central inlet opening facing downward and a peripheral outlet, an inlet trap communicating with said inlet opening, said housing having a circular opening at its top side, an impeller having a circular shrouding wall at its upper side substantially closing said opening, a shaft for the impeller, a separator chamber enclosing said housing and communicating with said outlet, and having means for retaining a charge of priming liquid which seals the impeller to the casing against entry of air during priming, said impeller housing being submerged in said charge of priming liquid in the separator.

9. In a self-priming centrifugal pump, a main casing in which there is a closed discharge chamber provided with a discharge opening at its upper end, a vertical impeller shaft, an impeller carried thereby, said impeller being shrouded on at least its upper side, an impeller housing with a central inlet at the bottom and an opening in the top, said opening being substantially closed by said shrouding on the upper side of the impeller, the housing having a main discharge outlet and an auxiliary discharge outlet both opening into said chamber, said auxiliary outlet being adapted to admit reentry of priming liquid into the housing during priming, and said impeller and housing cooperating to produce a mixture of air with the reentered liquid in the housing and to discharge the mixture through the main outlet during priming, said discharge chamber cooperating with the housing and serving to retain a charge of priming liquid and to permit separation of air from said liquid during priming.

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