

March 15, 1938.

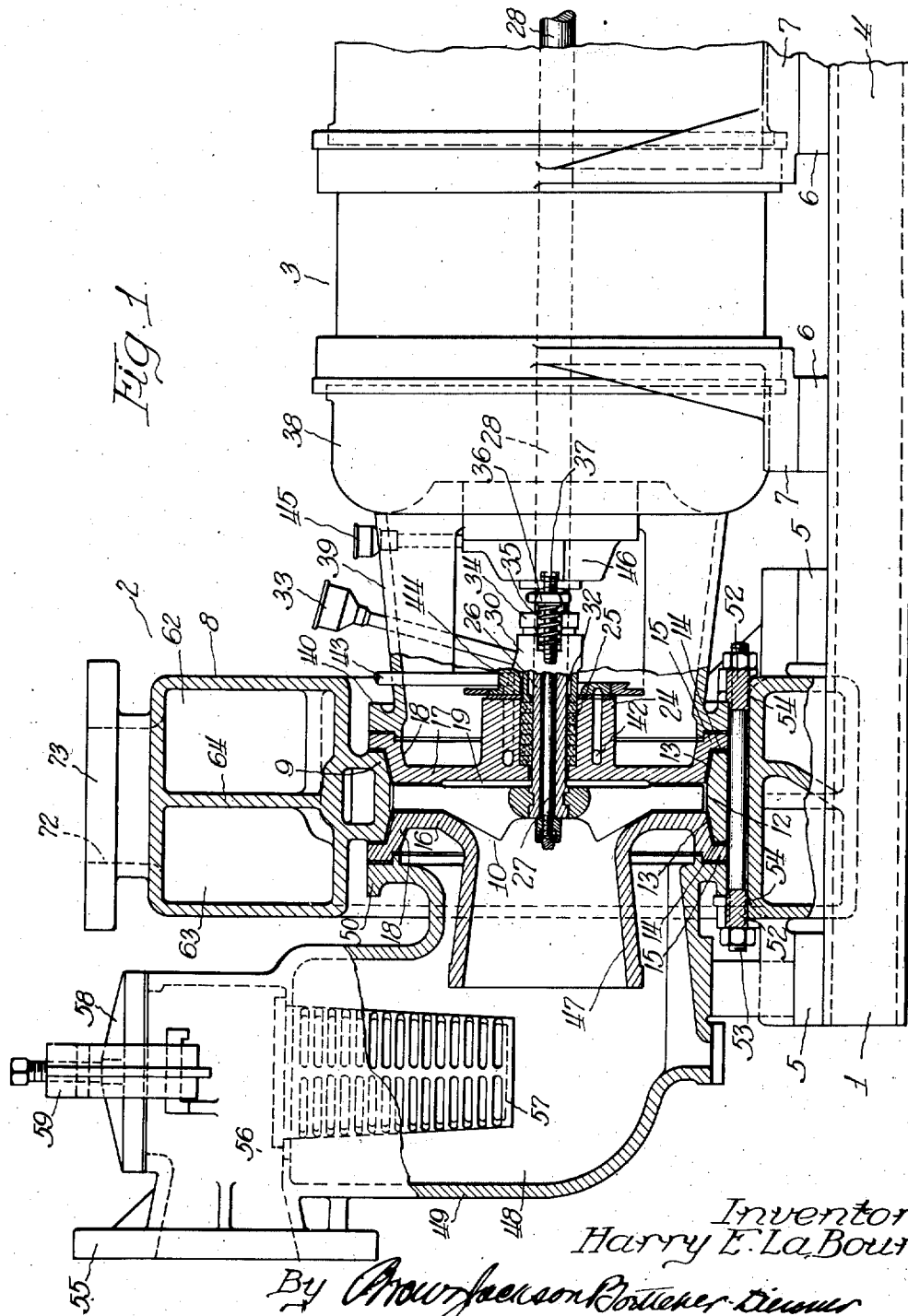
H. E. LA BOUR

2,110,883

SELF PRIMING CENTRIFUGAL PUMP.

Filed May 29, 1933

6 Sheets-Sheet 1



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H. E. LA BOUR

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SELF PRIMING CENTRIFUGAL PUMP

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6 Sheets-Sheet 2

Fig. 2.

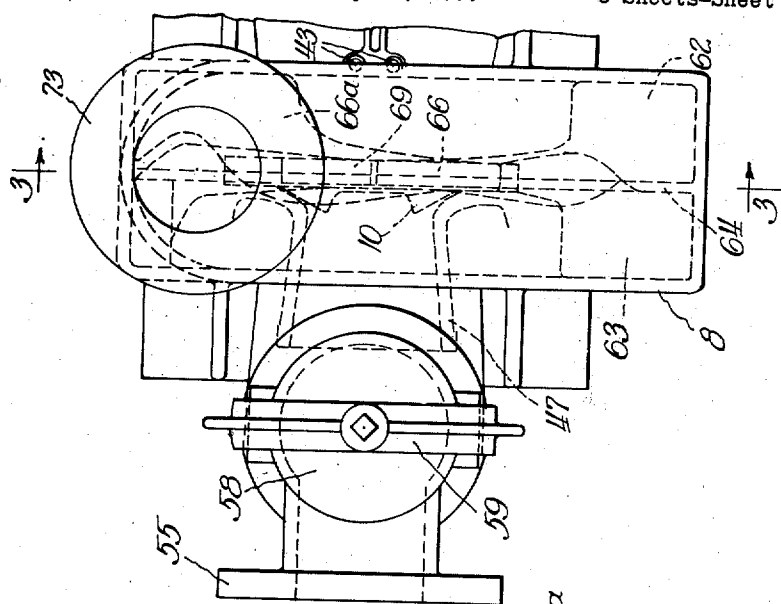
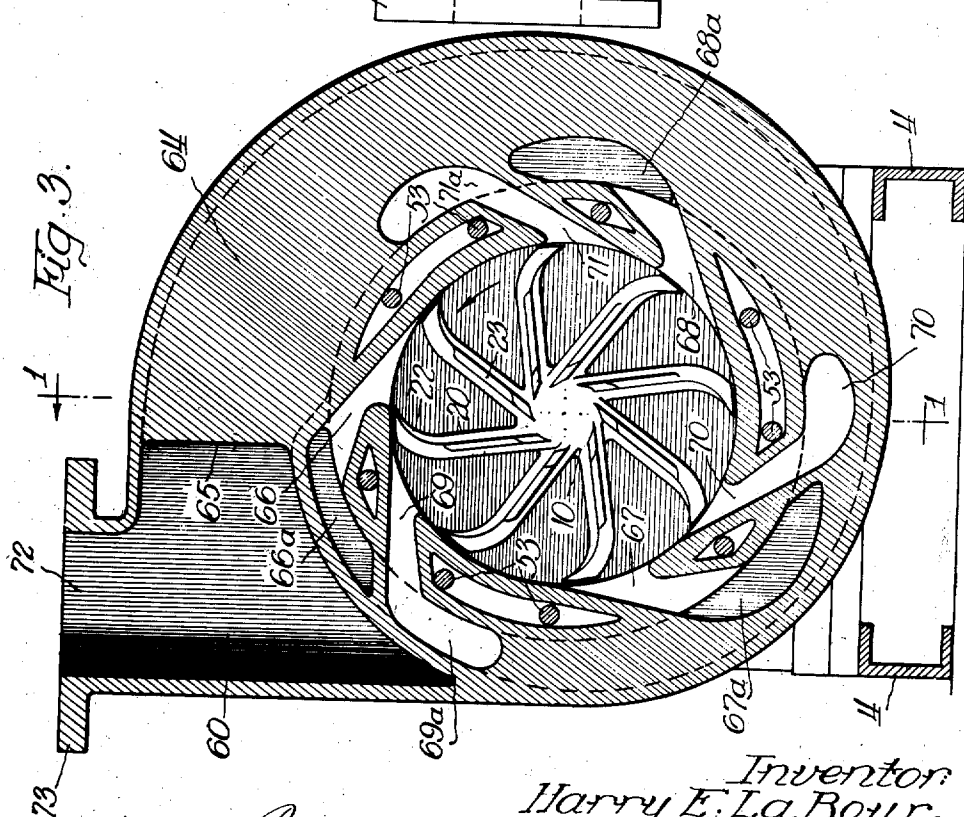


Fig. 3.



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Fig. 4.

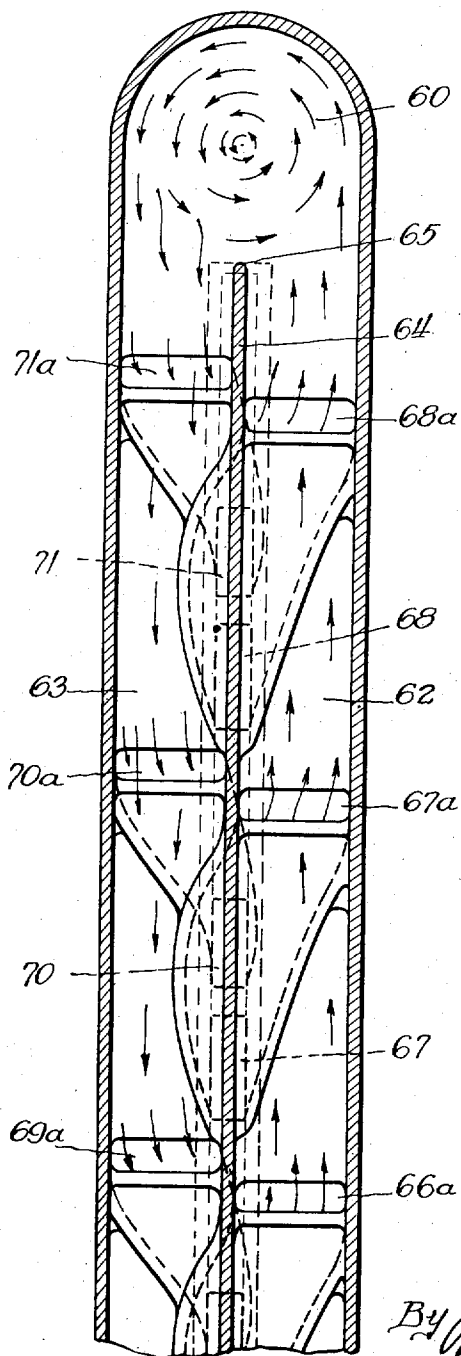
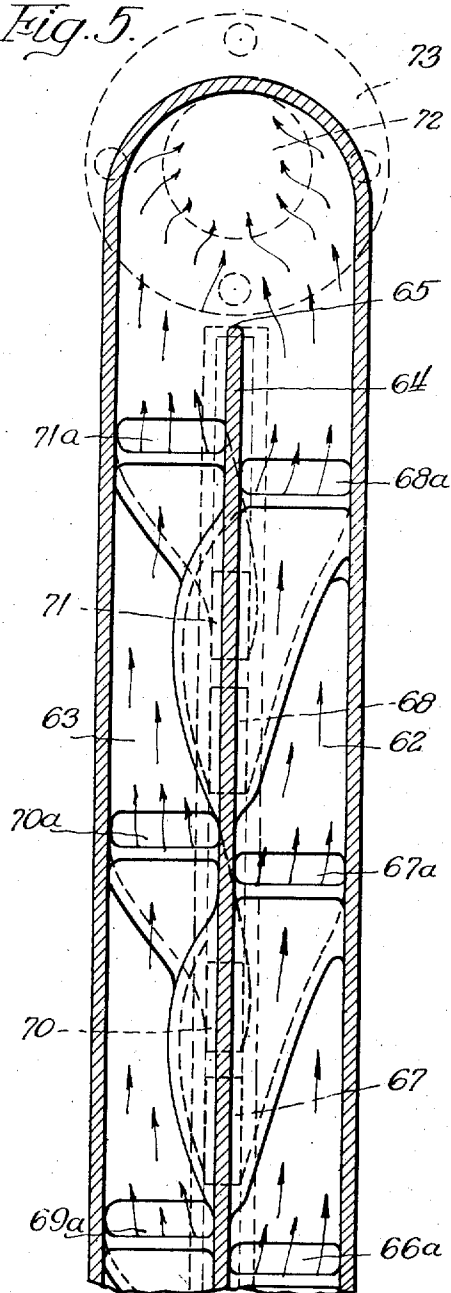


Fig. 5.



