

July 29, 1941.

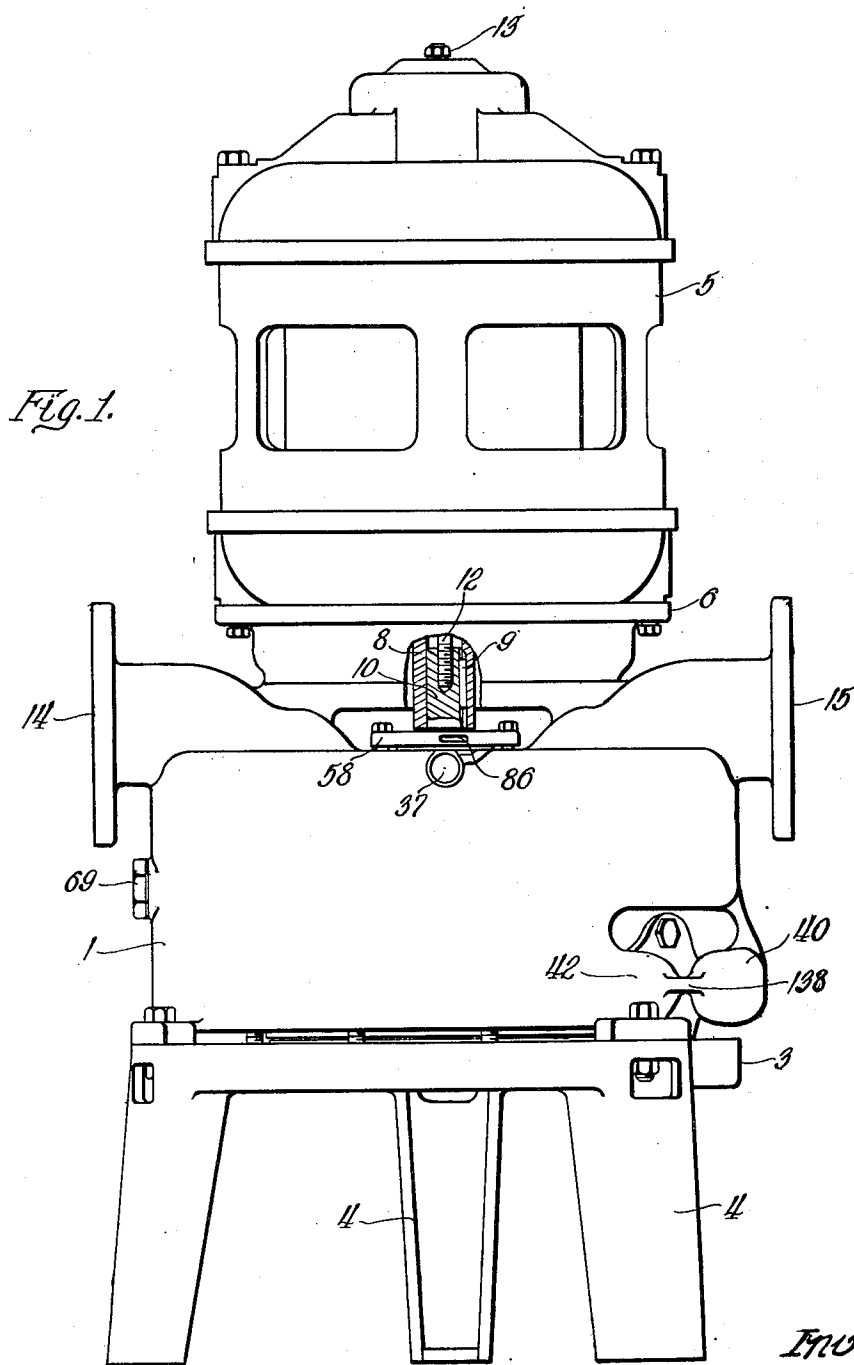
H. E. LA BOUR

2,250,714

CENTRIFUGAL PUMP

Filed Nov. 15, 1937

7 Sheets-Sheet 1



Inventor:
Harty E. LaBour
By Brown, Jackson, Butcher & O'Connell
Attys.

July 29, 1941.

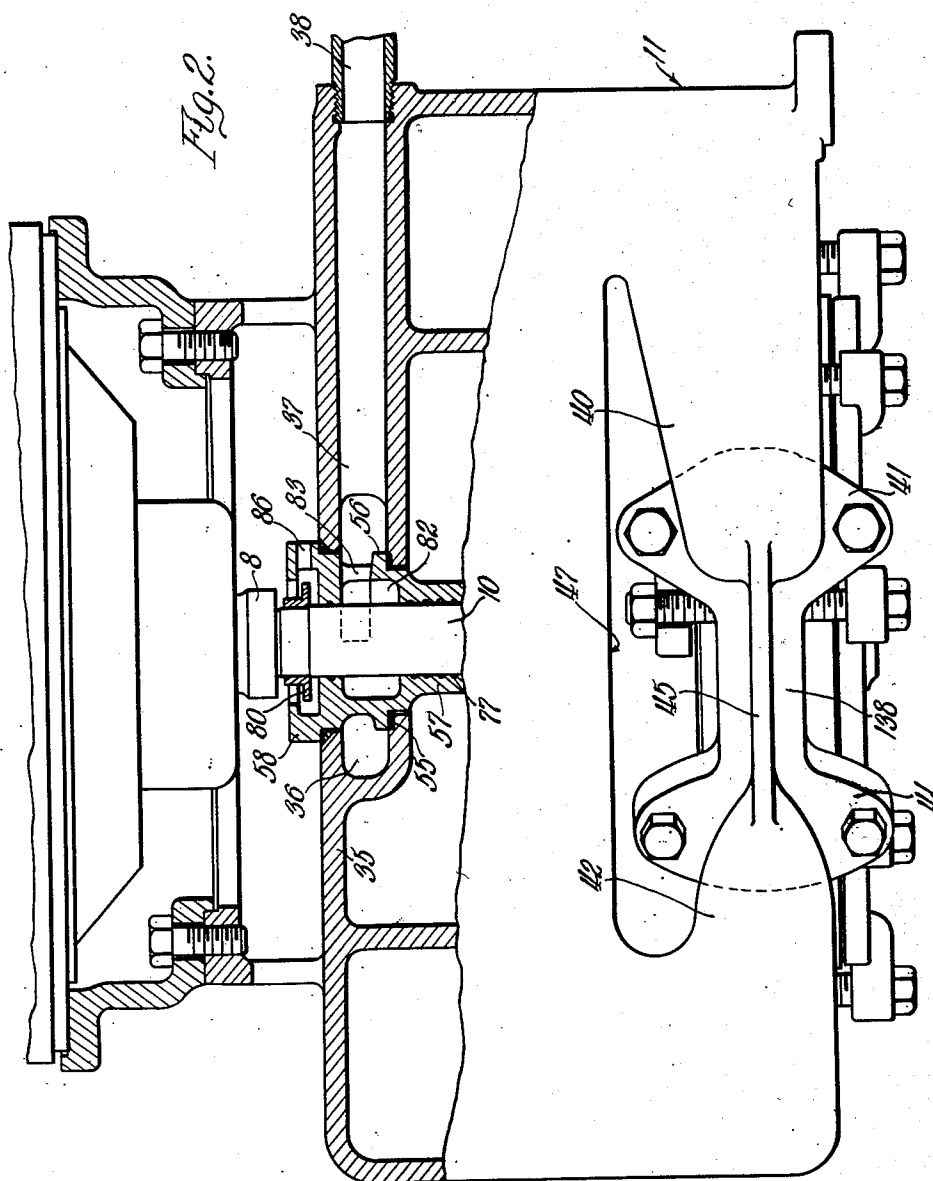
H. E. LA BOUR

2,250,714

CENTRIFUGAL PUMP

Filed Nov. 15, 1937

7 Sheets-Sheet 2



Inventor
Harry E. La Bour
By Brown, Jackson, Butcher & Quinn
Attys.

July 29, 1941.

