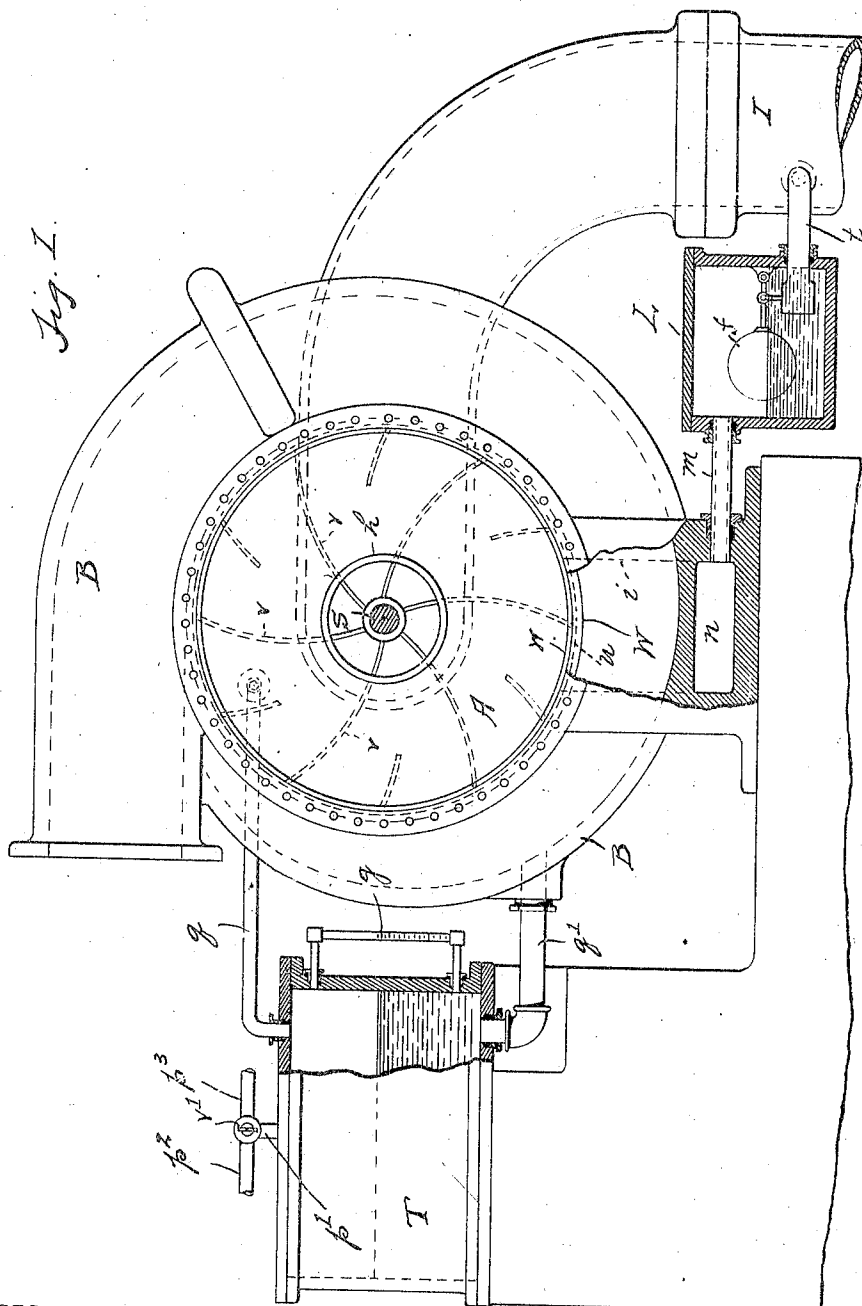


1,026,101.

E. A. MARSH.
CENTRIFUGAL PUMP.
APPLICATION FILED DEC. 23, 1910.

Patented May 14, 1912.

5 SHEETS-SHEET 1.



WITNESSES:

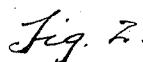
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CENTRIFUGAL PUMP.
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5 SHEETS—SHEET 2.