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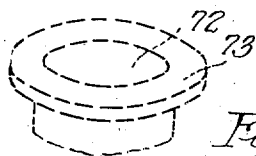


Fig. 6.



Fig. 7.

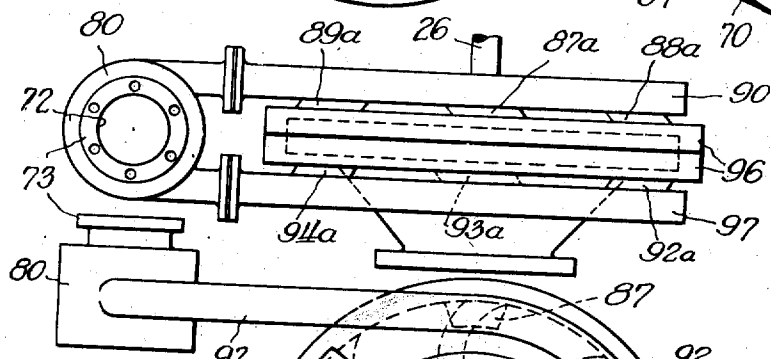
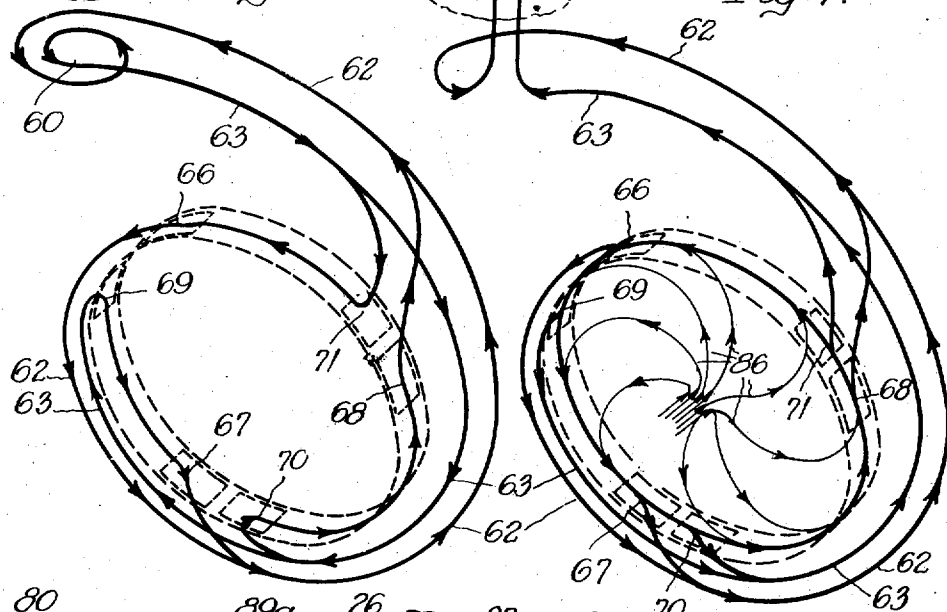


Fig. 13.

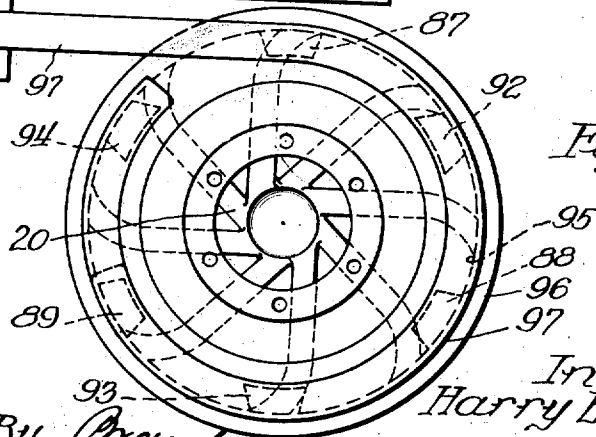


Fig. 14.

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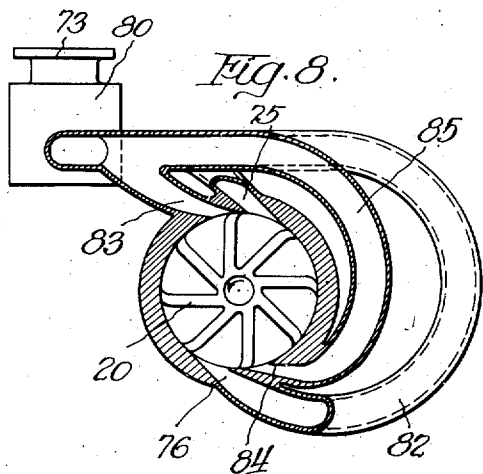
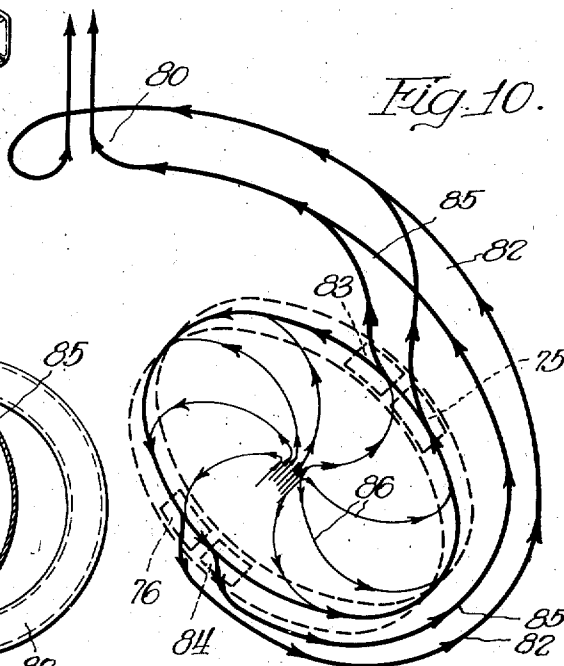
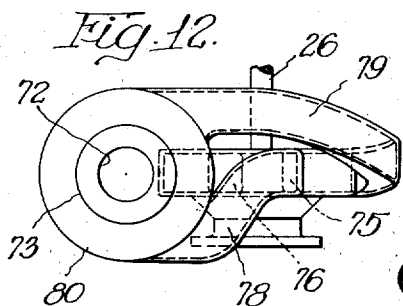
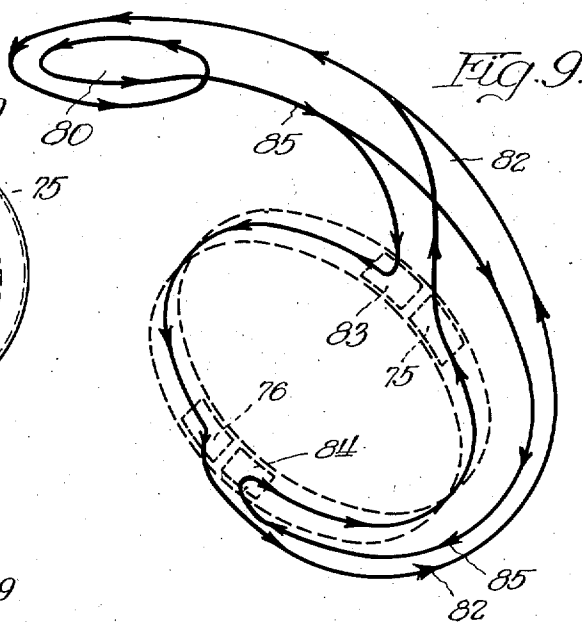
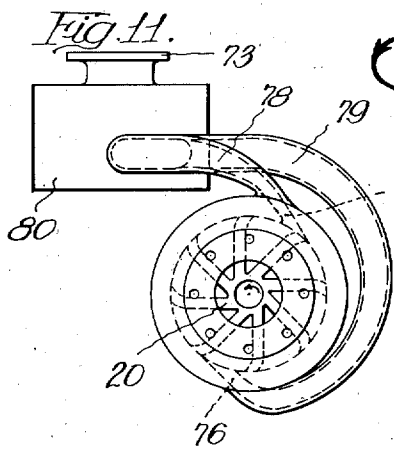
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SELF PRIMING CENTRIFUGAL PUMP

Filed May 29, 1933

6 Sheets-Sheet 5



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SELF PRIMING CENTRIFUGAL PUMP