H. E. LA BOUR

2,250,714

CENTRIFUGAL PUMP

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7 Sheets-Sheet 3

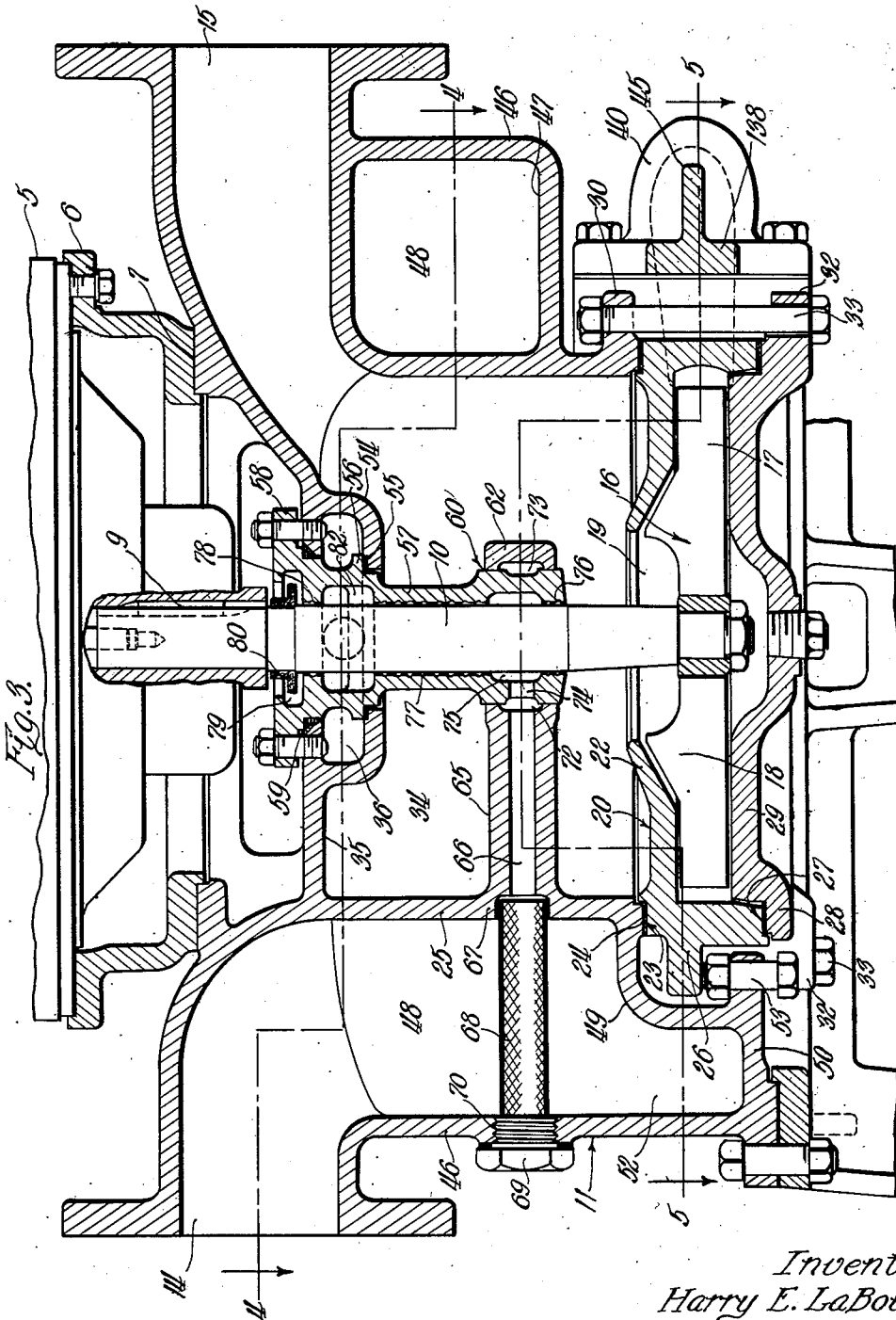


FIG. 3.

Inventor:
Harry E. LaBour

By Brown, Jackson, Bottcher & Quinn
Attys.

July 29, 1941.

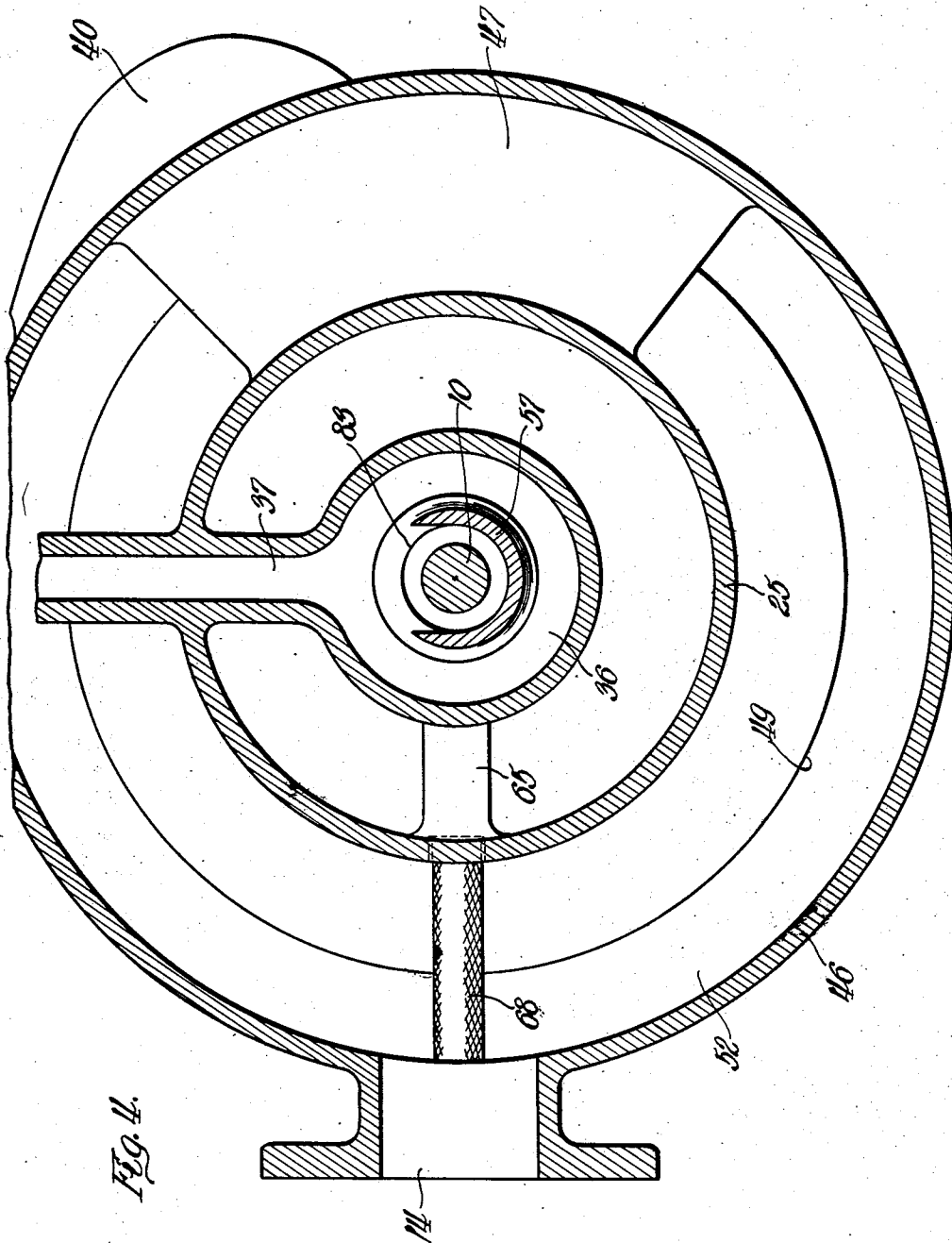
H. E. LA BOUR

2,250,714

CENTRIFUGAL PUMP

Filed Nov. 15, 1937

7 Sheets-Sheet 4



Inventor:
Harry E. LaBour

By *Brown, Jackson, Butcher & Quinn*
Attys.

July 29, 1941.