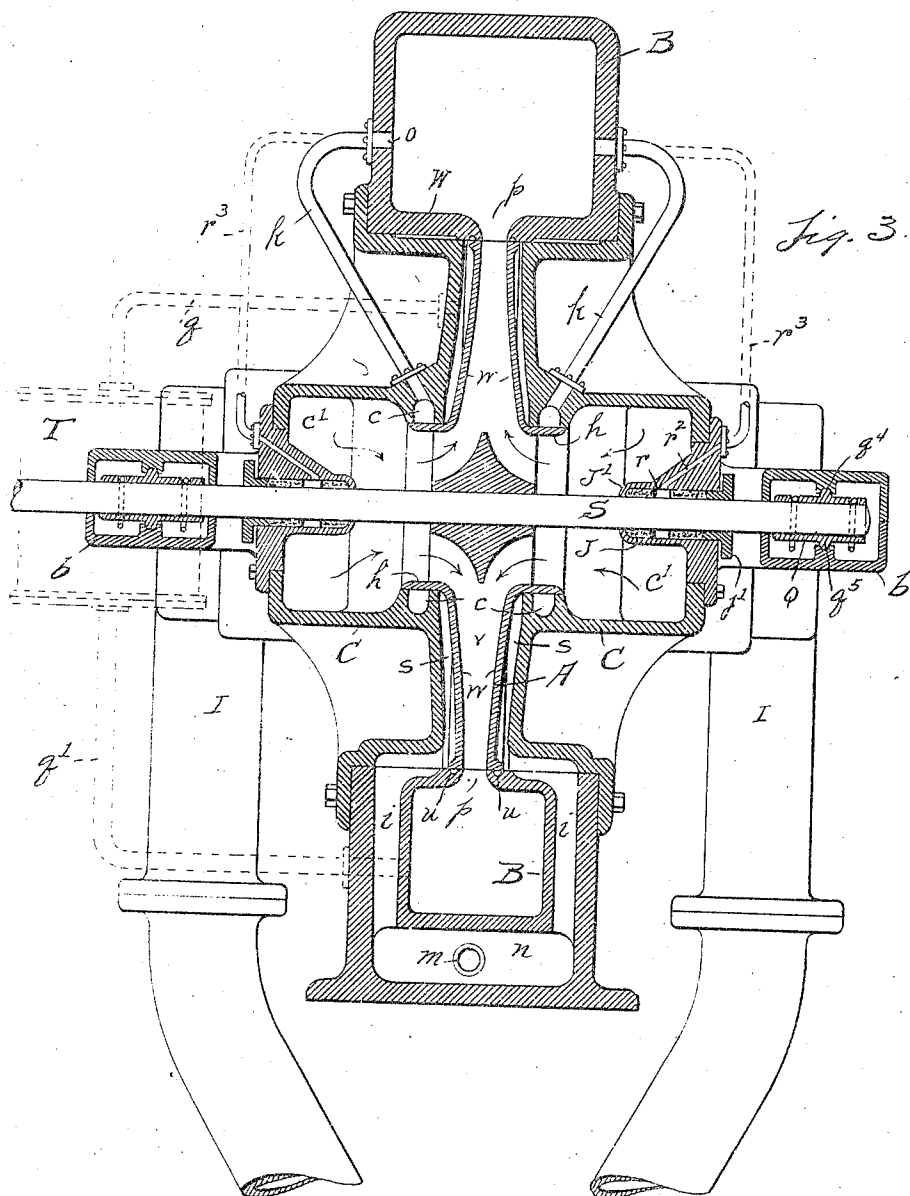
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5 SHEETS—SHEET 3.



WITNESSES:

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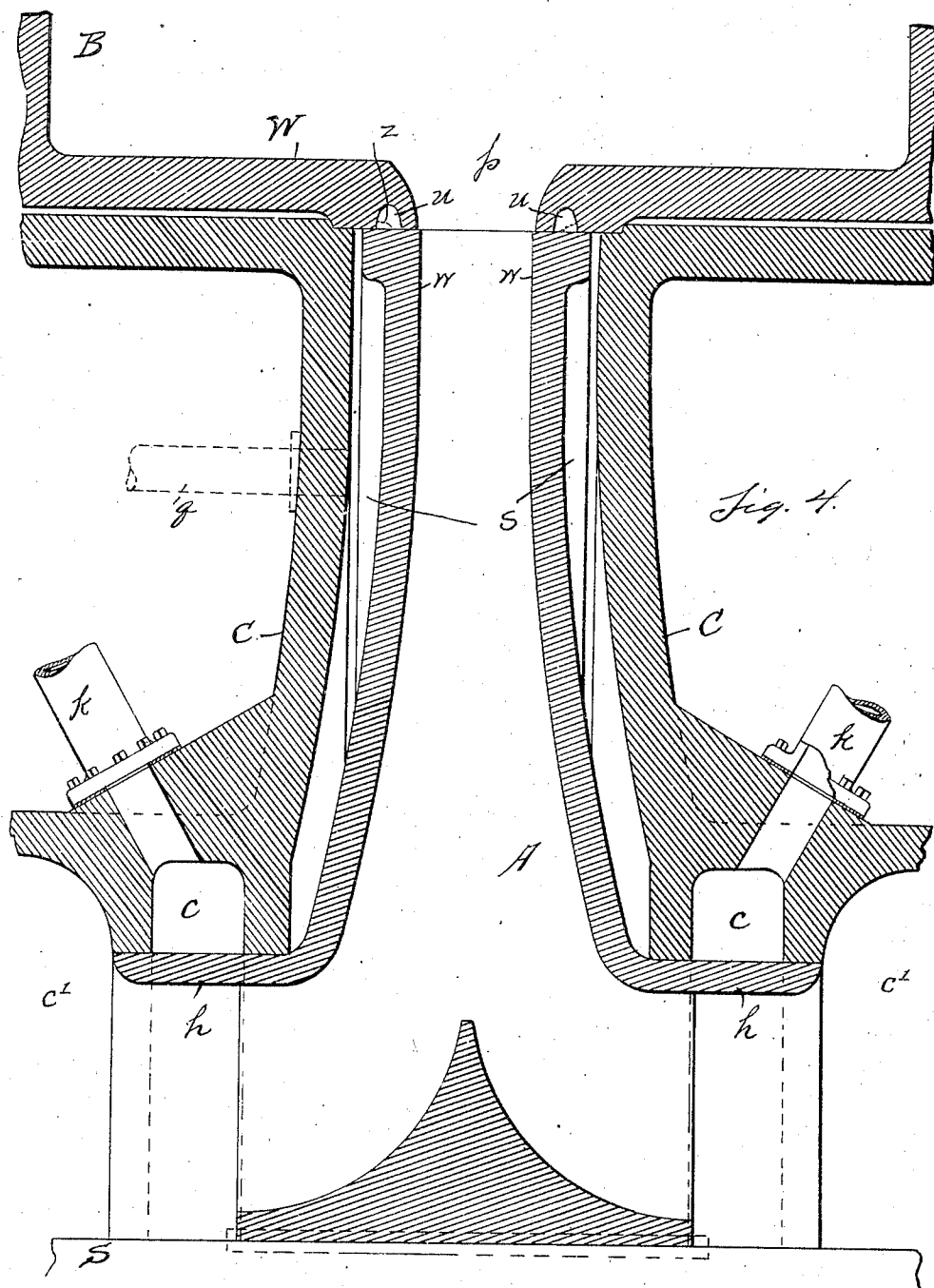
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1,026,101