Filed May 29, 1933

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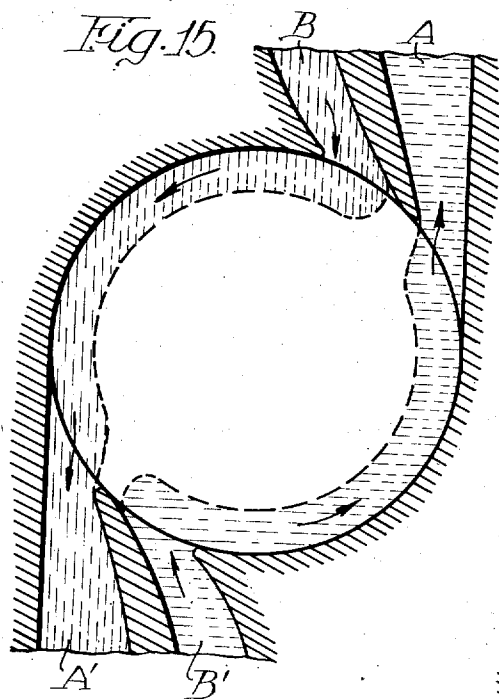
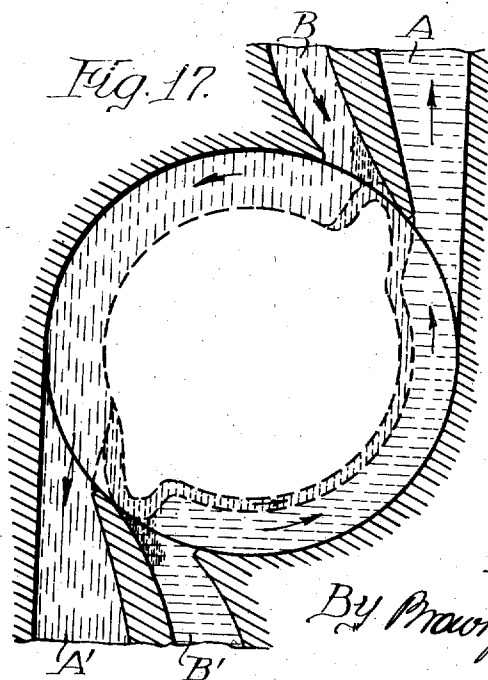
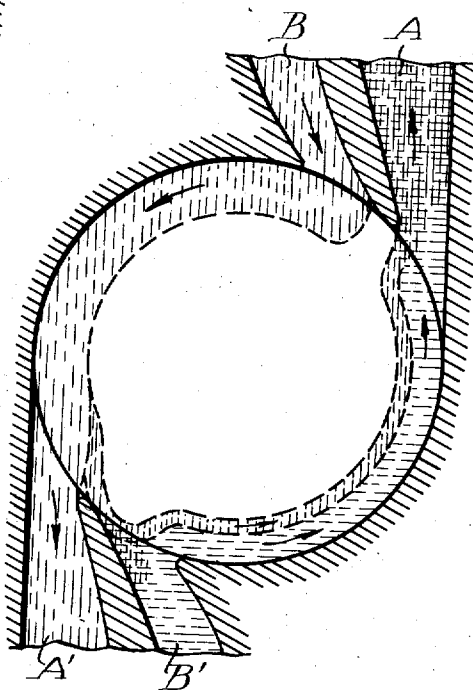


Fig. 16.



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UNITED STATES PATENT OFFICE

2,110,883

SELF-PRIMING CENTRIFUGAL PUMP

Harry E. La Bour, Elkhart, Ind.

Application May 29, 1933, Serial No. 673,469

33 Claims. (Cl. 103—113)

My invention relates to pumps, and more particularly to self-priming centrifugal pumps of the type disclosed in my United States Patent No. 1,578,236. This type of pump employs the principle of hydraulic balance in the auxiliary or priming throat. By the employment of this principle, the rate and direction of flow of liquid in the auxiliary or priming passageway may be automatically determined by the fluid which is being drawn through the suction pipe into the pump casing. When the pump casing is being evacuated by the withdrawal of air from the pump casing and the suction pipe, the direction of flow of liquid in the auxiliary or priming passageway is inwardly, and when the pump is pumping liquid the direction of flow is outwardly.

This application is a continuation in part of my application, Serial No. 629,617, filed August 20, 1932.

Pumps of the aforesaid class employ a charge of liquid operating in a closed cycle between pump runner and separator for evacuating the pump and suction line of air or other gas, and upon attaining a full complement of liquid the pressure developed in the auxiliary, or priming throat, is great enough to oppose return flow of liquid and preferably to serve as an additional discharge throat.

In passing through this cycle of operations, i. e., evacuation of the pump casing by pumping gas to a point where the suction pipe will be filled with liquid and pumping of liquid begins, two important phases of operation are exhibited. The first is the automatic compensation or control of rate of liquid reentry for changes in head or pressure difference available upon the auxiliary or priming passageway, causing return flow of priming liquid during gas pumping. The second is the automatic stopping or reversal of flow in the auxiliary or priming passageway. In this phase of operation not only may the return flow or recirculation be reduced or stopped, but in the full use of the principle the flow is actually reversed, thereby constituting the auxiliary or priming passageway an additional discharge passageway which increases both the capacity and the efficiency of the pump.

It is the chief object of the present invention to provide in a self-priming pump a structure and mode of operation which will employ the aforesaid principle to greater advantage than has heretofore been possible.

More specifically, it is an object of the invention to increase the gas pumping capacity of a given size of pump.

It is a further object of the invention to increase the gas pumping efficiency of self-priming pumps.

It is a further object to increase the vacuum attained by pumps of this general class.

It is a further object to produce a given rate of gas evacuation with a smaller amount of priming water than has heretofore been possible. This permits reduction in the volume of the inlet trap.

It is a further object to enhance the inherent stability of operation on priming and of equalizing the work upon the throats, particularly during priming.

It is a further object to shorten the time required to evacuate the pump casing and suction pipe.

The increases in gas pumping capacity and efficiency, with resulting reduction in time required for priming, and ability to draw higher vacua, are secured, as will be set forth in detail later, by improvement in the structure and mode of operation whereby the circulating liquid is employed in a more advantageous manner for entraining and discharging gas and by a novel utilization of the principle of compensation.

A further object of the invention is to increase the liquid pumping capacity of a given size of pump of this general class.

Another object of the invention is to improve the pumping efficiency of hydraulic pumps, particularly pumps of the self-priming class.

The increases in capacity and efficiency during liquid pumping are secured, as will be set forth in detail later, by improvement in structure and mode of operation, whereby the liquid is carried through a small angular travel and discharged through a plurality of throats operating in parallel about the periphery of the pump, and whereby an improved utilization of the action of reverse flow in the auxiliary or priming passageways is secured.

A further object of the invention is to improve the efficiency and increase the capacity for gas disentrainment or separation in pumps of this character.

This object is attained, as will be described more in detail hereafter, partly by the discharge of the mixture of gas and liquid in parallel from a number of throats disposed about the periphery of the impeller and partly by the gradual deceleration of the streams discharged from said throats in the curved tapered manifold. Thereby the gas bubbles are permitted to agglomerate through a relatively long, slow travel. An un-

usually small discharge or separator chamber may be employed. Kinetic separation may be largely or wholly avoided with the consequent avoidance in loss of head and consumption of energy entailed thereby, particularly in the liquid pumping phase.

The pump of the present invention aims, therefore, to improve the gas entraining action within the pump casing, and the gas disentraining action outside the pump, during priming, and to improve the liquid pumping action after priming.

A further object of the invention is to improve and facilitate the construction of pumps of the self-priming type and reduce the cost of a pump of a given capacity.

A feature of the preferred form of the pump of the present invention is an improvement of the balance of the impeller which tends to impose less load upon the bearings, and substantially eliminate or reduce noise and vibration. Thereby the wear upon the pump shaft packing is greatly reduced and substantial tightness is more easily maintained, and with less friction.

A further improvement of the preferred form of the present invention is an increase in delivery pressure attainable from an impeller of a given size.

A further object of the invention is to provide a more compact pumping unit.

According to the preferred form herein disclosed, a separate bearing for the impeller shaft need not be provided, as the impeller shaft forms merely an extension of the motor shaft and the bearings of the motor are, when the impeller is thus adequately balanced, amply sufficient to guide and support the impeller and its shaft. The pump unit may thus be made much shorter in an axial direction and the cost of the unit materially decreased.

Other and additional objects will appear from the following detailed description and claims.

In the drawings:

Figure 1 is a vertical longitudinal section through a pump embodying my invention, showing certain of the parts in elevation;

Figure 2 is a plan view of the pump end of the unit shown in Figure 1;

Figure 3 is a vertical cross section taken on the line 3—3 of Figure 2;

Figure 4 is a developed diagrammatic view illustrating the flow during the priming phase;

Figure 5 is a similar developed view illustrating the flow during liquid pumping;

Figures 6 and 7 are line diagrams illustrating the flow of the liquid during priming and during liquid pumping, respectively;

Figure 8 is a sectional view, largely diagrammatic, illustrating a self-priming pump having two pairs of throats;

Figures 9 and 10 are line diagrams illustrating the flow occurring in the pump of Figure 8 during priming and liquid pumping, respectively;

Figure 11 is a side elevational view and Figure 12 is a plan view of a pump employing a single pair of throats placed so as to secure a balanced operation during liquid pumping;

Figure 13 is a top plan view and Figure 14 a front elevational view of a modified form of pump, largely diagrammatic, illustrating an alternative method of securing the required unbalance between two sets of throats to initiate and maintain the priming action;

Figure 15 is a diagram of a pump employing two pairs of throats, illustrating a condition of flow unbalance when just the right amount of

priming liquid enters both bypasses or auxiliary passageways;

Figure 16 is a similar diagram, illustrating the action of the pump when one bypass or auxiliary passageway supplies more liquid than is necessary, with compensation upon the other bypass or auxiliary passageway; and

Figure 17 is a similar diagram, illustrating the action when the pressure difference is great enough to compel compensation on both bypasses or auxiliary throats.

Referring first to Figures 1, 2 and 3, the unit herein shown comprises a common base 1, the pump unit 2 and the motor unit 3.

The base 1 may be a continuous casting for supporting both the pump 2 and the motor 3 or it may be built up, as herein shown, of a pair of channel bars 4—4 with transverse bars 5—5 connecting the channel bars 4—4 to provide a suitable attachment for the pump, and a pair of similar cross bars 6—6 upon the channel bars 4—4 for providing a suitable mounting for the mounting legs or lugs 7—7 of the motor.

The pump unit comprises a main annular hollow casting 8 which has an inwardly extending annular projection or flange 9. This ring or flange 9 forms the inner periphery of the impeller chamber, in which the impeller 10 is mounted to rotate.

The inner periphery of the ring 9 is machined to provide a cylindrical surface embracing fairly closely the impeller 10. The ring has tapered shoulders 13—13 at the sides of the cylindrical bore 12 and it has radial faces 14—14 against which are adapted to rest the flanges 15—15 of the front and back plates 16 and 17, respectively. These plates have offsets 18 of similar configuration with their outer sloping surfaces machined to fit the sloping surfaces 13—13 on the ring 9. The plates 16 and 17 are machined to provide parallel annular surfaces adjacent the cylindrical surface 12 to provide a raceway in which the outer ends of the blades of the impeller 10 are confined. A clearance at 19 between the back face of the impeller and the adjacent face of the back plate 17 is provided. The impeller 10 is an open impeller having arms such as 20, the outer ends of which are curved backward with respect to the direction of rotation, as indicated at 22 in Figure 3. These arms have, adjacent the center, axially projecting vanes 23 to assist the entering liquid in taking up the motion of the blades or arms 20, so that the liquid, in entering the impeller chamber, is accelerated rotari-ally and radially with as little shock, or sharp change in direction as it is feasible to secure.