H. E. LA BOUR

2,250,714

CENTRIFUGAL PUMP

Filed Nov. 15, 1937

7 Sheets-Sheet 5

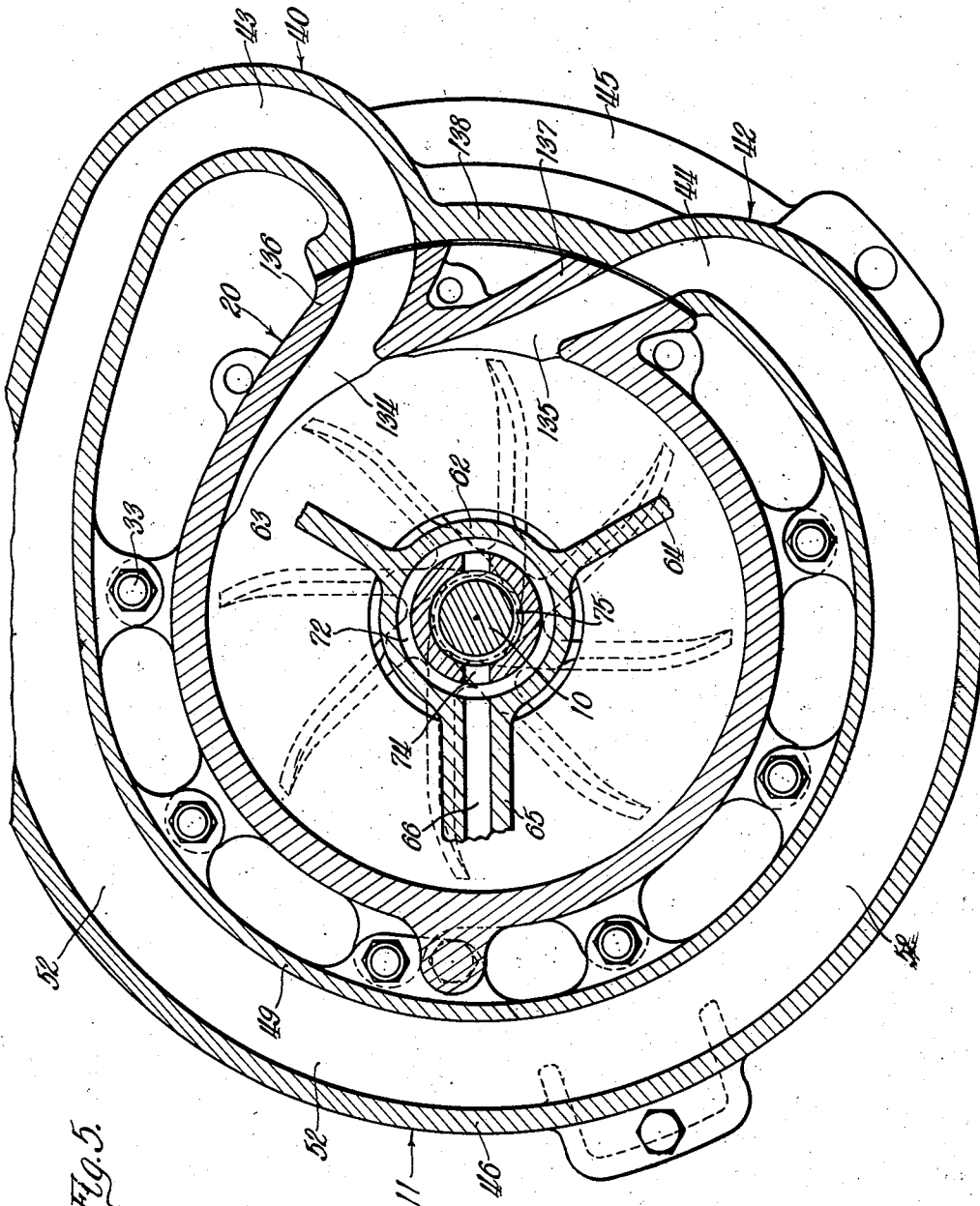


Fig. 5.

Inventor:
Harry E. La Bour

By Brown, Jackson, Butcher & O'Connell
Attys.

July 29, 1941.

H. E. LA BOUR

2,250,714

CENTRIFUGAL PUMP

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Fig. 7.

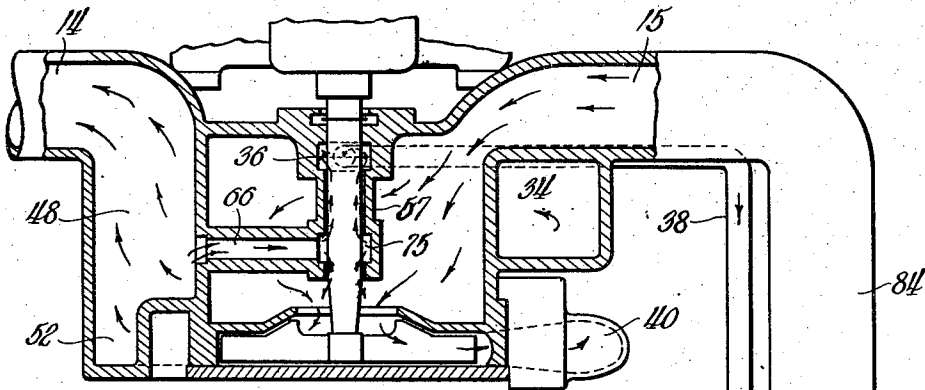
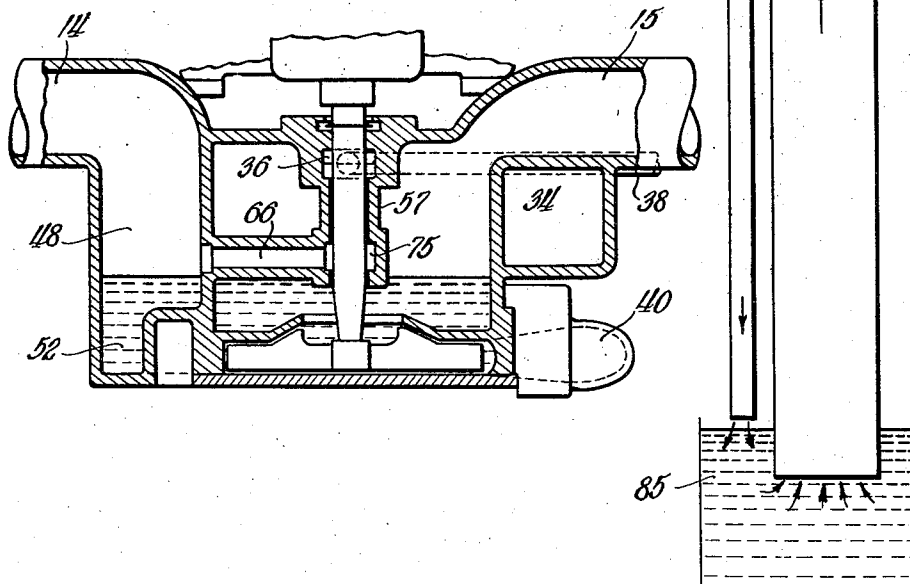


Fig. 6.



Inventor:
Harry E. LaBour

By *Brown, Jackson, Mitchell & Dixon*
Attys.

July 29, 1941.

H. E. LA BOUR

2,250,714

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7 Sheets-Sheet 7

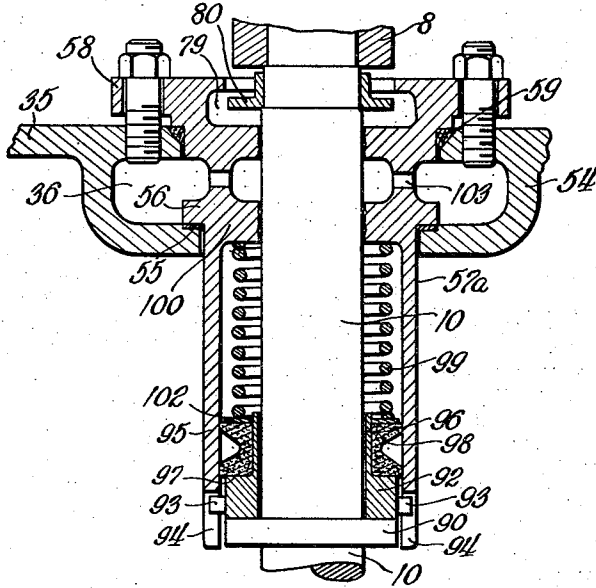


Fig. 8.

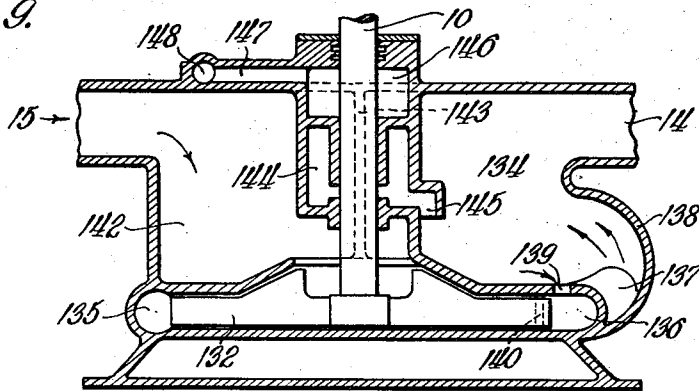


Fig. 9.

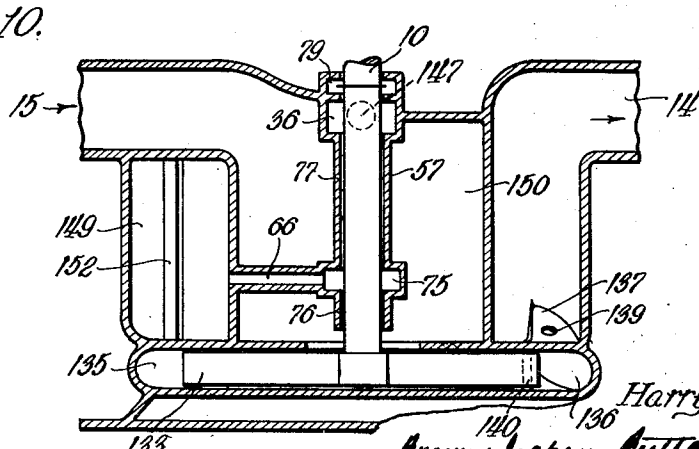


Fig. 10.

Inventor:

Harry E. LaBour

By *Brown, Jackson, Butcher & O'Connell*
Attys.

UNITED STATES PATENT OFFICE

2,250,714

CENTRIFUGAL PUMP

Harry E. La Bour, Elkhart, Ind.

Application November 15, 1937, Serial No. 174,522

18 Claims. (Cl. 103—113)

My invention relates to centrifugal pumps which are provided with means for trapping a charge of priming liquid by the use of which the pump is adapted to evacuate its suction pipe of air and pump liquid from a level below the intake of the pump.

The invention is particularly concerned with the provision of a vertical pump of the above type which is provided with means for sealing its own shaft with liquid by the double use of the trapped charge of priming liquid. This provides a unitary installation entirely automatic in its operation and due to the complete elimination of fibrous or other solid packing, of great utility, particularly for the handling of corrosive liquids, as well as for general service in pumping liquids.

While I have shown as the preferred embodiment a self-priming centrifugal pump operating on the peripheral reentry or hydraulic balance principle, this is by way of illustration, and not by way of limitation. The particular manner of priming is not the essence of this phase of the invention.

Centrifugal pumps are frequently employed for handling acids, alkalis, salts and corrosive fluids in general. Corrosive liquids tend to destroy fibrous packing and no adequate means for sealing the shafts of pumps employed in this service have heretofore been provided.

I am aware that it has been proposed heretofore to dispense with fibrous packing and to seal the shaft of a pump with liquid, but for centrifugal pumps called upon to raise liquid from a lower level by suction such provisions as have heretofore been made are not adequate, and for handling corrosive liquids, quite useless.

I am aware also that it has been proposed to dispose a centrifugal pump of the self-priming type in a vertical position, i. e., with the shaft vertical. Hence, I do not claim either of the above features as my invention.

In the preferred form of my invention, I employ a vertical self-priming centrifugal pump of the liquid recirculating type, having an intake trap and a discharge trap which latter serves as a gas separator. The shaft seal is formed by a sleeve surrounding a part of the shaft and providing a narrow annular liquid sealing gap and extending through the wall of the intake trap or intake connection, so that the inner end of the sleeve is subjected to the pressure prevailing in the intake trap or connection, and the outer end is subjected to atmospheric pressure, being preferably provided with an overflow chamber and an overflow connection leading back down to the source of liquid to be pumped.

Now when a pump of this class is started into operation, the circulation of the priming liquid by the impeller begins to evacuate air from the

casing and if the suction pipe be sealed with liquid it tends to produce a partial vacuum and thereby raise the liquid to the level of the pump. But if the shaft is not sealed, air can enter along the shaft and prevent building up or destroy the suction.

According to the preferred form of my invention, I employ a duct or connection for sealing liquid which extends from a point in the pump casing where sufficient hydraulic head is developed upon rotation of the impeller to convey sealing liquid into the annular gap to prevent entry of air during suction.

That is to say, the trapped liquid by which the pump primes itself serves a dual purpose. As soon as the impeller starts to rotate it drives the trapped liquid into the discharge trap or separator. At the same time some of the trapped liquid is caused to flow into the sealing gap and is drawn back into the intake side of the pump. Thereby the pump both seals and begins to prime itself as soon as the impeller is started. This function is new and of great utility.

In the practical operation of such a pump the pump is disposed above the source of liquid to be pumped and the connected discharge pipe is extended horizontally to discharge the liquid at a suitable level above the source. No check valves or valves of any kind are required, and as soon as the impeller stops rotating, the liquid may drain back through the pump, sufficient thereof being retained by the intake and discharge traps to form a suitable priming and sealing charge. The runback of pressure may result in a positive pressure above atmosphere in the pump casing and upon the inner end of the sealing gap, but whatever outflow occurs at this stage is relatively small, and it merely drains back to the source. If the suction pipe is unsealed while the pump is running as by failure of the supply, the pump will nevertheless trap a charge of priming liquid which is retained for the priming operation.

The sealing sleeve extends upwardly high enough that the overflow outlet lies above the atmospheric level at which liquid is trapped in the pump casing. Hence the trapped liquid will not escape when the pump is idle.

In the preferred form of the invention, the lower end of the sealing sleeve extends below the level of trapped liquid, but this is optional. The duct or connection for supplying liquid to the sealing sleeve preferably leads from the discharge trap to the sleeve so that liquid may flow by gravity when the pump is started, but this may be varied since the duct may lead from any point below the level of the liquid where sufficient hydraulic gradient is secured to cause sealing liquid to flow into the gap when the pump operates.

In the preferred form, the liquid supply duct or connection opens into the sleeve intermediate the ends of the sealing gap. The sealing liquid if it is under sufficient hydraulic head, as in liquid pumping, can flow both ways from the point where the duct opens into the gap. The downward flow is sufficient to seal during priming and the upward flow which occurs only when there is liquid pumping or back flow after operation merely escapes to the overflow. Each flow is relatively negligible on the efficiency of the pump. In fact the friction of the usual fibrous packing is frequently a greater loss than the loss occasioned by the sealing flow.

In the pump of the present invention I dispense with fibrous or other packing and substitute an open but flow-restricting gap. I deliberately permit flow of a part of the output of the pump through that gap. When the pump is disposed above the source of liquid, being a self-priming pump, it is readily seen that this runoff of liquid can, in case of liquids of any value, be conveyed by gravity back to the source, or, if of no value, to the sewer. I purposely make provision for such runback or runoff liquid. The gap provides the freedom from rubbing contact. The internal recirculation and the external runback or runoff, as the case may be, is the price which I pay for the freedom from rubbing contact. This organization has proven to be particularly advantageous for handling acids and the like. Location of the pump above the source of liquid is only one specific example of the capability of the pump to operate its suction under less than atmospheric pressure during priming and pumping. Other examples are vacuum filter or vacuum evaporators or vacuum heating systems. The pump may, in the latter examples, be located at any suitable point and the runback or runoff effected by the vacuum.

The present invention further embodies numerous features of novelty relating mainly to the construction of a novel form of self-priming pump.

A valuable characteristic of a self-priming pump of the type herein illustrated is the ability to continue to evacuate air until the suction is high enough to fill the suction pipe. Also the self-priming pump is not incapacitated by unsealing of the suction pipe as by failure of liquid at the source or the entry of slugs of gas during pumping.

The chief object of the present invention is the provision of a self-priming centrifugal pump which is capable of sealing its shaft with liquid as soon as the priming operation is initiated and which sealing action persists as long as the pump is in operation.

A further object is to make the pump automatically self-priming and self-sealing without the necessity for any attendance. In the preferred embodiment these actions are secured by a self-contained device which operates entirely automatically, and wherein both actions take place as soon as the impeller is rotated.

An object of the present invention is to provide an effective and compact vertical form of self-priming centrifugal pump. So far as I am aware, no self-priming open impeller type of centrifugal pump with vertical drive shaft has been developed heretofore. For handling chemicals or for disposal in restricted floor space this form of pump has marked virtues.

A further object is to provide a novel form of

pump body which permits of compactness and convenience of manufacture.

Another object is to provide a novel form of separator and a new and advantageous method of separation therein. This separator cooperates with the liquid supply means for the shaft seal.

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 embodiment of the same.

In the drawings:

Figure 1 is a side elevational view with a part cut away, of the vertical pump of my invention with the motor superposed;

Figure 2 is a side elevational view of the pump body with the parts in section to show the top of the liquid seal for the shaft and the overflow thereof;

Figure 3 is a longitudinal vertical section through the pump shown in Figures 1 and 2;

Figure 4 is a horizontal section taken on the line 4-4 of Figure 3;

Figure 5 is a horizontal cross-section taken on the line 5-5 of Figure 3;

Figure 6 is a diagrammatic cross-section showing the pump idle with a charge of liquid retained therein;

Figure 7 shows the pump in cross-sectional view as operating to pump liquid;

Figure 8 is a vertical longitudinal section through a modified form of seal;

Figure 9 is a vertical diagrammatic section through a modified form of pump of my invention; and

Figure 10 is a diagrammatic illustration of another modification of my invention.