The back plate 17 has a boss or hub 24 which is counterbored to receive the packing 25 for packing the impeller shaft 26. The impeller shaft is here shown as having the impeller cast thereupon, the shaft 26 in this case being provided with an axial bore to receive a tie rod 27 for holding the end of the impeller shaft 26 and the end of the motor shaft 28 in axial alignment and in suitable driving relation.

The motor shaft 28 may be provided with a central bore and the tie rod 27 extended completely therethrough.

Due to the balanced load upon the impeller 10, separate bearings for the impeller shaft are not required, the bearings of the motor 3 being sufficient to support the impeller and to cause it to run true.

The packing 25 is held in place and is compressed by a follower 30, this follower having an

annular recess 32 with which the grease cup 33 communicates. The outer end of the annular opening 32 is closed by packing received in the inner recess in the outer end of the follower 30 and in turn compressed by the second follower 34. The follower 34 is urged to the left by a pair of compression springs 35, one on each side of the shaft, these springs resting against a stirrup formed integral with the follower 34 at their left hand end and at the right hand end against a movable abutment which in this case is a hand wheel 36 threaded on the stud 37 abutting against the bearing of the motor 3.

The motor 3 is provided with a special end bell 15 38 having an integral bracket 39 which terminates in a suitable clamping flange 40 and which is clamped against the flange 15 of the rear plate 17, as will be later described.

The packing gland is cooled by suitable passageways 42 formed in the hub 24, and water circulating pipes 43—43 connect to said passageways through the medium of the plate 44, which is clamped to the end of the hub 24.

The top of the bracket 39 is provided with a slot 25 through which extends the connection for the grease cup 33 to the pump gland. Likewise, the connection from the grease cup 45 extending to the motor bearings 46 passes through the said slot. The sides of the bracket member 39 are open to permit access to the packing gland for servicing the same.

The front plate 16 is provided with a flaring inlet tube 47 which extends into the bottom portion of the intake trap 48. The intake trap 48 35 comprises a vertically extending, substantially cylindrical portion 49 and a lower transverse portion which surrounds the inlet neck or tube 47 and is provided with a clamping flange 50 substantially identical with the clamping flange 40 of the motor bracket. The trap 48 has a foot resting on the base 1. The flanges 40 and 50 are provided with annular piloting projections extending into recesses in the back and front plates 17 and 16, respectively, and said flanges are engaged by clamps 52—52 mounted upon the bolts 53—53, these bolts being suitably spaced about the peripheries of the clamping flanges and extending axially through the ring 9 in such positions as not to interfere with the passageways 50 extending through said ring 9, as will be described later. The clamps 52—52 rest in an axial direction against the outer edges of the clamping flanges 40 and 50, and in a radial direction with respect to the axis of the pump rest against the 55 adjacent cylindrical shoulders 54—54 of the hollow casting 8.

The intake trap 49 is provided with a pipe flange 55 for connecting to a suction pipe. An opening through this flange extends to the top of the trap 49 which is separated from the bottom by a wall 56, through an opening in which extends the inlet strainer 57. A removable cap or cover 58, held in place by the clamping yoke 59, permits access to be had to the interior of the 65 strainer 57.

The casting 8 contains the separating chamber 60 (see Figure 3) and provides also two circumferentially extending passageways 62 and 63, disposed side by side, separated by a central wall 64. This central wall 64 terminates at 65, short of the separating chamber 60.

Referring now to Figure 3, there are shown three pairs of discharge passageways distributed about the inner periphery of the impeller chamber, these discharge passageways comprising the

anterior or main discharge passageways or throats 66, 67 and 68, disposed at 120° with respect to each other, and auxiliary, or posterior passageways or throats 69, 70 and 71, respectively.

These throats are all substantially tangential with respect to the movement of the impeller. The throat 66 is continued as a passageway 66a which opens into the circumferentially extending duct or manifold 62, that is, on the right hand side of the dividing wall 64 as viewed in Figure 1. On the plan view of Figure 2 the throat 66 is shown in dotted lines, and similarly the continuation or passageway 66a which is shown in dotted lines turns to the right as viewed in Figure 1 15 and discharges into the manifold or duct 62. Likewise, the throat 67 is continued as passageway 67a, bending over into communication with the duct or manifold 62. The same is true of the third main discharge throat 68. It extends as a passageway over into the duct or manifold 62. The manifold or duct 62 then, in turn, opens into the separating chamber 60. The chamber 60 has a discharge opening 72 provided with a surrounding bolting flange 73.

The posterior, or auxiliary throats 69, 70 and 71 likewise have continuations comprising passageways 69a, 70a and 71a, opening into the duct or manifold 63. It is to be observed that the throats extend the full width of the impeller, that is, occupy the full axial length of the impeller channel, and since the wall 64 is disposed substantially in the median plane of the impeller, the wall 64 is bulged to provide throats and passageways suitable for leading liquid out 35 or in, as the case may be, across the full width of the impeller blades.

Referring now to Figures 4 and 5, I have indicated therein, more or less diagrammatically, a development of the circumferentially extending 40 ducts or manifolds 62 and 63, and the way in which the discharge throats communicate with the same.

Only two pairs of throats, namely, the pair 68—71 and the pair 67—70 are herein shown. The ends of the passageways and the manner in which they direct flow into the ducts or manifolds 62—63 is indicated in Figure 4, which shows the flow of liquid during the priming phase of operation.

Figure 5 shows the flow of liquid during the pumping phase when both sets of throats and their connected passageways discharge in parallel into the ducts 62—63 and these in turn discharge in parallel into the chamber 60 and out 55 through the flanged outlet opening 72.

A comprehensive understanding of the flow of the fluid during the two stages of operation may be obtained from Figures 6 and 7, and later by reference to Figures 15, 16 and 17 for the compensating action.

Assume that the suction flange 55 is connected to a suction pipe and the discharge flange 73 to an open discharge pipe, the pump being provided with a suitable priming charge, which may be the amount trapped in the intake trap, pump casing and passageways after a period of operation of the pump and the flowing back of liquid from the open discharge pipe back through the pump, intake trap, and into the suction pipe to break 70 the vacuum therein. It will be observed that the throats 71 and 68 provide a suction break for the downflow of liquid in the suction pipe. This permits air to pass down through the discharge chamber passageways 62—63 through throats 71 75

and 68, through the impeller chamber inlet tube 47 and through the inlet trap 49, without emptying the liquid from the remainder of the pump casing or the passageways. With such a charge of trapped liquid for priming purposes remaining in the pump the motor 3 is started, and this rotates the impeller 10 in its impeller chamber. Immediately thereupon, liquid is driven out through the discharge ducts and as much liquid as can be drawn from the intake trap 48 enters the pump casing and is discharged through the various throats of the pump. If sufficient liquid were immediately available to fill the runner, all six of the throats would continue to operate as discharge throats, discharging the liquid in two parallel groups of three into the manifolds 62 and 63, and they, in turn, discharging in parallel into the separating chamber 60. However, such action cannot continue, since insufficient liquid is provided for continued operation of the pump as a liquid pump. The discharge of a part of the priming liquid into the discharge passageways and separator immediately causes a deficiency of liquid in the impeller chamber, with the result that the pressure upon the throats rapidly drops and liquid tends to re-enter, by gravity, through the throats into the impeller chamber. Immediately upon the re-entry of liquid into the impeller chamber it is met by the rapidly moving blades and a mixture of air and liquid is formed and, by the centrifugal effect of the impeller, the mixture is driven out through the throats. However, since there is insufficient entering liquid to develop a full hydraulic pressure, and since the anterior throats are of sufficient capacity to carry out substantially all of the mixture which is formed, they rob the posterior throats and insufficient pressure is developed at the posterior throats to prevent the reentry of liquid. Thereupon an orderly recirculation is established, as indicated in Figure 6.

The amount of return flow depends upon the size of the auxiliary or priming passageways and the difference in pressure or head between the separator and the inner ends of the passageways where they enter the channel. As the suction is increased there is a tendency to increase the rate of inflow. Here it is that the novel compensating action takes place, as will be described in connection with Figures 15, 16 and 17.

Under the action of the rotating impeller when the pump is started, the trapped priming liquid distributes itself into two main working bodies or pools. The first is the transient moving pool of liquid in the impeller chamber, which, under the action of the impeller, entrains air and acquires centrifugal force to secure discharge at the main discharge ports. The second body or pool is that in the separating space of the separator and adjacent parts of the ducts. It also is a transient body being constantly replenished by liquid with entrained gas. The gas is liberated, and the liquid substantially free of gas replenishes the liquid pool or body in the impeller chamber. By this continuous interchange or circulation, the gas in the impeller chamber and the connected suction pipe is evacuated.

If the return of liquid through one of the auxiliary or priming ports is in excess of that which when mixed with air can be discharged out of the nearest discharge port, the excess is carried through a greater angular distance than that in which normal pressure is developed, and it impinges upon the next succeeding auxiliary or

priming port, thereby tending to reduce or stop the return of liquid through said second auxiliary port. This provides an inherent stability of action, maintaining proper distribution of the liquid charge in the two functionally separate bodies. Evacuation thereupon proceeds in a stable efficient manner.

When liquid is drawn into the impeller chamber through the suction pipe, the amount of liquid in the transient working body or pool in the impeller is increased above that which is normal for priming, and, as a result, the entraining action is reduced, and the pressure upon all the throats is increased with resultant discharge of liquid at all the ports, both main and auxiliary. The pump strives as it were to reduce the excess of liquid in the impeller chamber, and this continues so long as liquid in excess of the original entraining pool or body is present in the impeller chamber. If at any time the inflow of liquid from the suction pipe fails, the pump re-establishes the priming action above described.

Liquid is discharged through the duct or manifold 62 into the separator chamber 60. The manifold 62 is preferably of a volute configuration for the dual purpose of reducing the velocity of the stream and also of stratifying the same to assist in agglomerating the air into larger bubbles. The stream is turned back in the opposite direction in the chamber 60, with the result that satisfactory separation is secured in unusually small space. The proportioning of the volute discharge passageway 62 may be such as to effect sufficient reduction of velocity to provide the major air separating action. The most difficult part of separation is to agglomerate the minute bubbles into bubbles of sufficient size to make a marked difference in specific gravity or density. For two bubbles to agglomerate when adjacent to each other there must be allowed a certain amount of time for the film of liquid between them to thin out and break. Turbulence of the mixture tends to separate such bubbles before the skin or film between them breaks, which latter action is a necessary action before they join. Agglomeration of fine air bubbles is fostered by concentration of the entrained air in a part of the mixture. For example, if a uniform mixture of air bubbles and water be treated to cause all the air bubbles to gather in one part of the liquid, they tend to agglomerate by the greater tendency to contact each other, and longer period of contact. Concentration of the air bubbles in one part of the mixture may be secured by a number of different actions. One mode employed in the present case is to reduce the velocity and turbulence of the mixture stream. This permits, first, of gravity concentration, and second, of longer engagement or contact between adjacent bubbles, with consequent agglomeration of air bubbles, even if no free surface is present. Another mode also employed, preferably in minor degree, is concentration by inertia effect as, for example, by causing the liquid to follow a curved path. The denser fluid, i. e., the water with less entrained air, seeks the outer side of the path and the less dense fluid, i. e., the water with more entrained air, seeks the inner part of the path, and even if no free surface is presented in the path, agglomeration occurs. The removal of the agglomerated air is then readily effected by providing a free liquid surface. This surface need not be quiet, like a pool, but may be moving, as in the case of a stream, a whirlpool, or the like.

In the construction shown in Figures 1 to 5 the agglomeration occurs by reduction in velocity and reduction in turbulence, and also by the inertia effect, i. e., change in direction of flow. A highly developed inertia effect, or whirlpool, requires relatively high velocity of whirl and sufficient diameter and confinement to allow a free whirl to be established. While it is quite effective, and desirable in some cases, I find it to be undesirable where high efficiencies are to be secured, because of the loss of energy and interference with delivery when the pump is operating on the liquid pumping phase.

The discharge passageway 62 provides the decrease in velocity, decrease in turbulence and change in direction to secure agglomeration. The chamber 60 provides the free surface for actual separation of the air from the liquid. Under certain circumstances the upper ends of the passageways 62-63 may present free surfaces for the same purpose.

In the chamber 60 the liquid is subjected to a certain amount of separating action secured by centrifugal action, that is, by whirling the liquid on a vertical axis, or it may be secured by providing sufficient space to permit the air in the liquid to be separated by gravity or in any other preferred manner. While I have shown the liquid as being whirled in the chamber 60 during the priming phase (see Figures 4 and 6) it is not essential that the whirling action be employed, as gravity separation may be sufficient. Obviously, the chamber 60 may be made larger and the mixture introduced at high velocity to secure pure centrifugal separation.

The shape of the ducts 62 and 63 is, in general, that of a volute, that is, a constantly increasing passageway extending circumferentially of the pump chamber and in the design herein shown there is a tendency for the liquid to stratify upon the outer wall of the duct or manifold 63. This may be so controlled as to assist in the final separating of gas from liquid, or it may perform substantially the entire function of separating gas from liquid during priming.

As soon as liquid enters the intake connection 47 in sufficient volume to fill the impeller, the quantity to be discharged increases beyond the capacity of the throats 66, 67 and 68 to carry the same, with the result that pressure is developed in the throats 69, 70 and 71, and outward flow in said throats and passageways into the duct or manifold 63 occurs. Thereupon, both the main throats 66, 67 and 68, and the auxiliary throats 69, 70 and 71 become discharge throats, and both ducts or manifolds 62 and 63 become discharge passageways, discharging liquid in parallel to the chamber 60 and out through the discharge pipe connection.

I have found that by this construction a great increase in capacity for a given size of impeller is secured, and surprisingly high efficiencies are attainable. At the same time, the air handling capacity of the pump is greatly increased over known forms of pumps and the device operates quietly and smoothly to a degree not heretofore attained in any self-priming pump with which I am familiar.

While I have described above the preferred embodiment of the invention it is to be understood that certain advantages of my invention may be secured without embodying all of the features thereof.

Since a pump of this character must essentially

operate as a liquid pump, and does so for the major part of its operating life, it is highly important that the efficiency of the pump and its balance, when running as a liquid pump, be made as good as possible.

In Figures 15, 16 and 17 I have indicated the novel mode of compensation involved in the operation of the pump of the present invention. While these diagrams show only two pairs of throats it is to be understood that the mode of operation and the same principles are involved in three pairs of throats or more. During the priming stage, the impeller performs two chief functions, the first of which is to form a mixture of gas and liquid, and the second of which is to discharge the same from the pump casing through the discharge throat or throats. The two actions are in large degree antagonistic, in that the development of centrifugal force tends to disentrain the gas from the liquid, that is to say, there is a tendency for the air to be squeezed radially inwardly as the same is carried about, due to the development of centrifugal force. It is therefore apparent that the denser fluid is radially outermost and the lighter fluid, that is, the mixture of air and liquid containing the greatest amount of air, lies radially inward. It is desirable to carry the liquid no further angularly than is necessary to develop the desirable pressure. My present form of pump greatly reduces the angular carry of the mixture, as compared with previous forms of self-priming pumps, and thereby less disentrainment of the air occurs. Also, in the liquid pumping phase, it is undesirable to carry the liquid any further than is necessary to develop discharge pressure, and by reducing the angular carry, as I have done in the pump of the present invention, I have reduced the eddy current losses within the casing and I find, as a matter of fact, that the discharge pressure attainable with the same diameter of impeller is actually greater with the short angular carry.

Since the mixture tends to stratify, due to the centrifugal force developed by rotary motion, any greater depth of liquid in the pump channel than can be discharged through the discharge throat results in a discharge of the liquid containing the least air, whereas it is desirable to carry out of the casing the liquid containing the most air. Hence, it will be apparent that if the return flow of liquid is greater than that required to fill the discharge throat or throats, the excess of liquid is not only undesirable, but actually hinders the rapid evacuation of the casing and suction pipe. The rate of return flow of liquid from the separator to the pump casing through the by-pass or auxiliary passageway is controlled by the difference in pressure or head prevailing on the by-pass or auxiliary passageway. As the vacuum in the pump casing increases, greater difference between the pressure in the separator and the pressure in the pump casing arises, with consequent increase in the rate of return flow. This same difference in pressure tends to oppose the outflow of liquid at the discharge or main throats, but such difference in pressure is relatively minor compared with the discharge pressure developed by operation of the rotor, and hence no appreciable difference in rate of outflow occurs. But both of these tendencies work in the direction of returning the circulating water from the separator to the pump casing more rapidly. This may result, if not counteracted, in an excessive amount of liquid being present in the pump casing. It is

here that the automatic compensation which is illustrated in Figures 15, 16 and 17 assists in controlling the return of liquid in a manner which is highly beneficial to secure more rapid evacuation and greater efficiency of evacuation than has heretofore been possible in pumps of this class. In the diagrams of Figures 15, 16 and 17 the primary throats or discharge throats are indicated at A and A'. The auxiliary throats or by-pass throats are indicated at B and B'. The arrows indicate the direction of flow, and this flow within the casing is maintained by rotation of the impeller.

Figure 15 illustrates a condition of flow balance when just the right amount of water enters both by-passes. Hence the incoming stream from B meets the impeller, which mixes it with air, and the mixture is carried around and all of it is discharged through the throat A' into the separator, it being understood that all of the throats are connected to the separator. Similarly, liquid from the separator entering the throat B' meets the impeller, is mixed with air, and all discharges through the throat A. This is the ideal condition, and assuming that the pump starts with no difference in pressure between the separator and the pump casing, the design may be such as to secure initially such condition of operation. As soon, however, as a greater pressure difference occurs by carrying out a part of the air from the pump casing, the condition shown in Figure 16 begins to prevail. In that case, one of the auxiliary or by-pass throats, for example B, assumes the controlling action. More liquid flows through the throat B than heretofore because of the greater difference in pressure on the ends of the throat, and a larger quantity of liquid is carried on the left hand side of the diagram, as indicated. Since the throat A' cannot discharge all of the liquid carried by the impeller, a part of the mixture as indicated in Figure 16 is carried past the main throat A', and creates a pressure condition upon the throat B', tending to retard the flow of liquid from the separator through the by-pass B' into the pump casing. The same difference in pressure which operates on the throat B operates on B', but because of the opposition of the excess liquid carried by the throat A', throat B' is not able to supply the same amount of liquid that is supplied by the throat B. The excess which has been introduced at B thereby prevents excess occurring at the throat B', and conditions may be so selected as to permit the mixture, consisting of the liquid carried by the throat A and introduced by the throat B' and mixed with air, to be fully discharged at the throat A. Thus it will be seen that although the left hand part of the pump is working at some disadvantage for the evacuation of air, the right hand half in Figure 16 is still working at a high efficiency for the evacuation of air, because not only the heavier fluid, but also the lighter fluid containing more air, is being carried out the main discharge throat A.

If the difference in pressure between the separator and the pump casing is further increased, then conditions such as shown in Figure 17 may prevail.

In this case there is illustrated the action when the vacuum is sufficient to make both by-passes try to feed too much water. B still supplies more than B'. Both discharge throats are properly filled, and the excess from B tends to compensate or balance the action of B', the tendency of which is to supply an increased amount. But

the tendency is not completely overcome, and some of the excess liquid by-passing A' together with the liquid entering at B' is carried past the main discharge throat A, and begins to compensate on the first main throat B. The mutual control of the by-passes upon each other may be interchangeable, that is, either one may initially seize control or preponderance.

The result of the above described mode of operation is that evacuation of air is more rapid. There is less disentrainment of air due to the shorter travel, and a higher degree of vacuum can be reached than has heretofore been possible in pumps of this type. It is generally customary to make each of the by-passes with an area of about 80% of the main throats. It is desirable to make the capacity of the by-pass throats fairly large, since they become discharge passageways upon filling of the suction pipe and the pump with liquid. By the scheme of automatic and progressive compensation, the throats may be made so large that they would supply far more priming water than is required if compensation were not effected.

Obviously, while I have illustrated two pairs of throats, this invention is not confined to two pairs, nor is the action any different if more than two pairs of throats are utilized. Either one of the by-pass or priming throats may assume preponderance to dominate the return flow of liquid, it being a matter of indifference in the operation of the pump. Obviously, by suitable design, a particular throat may be given the dominating action. In experiments which I have conducted, the self-compensation, that is, the carrying of liquid from the throat B clear back to itself, as illustrated in Figure 17, does not occur until vacua around twenty-five inches or better are reached.

By the provision of a common separator connected to all of the discharge throats and the return throats in parallel, the action of the pump during priming, particularly as to the exterior path of the priming liquid, is stabilized, and the efficiency of the pump improved. This common separator equalizes the work of the various pairs of throats during priming. The separation of gas from liquid is also improved, particularly by the employment of the two manifolds between the discharge throats and the separator.