Referring first to Figure 1, I illustrates a vertical form of self-priming pump supported upon a base 3 having suitable supporting legs 4-4. Obviously, the base may be varied and the pump may be mounted on any suitable support or foundation. A vertical motor 5 is mounted by means of an adapter ring 6 upon a circular seat 7 formed on top of the pump. The motor shaft 8 has a socket which is provided with a key 9 which fits in a keyway in the socket and in a keyway formed in the impeller shaft 10. A suitable bolt or threaded rod 12 extends through the motor shaft and holds the motor shaft and impeller shaft together, the upper end of this rod or bolt being indicated at 13 in Figure 1. This detail may obviously be varied.

The motor 5 may be any suitable form of electric motor or it may, as a matter of fact, be any preferred form of motor, such as an internal combustion engine or the like. It is carried above the pump, well out of the way of spatter, drip, or the like, in a highly advantageous position. It will be observed that the floor space occupied by this unit is very considerably less than if the unit were laid on its side. Also, the freedom for making connection with the discharge connection 14 and the inlet connection 15 is noticeably superior to a horizontally mounted unit. These connections 14 and 15 are integral extensions of the pump casing provided with suitable pipe flanges for coupling to pipe, hose, or the like.

The impeller shaft 10 supports, at its lower end, a multi-blade impeller 16 which may be of any suitable or preferred design, as shown in Figures 3 and 5, a standard eight-bladed impeller of a construction heretofore employed by me and shown in detail in my co-pending application,

Serial No. 751,445, filed, November 5, 1934, which has matured in Patent No. 2,134,254, is employed herein. This impeller comprises relative straight blades with the ends thereof curved backward with respect to the direction of rotation. The curvature of the blades may optionally be varied. The outer portions of the arms or blades as indicated at 17 are of the same width or depth and towards the center the blade widens, as indicated at 18 (see Figure 3). A central recess 19 is formed in the impeller to facilitate the entry of liquid. This impeller 16 is disposed between two side plate members which, for convenience in manufacture, are separate parts. The upper plate member 20 has a conical or flared portion 21 adjacent the inlet pocket 19 in the impeller. It fits the top of the impeller with mechanical clearance only.

The circular finished seat 23 cooperates with a finished seat 24 formed on the lower end of the cylindrical wall 25 which forms a part of the main body of the pump. The member 20 has an annular flange extending downwardly to form the main part of the pump casing, this flange 26 being machined to provide a circular seat 27 which cooperates with the finished seat on the flange 28 of the bottom plate 29. A series of mating ears or lugs 30 and 32 are formed on the pump body and on the bottom plate 29, respectively, and bolts 33 clamp these three parts together, thereby forming a casing for the impeller and closing off the bottom of the chamber 34 which constitutes the intake trap or chamber communicating, at the upper right hand corner as viewed in Fig. 3, with the intake or suction connection 15 that leads to a suitable source of liquid to be pumped. A generally horizontal wall 35 closes the top of the intake trap 34, this wall forming a continuation of both the outlet connection 14 and the inlet connection 15. At its central part the wall 35 is formed into a hub-like enlargement containing an annular chamber 36 which is the overflow or drainage chamber. This drainage chamber 36, as will be described more in detail later, communicates through a tubular passageway 37 with an overflow or drainage pipe 38 (see Fig. 2).

The main part of the impeller casing 20—26 provides a peripheral cylindrical wall throughout the major part of the periphery of the impeller, the inside periphery of the flange or cylindrical wall having a suitable clearance with the ends of the impeller blades 16 which is slightly in excess of mechanical clearance, although this may vary. At the point 134 there is formed a main discharge throat for the medium operated upon by the impeller and posteriorly in the direction of rotation there is formed a secondary discharge throat 135 which serves as a priming throat during the priming stage of operation of the pump. The cylindrical portion 26 of the main impeller housing 20 has the short necks or bosses 136 and 137 formed thereupon and these are finished off to a suitable clamping surface, in this case shown as concentric with the axis of the main shaft 10, to be engaged by a clamping plate 138 formed integrally with the main casting or frame, which is designated 11. This clamping plate 138 has suitable clamping flanges 41—41 formed integral with the main body 11 which main body has the tubular or hollow extensions 40 and 42 which have passageways communicating with the throats 134 and 135, respectively. These two tubular members 40 and 42, which contain the passageways 43 and 44 are joined

by the integral part of the clamp 138 and by reinforcing flange 45 (see Figures 2 and 5).

The main pump body 11 comprises an outer cylindrical wall 46 which is coaxial with the shaft 10 and defines a complete cylinder down to the annular horizontal wall 47 which horizontal wall 47 does not extend completely around the body but joins the tubular or hollow extensions 40 and 42 as is shown in Figure 2. There is defined between the circular coaxial wall 25 and the circular coaxial wall 46 a separating chamber the bottom of which is formed at the right of Figure 3 by the bottom wall 47 but throughout the major part of the circumference the bottom of this hollow separating space 48 is defined by the curved annular wall 49 and the horizontal annular wall 50, (see Figure 3). The relatively narrow circular space 52 is defined between the outer cylindrical wall 46, the inner wall 49 and the bottom wall 50. This circular space in the bottom of the separating chamber is termed the "dead pocket," for the reason that the heavier liquid tends to gravitate into the same during priming and in conjunction with the passageways 43 and 44 this circular channel 52 forms a direct connection between the main throat 134 and the auxiliary or priming throat 135. By reference to Figure 2 it will be observed that the throats and passageways expand gradually in a vertical direction, whereby the velocity of the liquid outflowing from them is gradually reduced as they enter the separating chamber. Hence there is little tendency to form eddies by opposition of the two streams when the pump is operating to pump liquid.

It is to be observed that the impeller chamber may be varied in construction. For example, the peripheral wall 26 might be formed integral with the bottom plate 29 instead of with the top plate 20. Also it is to be observed that instead of a radial clamping action between the main body section 11 and the impeller casing body, the passageways might be split on a horizontal plane and the clamping secured entirely by vertical pressure or clamping action.

Considering the pump thus far described as a self-priming centrifugal pump, the operation is as follows: Assume that the intake 15 is connected to a suitable suction pipe which is sealed with liquid to be pumped and this liquid is disposed at a level below that of the pump. Assume that the pump has been charged with priming liquid substantially as shown in Figure 6. Thereupon, on starting the motor 5 and rotating the impeller 16 through the shaft 10, liquid will be drawn from the chamber 34 and expelled through the two passageways 134 and 135 into the annular space 52 and 48. The impeller thereby being cleared of liquid, a small drop in pressure has been produced by the displacement thus produced and the gravitational effect of the liquid tends to cause liquid to return through the passageways 43 and 44 into the throats 135 and 134, where the impeller, rapidly rotating, engages the same. Since the throat 134 is in advance of the throat 135 and since the two throats are substantially in opposition, the throat 134 will immediately seize the precedence and will cause a flow of liquid outwardly through the throat 134 and passageway 43 in the form of a mixture produced by the impact of the blades operating upon the return liquid through the throat 135 and the air in the impeller casing. The mixture is thus driven out through the throat 134 and liquid tends to flow in through

the throat 135, inducing an orderly and immediate priming action. This pump thereby tends to avoid the low vacuum or starting stall which sometimes occurs in self-priming pumps. The flow of liquid out through the passageway 43 into the space 52 and 48 tends to create a plenum of pressure upon the throat 135, slight in amount but having the desired tendency of causing inflow of liquid through the throat 135 to establish the priming circulation. Because of the long circuitous path from the throat 134 through the annular space 52 to the throat 135, there is a tendency for the mixture to rise above the more solid liquid disposed in the channel which I have termed the dead pocket 52. The continued carrying out of air by mixture with the priming liquid coming in at 135 and being ejected at 134 and separated in the space 52—48, results in the creation of a suction in the intake chamber 34 and connected intake passageway 15 until liquid is raised into the intake chamber 34 and then enters the impeller through the central opening in the top plate 20. Thereupon the impeller begins to discharge liquid at both throats 134 and 135 and liquid thereupon fills the space 48 and is discharged out through the discharge connection 14. The pumping of liquid then proceeds. In the event that the pump is shut down liquid tends to flow back through the discharge connection 14, reducing the level in the chamber 48 and 52 to the point of allowing air to be drawn back through the throats 134 and 135, or either of them, and to pass up through the liquid in the intake chamber 34 and to break the suction in the passageway 15 and in the suction pipe. Pumps of this character require no foot valves. Where corrosive liquids or the like are handled all valves or the like are highly undesirable.

It is to be observed that the pump so far described constitutes a novel and highly advantageous form of self-priming pump, assuming that only a conventional packing gland were employed to seal the shaft 10 to the casing of the chamber 34. However, it is observed that if conventional packing were employed, space would have to be provided for access to the packing gland, unless in each case such a packing gland were to be repacked or inspected the motor or parts thereof would have to be raised out of the way. By the provision of the novel form of packing gland of the present invention the pump and motor unit is made exceedingly compact and the disadvantages of solid or fibrous packing, that is, a packed rotary joint for keeping a fluid-tight connection between the revolving shaft and casing, are avoided.

Referring now to the particular features which provide the liquid seal between the rotating shaft and the pump casing, it is to be observed that since there is available a plenum of pressure as soon as the impeller 16 is rotated to drive liquid into the discharge chamber 48, this source of liquid for sealing the gap is employed, although it is to be understood that other provisions may be made for securing a source of liquid to maintain the seal when the pump is in operation. Also it is to be observed that while I have shown an intake trap and discharge chamber on substantially the same level, the discharge chamber might be on a considerably higher level if desired, or other means, under special circumstances may be relied upon for maintaining a working body of liquid in the pump in contact with the impeller, so that the pump may start its

operation, that is, may begin to pump liquid automatically.

The annular pocket or groove 36 formed in the hub-like extension 54 on the top plate 35 has a seat 55 which is adapted to be engaged by an annular flange 56 of a barrel member 57. This barrel member has a flange 58 at its upper end and beneath the flange there is provision for a yielding packing 59 whereby the barrel member 57 may make a tight joint at the seat 55 and a substantially tight joint at the packing 59.

The lower end of the barrel 57 has a cylindrical or slightly tapered machined surface 60 which fits closely in a ringlike member 62 supported preferably on three legs 63, 64 and 65 (see Figure 5). The manner of supporting this member 62 may obviously be varied. The leg 65 is hollow, having a passageway 66 therein. This passageway 66 leads to a recess 67 into which is seated a cylindrical screen member 68 mounted at its outer end upon a plug 69 which closes a threaded opening 70 in the wall 46. The plug 69 is a convenient method of supporting a removable screen to prevent impurities from getting into the liquid seal. The passageway 66 which thus communicates through the screen 68 with the discharge chamber, communicates at its inner end through a pair of mating annular grooves 72 and 73 with radial ports 74 which open into a groove or annular chamber 75 in the lower end of the barrel member 57. If a separate source of liquid is desired, a delivery tube may be introduced through the opening which is here shown as closed by the plug 69. Such tube then seats in recess 67 to communicate with the liquid supply passageway 66 and chamber 75. The barrel member 57 has the lower supply pocket 75 and the upper or overflow pocket 82 and the liquid slinger pocket 79, which pocket 79 is open at the top for overflow of liquid if difficulty should develop in the liquid seal and thereby giving an indication of trouble.

There is a flow constriction 76, namely, a fairly close fit, between the supply pocket 75 and the intake trap or suction side of the impeller 16. This constriction limits the flow of liquid at the pressure difference between the discharge chamber 48 and the intake chamber 34, but maintains a gas-tight seal at all times so long as the pump is operating upon liquid, even during priming, or so long as liquid is supplied to pocket 75 from any source. There is another constriction 77 of a similar character between the supply pocket 75 and the overflow or discharge pocket 82 in the barrel 57 tending to limit the flow of liquid from the supply pocket 75 which is substantially at discharge pressure, suitable labyrinth grooves may be employed at these constrictions. The pressure in the discharge or overflow pocket 82 and its communicating pocket 36 in the pump body is substantially atmospheric due to a relatively large opening 83 (see Figure 2) and the communication of the groove or overflow chamber 36 with the passageway 37 and drain pipe 38 which is intended to be entirely without restriction with respect to any amount of liquid that can be forced through the clearance between the barrel 57 and the shaft 10 along the restriction 77.

There is a further restriction 78 between the discharge or overflow pocket 82 and the slinger chamber 79, but this is not of primary importance. The slinger 80 which is fastened on and moves with the shaft 10 tends to prevent any

film of liquid from rising along the shaft 10 above the slinger pocket, where it would tend to creep to the motor shaft. Any liquid thrown off in the slinger pocket 79 by the rapidly rotating slinger 80 flows out through the drain opening 86, see Fig. 2, revealing a condition which should be cured.

The operation of the liquid seal is illustrated in Figures 6 and 7. Assume that the parts are in the position shown in Fig. 6 when the pump is at rest and the trapped liquid extends to the level indicated. At this time, no seal is necessary but obviously the parts may be so coordinated that the liquid will stand at a point above the bottom of the barrel or sleeve 57 which provides the liquid seal. As soon as the motor is started the impeller begins to drive the liquid out through the main discharge passageway 134 and to receive priming liquid from the separator space 48—52 through the auxiliary throat 135. This operation depresses the level in the intake trap 34 and raises the level in the chamber 48 so that liquid is available through the passageway 66 to charge the supply chamber 75 which lies intermediate the length of the barrel or sleeve member 57. This supplied liquid then tends to flow downwardly along the shaft between the shaft and the barrel to the constriction or clearance 76 which is thereby sealed by a continuous flow of liquid. Any excess flows up past restriction 77 and drains away. Thereby, by keeping pressure in the chamber 75 above atmospheric the seal is invariably maintained. The relations herein provided are such that the supply of liquid through the passageway 66 to the chamber 75 exceeds the leakage capacity of the clearances leading away from the supply chamber 75, hence the supply chamber 75 will always be able to maintain a pressure of liquid in contact with the shaft above atmosphere in either or both the lower restriction or clearance 76 and the upper restriction or clearance 77 which leads to the overflow or discharge chamber 36. This flow is illustrated in Figure 7. The small amount of liquid which is driven by the discharge pressure up through the clearance 77 and permitted to overflow and pass down to the source of liquid 85 by way of the drain pipe 38 is inconsequential when compared with the advantages of the seal, particularly in avoiding the frictional contact of fibrous or similar packing forced against the shaft as is the usual provision for the seal for pumps of this general character.

The suction which prevails in the intake chamber 34 tends to draw liquid through the clearance or restriction 76 and thereby assist the circulation for keeping this clearance clean. In other words, the full pressure difference created by the pump prevails upon the liquid in the clearance space or restriction 76. The amount of liquid so circulated is relatively inconsequential and the excess which escapes up through the greater restriction because of the longer path existing above the supply chamber 75, is merely drained to the main liquid supply 85 or elsewhere as desired. The present invention teaches maintaining a pressure of the sealing liquid upon the constriction 76 which is above atmospheric at the outer end for all variations of pressure below atmospheric at the inner end.

Upon cessation of the rotation of the impeller liquid flows back from the discharge pipe 14 and back through the impeller casing into the intake trap 34 until gas passes back and breaks the vacuum in the chamber 34, pipe 15, and suction

pipe 84, allowing the liquid column in the suction pipe 84 to drop back to the supply. Thereupon the parts are again in the position shown in Figure 6.

The seal is generally under suction. Under some circumstances as when the pump is stopped and the liquid flowing back, there is a pressure upon the inner end with a tendency to flood the seal, but it is to be remembered that the capacity of the overflow chamber 36 and drain pipe 38 and connected passageways is such that the constriction 77 always reduces the flow to a value which the drain pipe and passageways can readily dispose of without flooding.

It is now to be observed that the pump previously described, that is, the vertical self-priming pump of my invention, is peculiarly adapted for the use of the seal above described. However, it is also to be observed that the advantages of the pump can be secured with a more or less known form of seal, or with any preferred form of seal. Thus, for example, in Figure 8 I have illustrated an oil packed seal for use with my vertical pump and this oil seal may be substituted in the aforesaid pump without change of the pattern. In this construction the barrel member 57a has substantially the configuration of the barrel member 57 shown in Figure 3. However, the shaft 10 is provided with an integral collar or annular flange 90 which engages a wear ring 92 which is held against rotation by means of pins 93 engaging in slots 94 in the tubular portion 95 of the barrel member 57a. This stationary wear member 92 has an extending neck portion 96 to provide a shoulder 97. A grooved ring of elastic material such as rubber, synthetic rubber, or rubber substitute 98, embraces the neck portion 96 and seats upon the annular flat seat 97. A spring 99 which is disposed within the barrel member 95 reacting against the internal flange 100, presses the follower ring 102 down upon the upper surface of the elastic grooved ring 98, compressing the said ring and forcing the same radially to expand into engagement with the neck 96 and the inner wall of the barrel 95 and against the seat 97 whereby to form a tight annular seat between the wear member 92 and the tubular barrel member 95.