The discharges of all the anterior throats, such as 66, 67 and 68, enter the manifold and are mixed and equalized both in the manifold and in the separator 60, and the agglomeration of gas bubbles is promoted. The posterior or auxiliary throats such as 69, 70 and 71 receive a substantially uniform supply of priming liquid both as to amount and as to gas content. Hence, one pair of throats does not tend to shirk its duty, nor will another pair be overloaded. Neither will a surging action be set up by variations in the density (gas content) of the liquid passing through one pair of throats, or by one throat of a pair, or by one posterior throat in respect to a subsequent anterior throat. By divorcing the adjacent posterior throat from its immediately adjacent anterior throat, the tendency to cause fluctuations in pressure or surging is greatly reduced or prevented.

The external part of the priming circuit is stabilized and equalized through the use of the common separating chamber. Stability and efficiency of priming is promoted in the internal part of the priming circuit by a hydraulic compensation as between liquid entering one inlet

throat and liquid entering another inlet throat as heretofore described. The pump as a whole has a pronounced inherent stability. This is particularly important because of the relatively small amount of priming water which the pump employs for the amount of gas which is handled.

In the pump herein shown, particularly the pump in Figure 1, the discharge manifold 82 blends together the discharge streams of mixture and provides a preliminary separation of the gas from the liquid before the stream enters the separator 60. Here the gas rises out through the outlet 72 and the liquid passes through the priming manifold 63 towards the priming throats. In this manifold during this action, the liquid is further equalized, particularly as to gas content, so that substantially a uniform quality is supplied at each of the priming throats. Thus these manifolds, by the performance of new functions, secure new results or results which were performed less advantageously in the separator of previous self-priming pumps.

The efficiencies attainable are comparable with those of the best closed impeller type pumps, with all the simplicity of construction and clearances of the open type impeller.

It is not essential in the construction of the pump that the circular arrangement of manifold here shown be employed. The throats may communicate directly with the separator chamber, or two chambers might be employed.

While I have shown three pairs of throats in the pump of Figures 1 to 7 it is to be understood that any number of pairs which is found suitable may be employed, but I also wish to point out that it is not essential that the throats be arranged in closely grouped pairs. For example, in the structure illustrated in Figures 11 and 12, there are provided only two throats, 75 and 76, placed diametrically opposite each other with respect to the axis of the impeller. These two throats 75 and 76 communicate with the raceway for the impeller blades within the pump casing and communicate through separately formed ducts, or passageways 78 and 79, respectively, with a vortex separating chamber 80. Obviously, any other form of separating chamber may be employed. The two conduits 78 and 79 open substantially tangentially into the cylindrical separator chamber 80. An inlet trap is provided for the inlet 20, this being omitted for the sake of simplicity in illustration. When the pump is started up it is provided with a suitable priming charge, and assuming that the impeller chamber stands filled with water, the difference in the hydrostatic head upon the throats 75 and 76 is sufficient to start an unbalanced action. At the same time, the friction of the passageways 78 and 79 also assists in establishing a proper direction of flow. Since the hydrostatic head on the throat 75 is less than the hydrostatic head on the throat 76, assuming substantially equal pressures to be caused by the motion of the impeller 10, there is a tendency to drive the liquid out of the throat 75 more easily than out of the throat 76, and hence circulation in the direction causing the throat 75 to be the main discharge throat and the throat 76 to be the auxiliary, or priming throat, is usually instituted. If the throats are of the same capacity it is immaterial which one assumes the discharge function and which one the priming function during priming. I have found it generally desirable, where the throats are arranged in pairs, to make the posterior throat of the pair, which throat becomes the by-pass or priming throat, of

a capacity about 80% of that of the anterior or discharge throat. This proportion may be observed in the present pump when one throat is designed to assume the priming function.

It will be observed that where only a single pair of throats such as 75 and 76 are disposed diametrically with respect to each other, during priming one half of the impeller periphery is all that is doing active work. This unbalances the thrust radially on the impeller shaft during priming, but as soon as liquid pumping begins the effect is balanced, or substantially so, since liquid enters axially through the inlet opening and moves radially in all directions to fill the impeller 10 and to be thrown out on two sides of the same, whereby the radial forces are substantially balanced.

In Figure 8 I have shown how two pairs of throats may be employed in a pump of this character to secure a balanced effect during both priming and liquid pumping.

In this case the main or anterior throats 75 and 76 are connected to a manifold or duct 82 which, in turn, leads tangentially into the separator chamber 80 for providing centrifugal separation. The posterior throats 83 and 84 are connected to the separator 80 by a duct or manifold 85. The form of separator and its mode of operation is optional.

The operation of this form of device will be apparent from the diagrams of Figures 9 and 10 and from the foregoing description. The anterior throats 75 and 76 rob the posterior throats 83 and 84 of liquid, causing regions of reduced pressure to occur at said throats, with the result that while liquid, or liquid mixed with gas, is discharged out of the anterior throats into the separating chamber, liquid from which gas has been separated in the chamber 80 is returned through the throats 83 and 84 into the impeller 10. Since each half of the impeller 10 is used equally during both priming and liquid pumping, the balanced effect which it is desired to secure is thereby attained during both phases of operation.

In the diagrams of Figures 7 and 10 the axial inflow of liquid and its movement by the impeller is indicated by the lines 86-86.

In Figures 13 and 14 I have illustrated a modified form of construction. In this case the primary throats, or throats which are invariably discharge throats, are indicated at 87, 88 and 89. They are connected by passageways 87a, 88a and 89a with the duct or manifold 90 which discharges into the separator 80. Equally spaced angularly with respect to the primary discharge throats are the auxiliary discharge throats 92, 93 and 94.

All of these throats, instead of discharging tangentially with respect to the inner cylindrical wall 95 of the casing 96, discharge laterally therefrom. The throats 92, 93 and 94 are connected by short passageways 92a, 93a and 94a with the duct or manifold 97 which also leads to the centrifugal separating chamber 80.

In the present instance the shape of the throats is such as to determine the discharge in favor of the group 87, 88 and 89 by widening the outer, or peripheral portion of the throats, whereas the group 92, 93 and 94 upon the opposite side of the casing is formed with a narrower peripheral portion. As a consequence, when there is insufficient liquid to fill all of the throats the tendency is to discharge the mixture of air and liquid during the priming phase out of the throats 87, 88 and 89 and to secure reentry through the throats 92, 93 and 94.

Obviously, instead of having the throats all equally spaced angularly about the periphery of the casing, these throats may be grouped in pairs if desired.

5 Also, while I have shown both groups of throats as opening axially instead of tangentially, the group of primary throats 87, 88 and 89 may be disposed tangentially and the auxiliary throats arranged to open axially. Also, if desired, tangential throats for the primary discharge may be provided and axially disposed throats registering with each other from opposite sides of the casing may be provided. In this case three ducts, or manifolds would be employed, the primary duct opening tangentially into the separator 80 and the return duct, preferably with a common opening from a lower point in the separator 80, if desired.

From the foregoing it will be seen that various methods of producing the desired unbalance in pressure in the two sets of throats may be employed. The preferable embodiments are those in which the reaction of the various throats is balanced substantially radially and axially upon the impeller, so that it may run substantially without the necessity for guiding bearings. In the construction shown in Figures 1 to 3, inclusive, the impeller shaft is short and forms merely a rigid extension of the motor shaft without requiring any bearings in addition to the motor shaft bearings. Where the impeller tends to run true by balancing the stresses thereupon it is much simpler to maintain the packing tight and far less wear upon the bearings occurs.

35 While I have shown a form of impeller which is highly advantageous, it is to be understood that the invention is not limited to this specific form. The impeller is substantially self-balancing in an axial direction during both the priming phase and during the liquid pumping phase. The forwardly extending vanes 23 of the impeller 10 assist in directing the liquid and giving it the proper motion to enter the actual working space or channel in which the blades or arms of the runner move, so as to secure a gradual acceleration, both axially and radially, as well as circumferentially.

I do not intend to be limited to the details shown and described, except as they are recited in the appended claims. It will be apparent to those skilled in the art that various modifications and refinements will at once occur to those skilled in the art, all of which are contemplated as coming within the spirit and scope of my invention.

I claim:

1. In a self-priming pump, the combination of a casing having a central inlet and containing a channel for an impeller, an impeller lying in a vertical plane and being mounted on a horizontal axis to run in said channel, there being an even number of substantially tangential discharge outlets from said channel, the maximum angular distance between adjacent outlets which are connected to different passageways being not substantially greater than 180°, a separator having its longitudinal axis disposed substantially vertically, a first passageway serving always as a discharge passageway connecting half of said discharge outlets to said separator at one side of the axis thereof, and a second passageway serving on the priming phase as a priming passageway and on the liquid pumping phase as a discharge passageway connecting the other half of said outlets to the separator at the other side

of the axis thereof, said passageways opening into said separator substantially horizontally and at substantially the same level, said separator having an outlet opening at the top of the same.

2. In a pump of the class described, the combination of a casing providing an impeller chamber and an axial inlet, said chamber having a plurality of pairs of throats disposed about its periphery, a separator, said pairs of throats being spaced angularly about said periphery by greater angular distances than are the throats of each pair, said angular spacing between adjacent pairs of throats being not substantially greater than that within which the mixture of gas and liquid receives its full discharge velocity from the motion of the impeller, each pair of throats comprising a main discharge throat serving always for discharge of liquid, and an auxiliary or priming throat, serving during priming for the return of liquid from the separator to the impeller chamber, a duct connecting all of the main throats to the separator, and a duct connecting all of the auxiliary throats to the separator, said ducts and separator serving to stabilize the action of the pump during priming.

3. In a pump of the class described, the combination of the casing providing an impeller chamber and an axial inlet, said chamber having a plurality of pairs of throats disposed about its periphery, each pair comprising a main throat and an auxiliary throat, a separator chamber having a cylindrical wall, a manifold duct connecting the main throats and leading the discharge thereof into the separator chamber substantially tangentially of said cylindrical wall, said duct producing agglomeration of air bubbles of the mixture of air and liquid discharged therein, a second manifold duct connecting the auxiliary throats with the separator chamber, said ducts extending peripherally of said impeller chamber, said ducts and separator serving to stabilize the action of the pump during priming.

4. In a pump of the class described, the combination of a casing providing an impeller chamber and an axial inlet, said chamber having a plurality of pairs of throats disposed about its periphery, each pair comprising a main throat and an auxiliary throat, a separator disposed at the upper end of the pump casing, said casing comprising a hollow annular portion encircling the impeller chamber, a dividing wall extending around the major part of the periphery and dividing said hollow annular portion into two passageways which terminate in said separator, said main throats being connected to one passageway and the auxiliary throats being connected to said other passageway.

5. In a pump of the class described, a hollow annular casing having two peripherally extending passageways constituting manifolds and having an enlargement with which said passageways connect, constituting a separator chamber with an outlet for gas during priming and for liquid during liquid pumping, a plurality of pairs of throats, said pairs of throats being equally spaced about the inner periphery of said casing, each pair comprising a main discharge throat and an auxiliary throat, the main throats communicating with one passageway and the auxiliary throats communicating with said other passageway, a pair of side plates cooperating with said annular casing to define an impeller chamber, and an impeller in said impeller chamber, said impeller having a shaft mounted in one

of said plates, the other plate having an inlet opening substantially centrally thereof.

6. In a pump of the class described, an annular casing having a centrally disposed radially inwardly extending annular ring and a hollow casing extending about the ring, said casing having an enlargement forming a separator chamber and having a dividing wall extending throughout the major part of the periphery and terminating short of the separator chamber, substantially tangential main discharge passageways extending through said ring and leading to one side of said dividing wall, substantially tangential auxiliary discharge passageways extending through said ring and leading to the other side of said dividing wall, inwardly dished side plates having margins resting against the sides of said ring, said ring and side plates defining an impeller chamber, an impeller mounted for rotation in said impeller chamber, and bolts extending through said ring outside the margins of said side plates for clamping said side plates against the ring.

7. In a pump of the class described, an annular casing having a centrally disposed inwardly extending annular ring and a hollow casing extending about the ring, said casing having an enlargement forming a separator chamber and having a dividing wall extending throughout the major part of the periphery and terminating short of the separator chamber, substantially tangential main discharge passageways extending through said ring and leading to one side of said dividing wall, substantially tangential auxiliary discharge passageways extending through said ring and leading to the other side of said dividing wall, inwardly dished side plates having margins resting against the sides of said ring, said ring and side plates defining an impeller chamber, an impeller mounted for rotation in said impeller chamber, one of said plates having a substantially axial inlet opening into the impeller chamber, the other having a gland for the shaft of said impeller, an inlet trap having a flange resting against the flange of said inlet plate, a motor bracket member having a flange resting against the flange of the other side plate, and bolts extending through said ring radially outside of said flanges and clamping said flanges against said ring.

8. In a self-priming pump, a pump casing comprising an impeller chamber, an impeller mounted for rotation therein, said chamber having an inlet for liquid leading into that part of the impeller lying radially inward of the periphery thereof, a separator chamber having an outlet for the fluid discharged by the pump, two manifolds, and a plurality of pairs of adjacent discharge passageways, said pairs being equally spaced about the periphery of the impeller chamber and like ones of said pairs being connected by said two manifolds respectively to said separator, said manifolds and separator serving to stabilize the action of the pump during priming by pooling the incoming and outgoing streams.

9. In a self-priming pump, a pump casing providing an impeller chamber, an impeller mounted to run in said impeller chamber, a plurality of substantially tangential discharge throats spaced substantially equally about the inner periphery of the impeller chamber to provide a multiple throat discharge, the angular spacing between throats being not substantially greater than that in which the liquid receives the necessary discharge velocity from the motion of the impeller, a separator to which said discharge throats are connected, and a passageway between the sepa-

rator and a part of the impeller chamber wherein pressure is developed by operation of the impeller when it is supplied with water for returning liquid from the separator to the impeller chamber during the priming phase whereby return of liquid through said passageway during the liquid pumping phase is prevented, said separator having an outlet through which the pumped fluid is discharged, said separator acting to equalize the effect of said discharge throats upon said return passageway during priming.

10. In a self-priming pump, a pump casing providing an impeller chamber, an impeller mounted for rotation in said chamber, a separator chamber having an outlet for fluid discharged by the pump, there being a plurality of discharge throats spaced substantially equally about the periphery of the impeller chamber and all leading to the separator and serving at all times to discharge liquid from the impeller chamber, the angular spacing between throats being not substantially greater than that in which the liquid receives the necessary discharge pressure from the motion of the impeller, and means for conducting liquid from the separator to the interior of the impeller chamber during the priming operation, said means comprising an auxiliary throat which is subjected to lower hydraulic pressure during the priming operation than are the discharge throats, said auxiliary throat being subjected to sufficient hydraulic pressure during liquid pumping that recirculation is substantially prevented, said separator serving to equalize the gas content of the liquid returned through said auxiliary throat.

11. In a self-priming pump, an impeller chamber, an open impeller mounted for rotation therein, a separator, said chamber having multiple discharge throats spaced about the periphery thereof to provide a balanced discharge from said impeller, and a plurality of ducts connecting said discharge throats to said separator, said pump being organized to compel outflow invariably from the impeller chamber through all of the throats and through both of the ducts when the pump is pumping liquid, and to compel return flow from the separator through one of said ducts and at least one of said discharge throats when the pump is operating on the priming phase, said ducts being disposed laterally of each other and on opposite sides of the median plane of the impeller chamber, and having walls formed integral with the walls of the impeller chamber.

12. In a self-priming pump, a casing comprising an impeller chamber having an inlet opening and having a plurality of pairs of substantially tangential throats, an impeller mounted to rotate in said chamber, a separator chamber disposed substantially at the top of the impeller chamber, a pair of tapered volute shaped manifolds leading at their largest cross section into said separator chamber, the throats of each pair anterior in respect to the direction of rotation of the impeller being connected to one manifold and the throats of each pair posterior in respect to the direction of rotation of the impeller being connected to the other manifold, said separator through which gas is released during priming and through which liquid is discharged during liquid pumping serving to equalize the return flow of priming liquid to the throats which are connected to said other manifold, both as to amount and as to gas content, and serving to stabilize the action of the pump.

13. In a self-priming pump, a casing comprising an impeller chamber having an inlet open-

ing and having a plurality of pairs of substantially tangential throats, an impeller mounted to rotate in said chamber, a separator chamber, a pair of volute shaped manifolds leading into said separator chamber, the throats of each pair anterior in respect to the direction of rotation of the impeller being connected to one manifold and the throats of each pair posterior in respect to the direction of rotation of the impeller being connected to the other manifold, said manifolds lying in planes substantially parallel with the plane of the impeller, said separator chamber being approximately circular and having its circular axis substantially parallel to the plane of the impeller.

14. In a self-priming centrifugal pump, a pump casing comprising a central inlet, an internal channel, a runner operating in said channel, there being a plurality of pairs of outlets from the channel, a separator chamber into which all of said outlets open, each pair of outlets comprising a main outlet and an auxiliary or priming outlet, said main outlet of each pair being with respect to the direction of rotation of the impeller anterior to the auxiliary or priming outlet whereby during priming of the pump the auxiliary or priming outlet of one pair supplies from the separator chamber liquid which is introduced into the peripheral part of the impeller to be mixed with gas in the casing, some of said introduced liquid being discharged at the main outlet of another pair and some being carried beyond said main outlet of the other pair, and the liquid which is carried beyond said main outlet of said other pair retards the inflow of liquid from the separator through the auxiliary or priming throat of said other pair into the pump casing whereby to increase the efficiency and stability of the priming action.

15. In a pump, the combination of an annular frame casting having a substantially cylindrical interior peripheral wall forming the bottom wall of a channel, there being openings at a plurality of substantially equidistant points in said cylindrical wall forming throats, the annular casting having a peripheral manifold passageway formed therein extending partially around the outer periphery of the pump and there being tangential passageways for conducting fluid discharged through said openings into the manifold passageway, said manifold passageway conducting the liquid from said throats in the same peripheral direction throughout, a pair of side plates clamped against said annular frame casting, said plates having planar surfaces cooperating with said circular wall to define a channel, and a runner having blades traveling in said channel.

16. In a pump, the combination of an annular frame casting having a substantially cylindrical interior peripheral wall forming the bottom wall of a channel, there being openings at a plurality of substantially equidistant points in said cylindrical wall forming throats, the annular casting having a peripheral manifold passageway formed therein extending partially around the outer periphery of the pump and there being tangential passageways for conducting fluid discharged through said openings into the manifold passageway, said manifold passageway conducting the liquid from said throats in the same peripheral direction throughout, a pair of side plates clamped against said annular frame casting, said plates having planar surfaces cooperating with said circular wall to define a channel, a runner

having blades traveling in said channel, and bolts disposed parallel to the longitudinal axis of the annular casting, said bolts extending through the annular casting radially within said manifold passageway and being spaced angularly between the tangential passageways, said bolts clamping the side plates against the annular casting.

17. A self-priming pump having a casing provided with an inlet, an open runner, a single separator and a plurality of pairs of passageways providing communication between the casing and the separator, each pair of passageways comprising a discharge passageway and a return passageway during priming, said separator serving to equalize the work of said throats and to stabilize the operation of the pump during priming and having a common outlet for the fluid being pumped.

18. A self-priming pump comprising a casing having a central inlet for liquid, an open runner therein, a single separator, a plurality of pairs of tangential throats all leading to the separator and all serving as discharge passages in parallel when the pump is pumping liquid, the anterior throat, in the direction of rotation of the runner, of each pair serving as a discharge passageway for discharging a mixture of gas and liquid from the casing to the separator, and the posterior throat, in the direction of rotation of the runner, of each pair serving to receive liquid freed of gas from the separator into the casing while liquid is being circulated during the priming operation, said separator serving to equalize the work of said throats and to stabilize the operation of the pump during priming and having a discharge outlet for the fluid being pumped.

19. A self-priming pump comprising a casing having a central inlet for liquid, an open runner therein, a single separator disposed substantially at the top of the casing, a plurality of pairs of tangential throats disposed at substantially equal distances about the inner periphery of the casing and all leading to the separator and all serving as discharge passages in parallel when the pump is pumping liquid, the anterior throat, in the direction of rotation of the runner, of each pair serving as a discharge passageway for discharging a mixture of gas and liquid from the casing to the separator, and the posterior throat, in the direction of rotation of the runner, of each pair serving to receive liquid freed of gas from the separator into the casing while liquid is being circulated during the priming operation, said separator comprising a chamber with a wall curved in a horizontal plane to cause horizontal circular travel of the circulating liquid during priming, said separator serving to equalize the work of said throats and to stabilize the operation of the pump during priming and having a discharge outlet for the fluid being pumped.

20. A self-priming pump comprising a casing, an open runner therein, a single separator, a plurality of pairs of tangential throats all leading to the separator and all serving as discharge passages in parallel when the pump is pumping liquid, the anterior throat, in the direction of rotation of the runner, of each pair serving as a discharge passageway for discharging a mixture of gas and liquid from the casing to the separator, and the posterior throat, in the direction of rotation of the runner, of each pair serving to receive liquid freed of gas from the separator into the casing while liquid is being circulated during the priming operation, said separator

comprising a substantially cylindrical chamber with the axis substantially vertical and a pair of substantially parallel volute manifolds for the two sets of discharge throats, said manifolds opening substantially tangentially into said separator at opposite sides thereof.