The annular chamber 36 in this case is a closed oil retaining chamber and is maintained full of a suitable lubricant such as a heavy oil or grease, if desired, of a consistency such that it will flow to the wear parts 92 and 90. The wear occurring between the parts 92 and 90 is readily taken up by the spring 99 and follower ring 102 forcing the yieldable expansion ring 98 downwardly to take up the wear as it occurs.

Now it is to be observed that the principles of the liquid seal as applied to a vertical type pump are not limited to its employment in a self-priming pump.

The liquid for maintaining the seal may be derived from any suitable source providing adequate delivery and pressure to maintain the flows above described and illustrated. Thus for a pump pumping a grit-bearing liquid, liquid free of grit may be supplied to keep the seal free of grit.

It is further to be observed that the self-priming pump of my invention may be varied. Thus, in Figures 9 and 10, I have shown a single throat self-priming pump in which the impeller cooperates with a volute having a single outlet into the discharge and separating chambers. Thus, in Figure 9, the impeller 132, which is shown as a substantially straight-bladed impeller

although the curvature of the blades is a matter of selection, cooperates with the volute 135 which has an outlet 136 terminating in a short flared discharge neck 137 forming a continuation of the volute and terminating in or adjacent the bulged portion of the casing at 138. An opening at 139 just in advance of the cut-off which is indicated in dotted lines at 140, allows return of priming liquid during the priming operation to create the circulation of priming liquid back into the impeller in advance of the cut-off 140, the mixture being discharged through the opening 136 in the short neck 137 leading to the chamber 134. The chamber 134 and the intake trap or chamber 142 are separated by a diametrical wall 143 shown in dotted lines in Figure 9. The liquid seal for the shaft is illustrated in Figure 9 as comprising the supply chamber 144 which receives liquid through an opening 145 from the discharge or separator chamber 134 and the overflow or drainage chamber 146 which has the drainage passage 147 leading to a drain pipe 148 returning the liquid to the main source 85. In this structure, instead of an annular separating chamber and the cylindrical central inlet trap, two semi-cylindrical or substantially semi-cylindrical chambers 134 and 142 are provided. The operation of this pump is, in kind, similar to the operation of the pump shown in Figure 1. In detail, the priming and separating actions are different, as above indicated, namely, that a single throat is provided and that either the return flow may occur back through the single throat or through a lateral opening 139, as illustrated in Figure 9. The lateral opening 139 facilitates the separation of the discharge or mixture stream from the inflow of priming liquid to produce a more efficient priming action. However, the opening 139 may be omitted and provision made for the priming water to return through the single throat back into engagement with the impeller.

In Figure 10 I have shown a substantially similar pump and volute, the discharge neck 137 being disposed further back in order to compel the travel of discharge liquid therefrom around the central cylindrical intake trap 150. The discharge or separating chamber 149 is an annular chamber in which the whirling separation may be set up and this whirl may be controlled by the disposition of suitable vanes or baffles such as 152, at suitable points around the inside of the said chamber. In this case the continuation of the volute or discharge neck 137 is disposed beyond the discharge connection 14 so as to compel travel of the liquid completely around the inner chamber 150 before reaching the discharge connection 14. The opening for return of priming liquid is at 139, in advance of the cut-off 140. The cut-off 140 in each case has mechanical clearance only with the tips of the blades.

The characteristics of a pump of this type are disclosed in my copending application, Serial No. 175,187, filed November 18, 1937, which has matured in Patent No. 2,184,349, showing a single throat, horizontal type of self-priming pump.

The liquid seal shown in Figure 10 is shown diagrammatically and is substantially identical with that shown in Figures 1, 2 and 3, like reference numerals indicating like parts throughout.

From the above it will be understood that I have provided a vertical form of self-priming pump of peculiar and novel characteristics, and

that while a conventional form of seal for the shaft may be employed, this form of self-priming pump is peculiarly adapted to the employment of my novel liquid shaft seal. The liquid shaft seal for a vertical pump is not, however, limited to self-priming pumps, as I have above indicated, but has a wider application, as herein taught.

While I have shown the motor as mounted directly upon the pump body, it is to be understood that this is illustrative only of one way of driving the pump. A driving or bearing bracket may be employed instead, and the motor mounted upon such bearing bracket, or a pulley may be mounted upon the shaft or other means for driving the pump may be employed. However, the position of the motor and the particular mounting of the same upon the pump is of distinct advantage.

I therefore do not intend to be limited to the specific forms herein shown and illustrated, except as recited in the appended claims.

I claim:

1. In a self-priming centrifugal pump having an impeller with a vertical impeller shaft, a liquid sealing sleeve loosely disposed about the shaft and forming with the shaft a gap adapted to be rendered gas tight by the introduction of liquid, means to trap a charge of priming liquid in the pump, and a duct extending from the delivery side of the impeller to the inside of the sleeve for delivering a flow of said trapped liquid to the inside of the sealing sleeve and into said gap during priming to seal the shaft during priming, said flow of liquid being wholly internal of the pump, and being produced by rotation of the impeller.

2. In a vertical self-priming centrifugal pump a casing comprising a trapped inlet, a separator, an impeller housing between them, said trapped inlet, separator, and housing being adapted to trap a charge of priming liquid, an open impeller in the housing and a vertical impeller shaft therefor, a sealing sleeve for sealing the shaft to the casing loosely embracing the shaft to provide a liquid sealing gap, the inner end of the sleeve being subjected to suction produced by the impeller and the outer end being open to atmosphere and a passageway leading from the separator at a point below its discharge level to the inside of the sleeve at a point intermediate the ends of the sleeve and below said discharge level, rotation of the impeller producing sufficient difference in head upon the ends of the passageway to cause an internal circulation of the priming liquid from the separator through said passageway and into the sleeve to seal the shaft against entry of air during priming.

3. The improvement of claim 2 characterized by the disposal of the upper end of the sealing sleeve on a level approximately at the level of the outlet of the separator whereby liquid will not escape from the top of the sleeve during priming nor when the pump is idle, and a drain open to atmosphere at the top of the sleeve, said drain comprising a conduit to lead sealing liquid escaping from the top of the sleeve during liquid pumping away from the pump casing and to deliver it by gravity to a point below the level of the pump.

4. In a vertical self-priming centrifugal pump, an impeller housing having a central inlet opening facing upwardly, an impeller therein, a vertical shaft for the impeller, a separator and

a trapped inlet connection, said inlet connection leading to the central inlet opening of the housing, a liquid sealing sleeve for liquid sealing the impeller shaft to the inlet connection, said sleeve loosely embracing the shaft to provide a liquid sealing gap, said inlet, housing and separator trapping a charge of sealing liquid which liquid lies below the outlet of the separator and below the top of the sleeve when the pump is stopped, and a supply duct leading at its outer end from the separator at a point below the outlet of the separator to the inside of the sleeve at a point intermediate the ends of the sleeve, rotation of the impeller creating sufficient difference in head between the outer and inner ends of the duct that the priming liquid flows from the separator through the duct into the sleeve to seal the gap against entry of air during priming.

5. The improvement of claim 4 further characterized by the disposal of the separator concentrically about the trapped inlet connection, and the disposal of the sealing sleeve within the trapped inlet connection, the impeller housing comprising separable superposed portions, the bottom portion being separately removable downwardly to permit removal of the impeller.

6. In a vertical self-priming centrifugal pump, an impeller casing having an upwardly facing central inlet opening and having main and auxiliary discharge passageways disposed adjacent each other at the periphery, the auxiliary discharge passageway opening into the impeller at a point where the discharge of liquid and entrained gas has produced a region of reduced pressure in the impeller during priming, said auxiliary passageway conducting priming liquid from the separator into the impeller, an impeller having a vertical shaft, an annular separating space communicating with both of said passageways and having a discharge outlet at its top, and a central cylindrical inlet trap inside the annular separating space and having an annular wall in common with the separating space, a suction inlet connection at the top of said trap, said separating space and said trap being adapted to retain a charge of priming liquid at a level above the said inlet opening.