21. A self-priming centrifugal pump, a casing having a central inlet and comprising a circular channel of uniform depth, an open runner having substantially uniform clearance with the periphery of the channel, a plurality of pairs of adjacent throats tangential to the periphery of the channel, said pairs being spaced substantially uniformly about the periphery of the channel, and a common separator connected to all of said throats, anterior ones of each pair being connected by a common manifold to said separator and posterior ones of each pair being connected by a second common manifold, said manifolds comprising volutes having their outlet ends extending substantially horizontally into a common separator chamber and providing additional space within which gas separation may take place, said separator having an outlet for the fluid being pumped, and serving in combination with said manifolds during priming to equalize the work upon the throats.

22. In a self-priming pump, an impeller, a casing therefor provided with a central inlet and having a plurality of substantially equally spaced tangential discharge throats, a common separator for said discharge throats, and means for returning liquid from the separator to the peripheral part of the impeller for circulation through the impeller and formation of a gas and liquid mixture which is driven out of the casing through the discharge throats in parallel during priming of the pump, said separator having an outlet for the fluid being pumped, said separator during priming blending the fluids discharged through said discharge throats and equalizing the gas content of said liquid returned to the impeller during priming.

23. In a self-priming pump, the combination of a runner casing and runner, said casing having a single central inlet and a plurality of pairs of peripheral throats and a common separator to which all of the throats are connected, said separator having an outlet for the fluid being pumped, the throats of each pair being so close to each other that the runner does not have sufficient angular travel to build up discharge pressure between them, the pairs being separated by only sufficient angular distance to allow discharge pressure to be built up between them, whereby during the priming operation the mixture of gas and liquid is not subjected to unnecessary centrifugal separation, the discharge of liquid from a pair of throats during pumping of liquid entering the separator on opposite sides of the axis of the separator to provide parallel discharge flow through the outlet, the fluid streams discharged during priming from corresponding throats of each pair being all blended in said common separator and the other throats of each pair being supplied with liquid from said common separator, whereby to equalize the work upon said pairs of throats and to stabilize the action of the pump during priming.

24. The combination of claim 23, wherein the pairs of throats are substantially equally spaced about the periphery of the casing and are connected by two manifolds to the separator, one manifold connecting those throats of each pair which are anterior in the direction of motion of

the runner and the other manifold connecting the throats of each pair which are posterior in the direction of motion of the runner, the throats of the first half discharging in parallel through the first manifold to provide a single stream entering the separator.

25. In a self-priming pump, the combination of a casing comprising a peripheral portion for cooperation with an impeller and having a central inlet, an impeller having vanes for driving liquid from the central inlet into the peripheral portion during liquid pumping, said casing having a series of ports disposed about and opening out of said peripheral portion, a first manifold connecting alternate ones of said ports, a second manifold connecting the other ones of said ports, and a discharge and separating chamber in which gas is liberated from the liquid entering the same and through which one manifold discharges into the other in series during the priming operation of the pump, said chamber having an outlet through which gas alone is discharged during priming and through which both manifolds discharge liquid in parallel during liquid pumping, said ports connected to the first manifold being spaced apart by an angular distance not substantially greater than that within which the fluid being moved acquires full discharge pressure by normal motion of the impeller.

26. The combination of claim 25 wherein the impeller is an open impeller having blades curved backwardly with respect to the direction of rotation, and wherein the peripheral portion of the casing provides a channel which is substantially cylindrical at its periphery, and wherein the ports connected to the first manifold open out substantially tangentially from said channel.

27. A casing member for a self-priming pump, comprising a ring-like member having an inner cylindrical periphery, an annular seat at the side of the ring for receiving a circular plate, there being a plurality of pairs of substantially tangential outlets from the cylindrical periphery, walls defining passageways from said outlets, a separator chamber having a cylindrical inner wall with a vertical axis and an outlet at the top, means defining two tapering volute manifolds extending circumferentially of said ringlike member and having their larger ends opening substantially horizontally into the sides of the separator, alternate ones of said passageways leading into one manifold and the other passageways leading into the other manifold.

28. In a self-priming centrifugal pump, the combination of a casing providing a pumping chamber having a peripheral portion for cooperation with an impeller and providing a central inlet for liquid to the impeller, an impeller having vanes for driving the liquid from the central inlet to the channel during liquid pumping, a separating and discharge chamber having an outlet, said peripheral portion having a series of throats all of which discharge liquid in parallel into the second named chamber and through the outlet when liquid is supplied to the inlet, and when liquid supply at the inlet fails, discharge of liquid in parallel ceases and liquid from said second chamber reenters the pumping chamber through a plurality of said throats to be mixed with air by rotation of the impeller and again discharged into said second chamber, said second chamber tending to equalize the flow of priming liquid through said reentry throats, excessive reentry of liquid at one of said reentry throats into the impeller causing the creation of a pressure

at an adjacent point of reentry tending to limit reentry of liquid at said second point.

29. In a self-priming pump, a pump casing having a single continuous channel open toward the center of the casing and having an inlet opening communicating with the central part of the casing, a single open type impeller running in said channel, a plurality of priming and discharge openings disposed at angularly spaced points about said channel, the angular distance between a priming opening and its nearest cooperating discharge opening being not substantially greater than that within which the impeller forms and builds up discharge pressure of a mixture of air and liquid during priming, a separator and discharge chamber having an outlet through which gas is discharged during priming and through which liquid is discharged during liquid pumping, a passageway of substantially greater cross section than that of the sum of the discharge openings for conducting all the mixture discharged by said discharge openings to said separator and permitting agglomeration of gas bubbles as the mixture is being conducted, and a passageway leading from the separator to said priming openings for the return of priming liquid substantially free of entrained gas, said separator and said passageways serving to equalize the circulation of liquid in both amount and gas content during priming, all of said openings serving as parallel discharge openings when liquid is supplied to the inlet of the pump.
30. A pump of the class described, comprising an impeller adapted to receive liquid axially and to discharge the same substantially tangentially, a casing having a peripheral portion embracing the peripheral portion of the impeller and having a central inlet for fluid to be pumped, said casing having pairs of throats spaced about said peripheral portion by angular distances substantially great enough only to permit the impeller to build up the desired liquid discharge pressure between the posterior throat of one pair and the anterior throat of another pair, whereby the mixture of gas and liquid formed during priming is subjected to minimum centrifugal separation, a chamber having inlet means through which the liquid from all the anterior throats enters in a common stream in the same direction during either priming on liquid pumping, whereby during priming the gas contents of said common stream is equalized, said chamber having a discharge outlet through which gas is discharged during priming and through which liquid is discharged during liquid pumping, and conduit means through which liquid freed from gas flows from the chamber to said posterior throats and into the peripheral part of the impeller during priming, excessive re-entry at one priming throat being caused to hinder re-entry of priming liquid at the next adjacent priming throat, whereby the efficiency of entrainment of gas is enhanced, said posterior throats serving as discharge throats during liquid pumping.
31. In a self-priming pump, a pumping chamber with a central inlet having an even number peripherally disposed throats, an impeller in the chamber serving when liquid is supplied at the inlet to discharge liquid at all of said throats in parallel, a manifold of relatively great cross section at its central part and having an outlet at said central part for the fluid being pumped, said manifold being progressively reduced in cross-section from said central part to both ends, one half of said manifold being connected to alter-

nate ones of said throats and the other half of said manifold being connected to the others of said throats, said two halves of the manifold being curved peripherally about the pumping chamber, and when liquid at said inlet fails said impeller forming a mixture of air and liquid in the chamber and driving the same through said alternate throats in parallel into the one-half of the manifold wherein the gas separates from the mixture and passes out said outlet, the liquid from which gas has been liberated passing through the other half of the manifold and through the other half of said throats into the periphery of the impeller, the maximum angular distance between cooperating adjacent throats connected to different halves of the manifold being only substantially the distance within which the mixture attains discharge velocity, the travel of the priming liquid in said manifold being at a relatively low velocity and in a long path as compared with its travel in the casing, said manifold equalizing the supply and gas content of the priming liquid and serving to stabilize the action of the pump.

32. A self-priming centrifugal pump comprising an impeller casing in which an impeller is mounted to run for entraining gas and liquid during priming and for imparting centrifugal force to the mixture to discharge the same, said casing having an axial inlet to which a suction pipe for water is adapted to be connected, a separator having an outlet at its upper end for the discharge of gas during priming and liquid during liquid pumping, the impeller casing having a plurality of angularly spaced discharge ports which communicate with the separator, the angular spacing between discharge ports being not substantially greater than that required to develop full discharge pressure when the pump is supplied with liquid, means to trap sufficient liquid to establish a working charge for evacuating gas from the impeller chamber during priming, rotation of the impeller causing the trapped liquid during priming to be distributed partly in the impeller casing as a transient moving pool of liquid entraining gas and passing out of the discharge ports simultaneously at a plurality of angularly spaced points to the separator and partly as a transient moving pool of liquid in the separator which latter pool gives up the entrained gas and permits its escape at the said outlet of the separator, there being a plurality of auxiliary ports in the impeller chamber communicating with the separator and through which liquid from the pool in the separator is returned to replenish the pool in the impeller chamber, said auxiliary ports being so disposed with respect to the discharge ports that an excess of returning liquid at one auxiliary port is carried through a greater angular distance than that in which normal pressure is developed and impinges upon another auxiliary port with the effect of reducing the return flow whereby the circulation between said ports is stabilized and maintained in efficient operation, said pump being organized to discharge liquid through both the discharge ports and the auxiliary ports when the inflow of liquid at the inlet increases the amount of liquid in the transient pool in the impeller chamber.

33. In a centrifugal pump, an impeller chamber having an impeller channel and an impeller therein adapted during priming to form a mixture of gas and liquid and to impart centrifugal force to the mixture to discharge the same, a separator having an outlet for gas during priming,

5 a pair of auxiliary throats leading to the impeller
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to the impeller channel during priming, said
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a discharge throat disposed between said auxil-
iary throats and leading from the periphery of
the impeller channel to the separator for the
discharge of mixture during priming, said dis-
charge throat being separated from one of said
auxiliary throats by an angular distance not sub-

stantially greater than that required for building
up normal discharge pressure of mixture during
priming, whereby the entry of excessive priming
liquid from the auxiliary throat anterior to the
discharge throat in direction of rotation of the
5 impeller will cause liquid to be carried past the
discharge throat and exert a retarding effect
upon the return flow of the auxiliary throat
which is posterior to the discharge throat in the
direction of rotation of the impeller. 10

HARRY E. LA BOUR.

CERTIFICATE OF CORRECTION.

Patent No. 2,110,883.

March 15, 1938.

HARRY E. LA BOUR.

It is hereby certified that error appears in the printed specification
of the above numbered patent requiring correction as follows: Page 8, second
column, line 27, claim 3, for the article "the" read a; page 10, first col-
umn, line 33, claim 14, after "the" insert said; page 12, first column,
line 50, claim 30, for "on" read or; and that the said Letters Patent should
be read with these corrections therein that the same may conform to the
record of the case in the Patent Office.

Signed and sealed this 3d day of May, A.D. 1938.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents

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