7. In combination in a vertical self-priming centrifugal pump, an impeller casing having an impeller and having an inlet opening, an intake trap coaxially of and above the impeller casing, a suction connection at the top of the inlet trap, an annular separator lying outside of and embracing the intake trap and extending radially beyond the impeller casing, a discharge connection at the top of said separator, and a vertical impeller shaft extending through the top wall of the intake trap only, said impeller casing having a tangential discharge outlet leading into the separator, said trap and separator being adapted to retain a charge of priming water at a common level, which level lies above the inlet opening.

8. In a vertical pump, an impeller casing having an impeller and having an inlet opening, a substantial cylindrical intake trap disposed centrally of and above the impeller casing, a separator comprising an upper annular portion disposed outside of said trap and having an annular wall in common with said trap, and having a depending lower portion coaxial of the impeller casing and radially disposed outside the impeller casing, a discharge connection at the top of the separator, a pair of discharge passageways leading from the impeller casing into said de-

pending portion of the separator, said pair of passageways comprising a main discharge passageway and a priming passageway said priming passageway being disposed behind the point of discharge of mixture from the impeller through the main passageway, and serving to admit priming liquid into the impeller during priming and a vertical impeller shaft extending upwardly through the top wall of the intake trap, said trap having an inlet connection disposed at the top thereof, the entire impeller casing being disposed below the level at which the intake trap is adapted to trap liquid for priming.

9. In a pump of the class described, the combination of a main casing section comprising an inner chamber constituting an intake trap which is closed at the top and provided with an intake connection at the top thereof, and an outer annular separator chamber closed at the top and having a discharge connection at the top thereof, a sectional impeller casing comprising two removable side plates rigidly secured upon the bottom of the main casing section, the impeller casing and the main casing section having communication between the inner chamber and the intake of the impeller chamber, and between the discharge of the impeller chamber and the outer annular chamber.

10. A liquid seal for sealing a vertical centrifugal pump shaft comprising an inlet chamber leading to the eye of the impeller and subjected to the suction of the pump, a sealing sleeve disposed mainly in the chamber and having an overflow chamber with an overflow connection at its upper end substantially at the top of and opening to the outside of the inlet chamber, a sealing liquid supply chamber in the inlet chamber for supplying liquid to the inside of the sleeve, intermediate the ends of the sealing sleeve, a liquid trap in the discharge of the pump, means comprising a duct leading from the trap to the liquid supply chamber for supplying sealing liquid to said supply chamber from said discharge trap by gravity flow to maintain a gas-excluding liquid seal within the sleeve between the inlet chamber and the supply chamber during priming, and a pump shaft disposed within but out of contact with the sealing sleeve, said shaft being external to the discharge trap.

11. In a centrifugal self-priming pump, the combination of a gas and liquid separator on the discharge side, a pump casing having an open impeller therein, a shaft for the impeller, a central intake connection for the pump casing and impeller, said connection surrounding a part of the shaft, a liquid seal sleeve joined to the intake and being adapted to hold a liquid seal about the shaft without the necessity for packing material, and a liquid supply connection for the sleeve, said connection extending from the separator to the sleeve and having an inlet opening which lies below the level of liquid in the separator when the impeller is rotated, the junction of the supply connection with the sleeve lying within the central inlet connection the top of the sleeve lying above the level of liquid trapped in the separator when the impeller is not rotating.

12. In a self-priming centrifugal pump of the type which traps and retains a charge of priming liquid by which liquid the impeller entrains air and discharges it into the separator to evacuate the suction line, the improvement which comprises a shaft seal sleeve about the impeller shaft spaced therefrom by a constricted but fixedly open annular gap, the inner end of said

gap opening into the suction side of the impeller, the outer end of the gap lying above the level of the trapped charge of liquid, and a duct leading from the discharge side of the impeller to a point intermediate the ends of the gap, rotation of the impeller producing sufficient hydraulic head of the trapped liquid in the separator upon said duct to cause liquid to flow through the duct and into the gap to seal the shaft simultaneously with the entrainment and discharge of air by the impeller into the separator through the medium of said trapped charge of liquid substantially without loss of liquid at said seal or at the outlet of the separator.

13. A sealing sleeve for a vertical pump shaft, said sleeve having a bore slightly larger than the diameter of the shaft to be sealed, and comprising a tubular member having three annular pockets in its bore comprising a lowermost pocket constituting a supply pocket which communicates with said duct, an overflow pocket having an atmospheric drain connection and a slinger pocket at the top of the sleeve which opens to the outside of the top of the pump, said sleeve being provided at its upper end with an annular shoulder for engaging the wall of a pump casing.

14. A self-priming centrifugal pump comprising a hollow casing including a runner housing containing a runner, the runner having a vertical shaft, inlet means to conduct liquid to the runner and means to conduct the discharge of liquid operated on by the runner from the casing, a shaft sealing sleeve joined to the housing and embracing the shaft, the sleeve having a liquid supply pocket and a liquid drain pocket opening externally of the pump, there being an annular restricted gap between the sleeve and the shaft extending from the supply pocket to the drain pocket and an annular restricted gap between the sleeve and the shaft extending between the liquid supply pocket and the inner end of the sleeve, said casing being provided with a conduit for liquid driven out of the impeller casing, said conduit having an enlargement serving as a gas separator and having an outlet, a liquid supply passageway for supplying liquid by gravity flow from said separator to the liquid supply pocket during self-priming of the pump and a gravity drain passageway extending from said liquid drain pocket, said casing being adapted to trap a priming charge of liquid which serves as a gas evacuating medium during priming, the outlet of the separator being disposed above the top of the priming charge in the separator during priming and the drain pocket being disposed above the priming charge when the pump is standing idle, whereby the priming charge is retained, the liquid supply pocket and its supply passageway being disposed below the top of the priming charge in the separator during priming.

15. A vertical self-priming centrifugal pump comprising, a casing in which a priming charge of liquid is retained at all times, and said casing comprising an inlet duct, an impeller chamber and a separator with an outlet high enough to avoid loss of the priming charge during priming, an impeller with a vertical shaft, the impeller cooperating with the priming charge during priming to discharge air continuously from the impeller chamber into the separator, a loose fitting liquid sealing sleeve about the shaft, said sleeve being joined and sealed to the casing and having an overflow outlet high enough to avoid

loss of the priming charge during priming and while the impeller is at rest, and means for supplying liquid to the inside of said sleeve to liquid seal the shaft with respect to the surrounding sleeve without loss of the priming charge during priming, said shaft being thereby sealed with respect to the casing of the pump without the necessity for rubbing contact.

16. In combination with a vertical self-priming centrifugal pump of the type having a casing and a cooperating impeller with an impeller shaft and which employs a priming charge of liquid to remove gas continuously from the intake side of the impeller to the discharge side thereof by entrainment during priming and which has means for trapping such priming charge, of a vertically extending liquid filled sleeve joined to the casing, said sleeve providing an annular gap with the shaft for sealing the shaft to the casing with liquid only and having no external outlet for sealing liquid below the minimum level of the priming charge, and means for keeping a supply of sealing liquid in said sleeve during priming.

17. In a self-priming centrifugal pump the combination of a pump body comprising means for trapping a charge of priming liquid, inlet means for permitting the admission of fluid to the top of said trapping means, means for separating air from liquid, means for permitting the discharge of fluid from the top of said separating means, means for discharging a mixture of air and liquid into said separating means from said trapping means, said discharge means comprising a shaft rotatable with respect to the body, said body comprising means forming a sealing gap between said shaft and said body, the inner end of said gap being subjected to suction by said mixture discharging means, and means supplied with liquid by said discharging means for conducting liquid into the outer end of said gap to produce a flow of sealing liquid through said gap.

18. A self-priming centrifugal pump of the type which has means for recirculating priming liquid whereby continuous air removal may be secured and which is capable of being disposed above the source of liquid to be pumped, comprising the combination of a casing closed at the bottom and adapted to trap and retain a charge of priming liquid, means whereby liquid from the said charge is recirculated during priming through the impeller to entrain air and carrying it out in the resultant mixture, means to utilize the charge of liquid as a liquid seal against the re-entry of air into the suction side of the impeller, an impeller in the casing, said impeller having a vertical impeller shaft extending out of the top of the casing, said liquid seal means including a sleeve joined to the casing and surrounding the shaft and separated therefrom by an annular flow restricting gap of substantial length, the inside of the sleeve at a point within the casing communicating with the discharge side of the impeller, the sleeve extending above the charge of liquid in the pump casing during priming to prevent loss of liquid from said priming charge during priming, said sleeve having at its upper end an overflow pocket, and a drain connection from said pocket for automatically draining away to a point below the pump the liquid escaping out through the gap during liquid pumping.

HARRY E. LA BOUR.