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Patented May 14, 1912.

5 SHEETS-SHEET 4.



WITNESSES:

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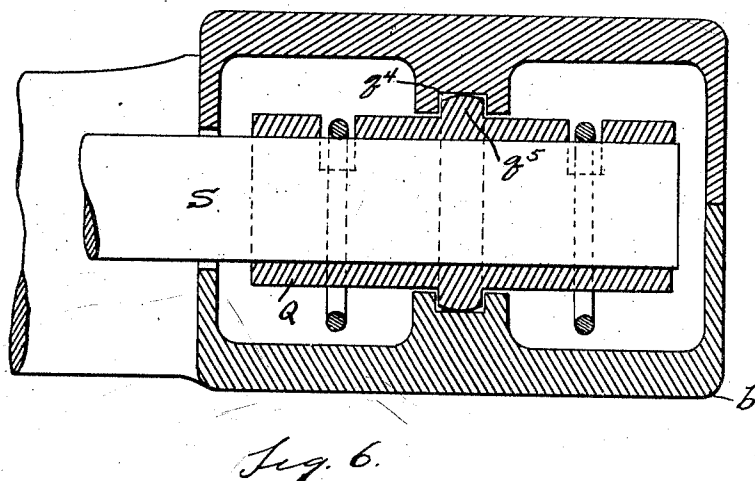
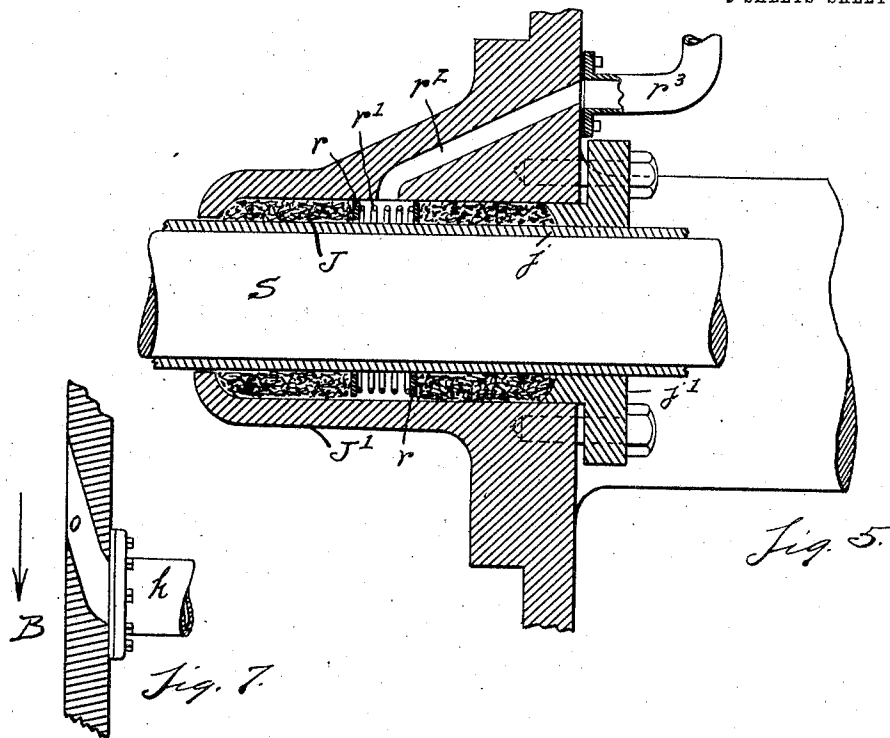
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1,026,101.

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APPLICATION FILED DEC. 23, 1910.

Patented May 14, 1912

5 SHEETS—SHEET 5.



WITNESSES:

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UNITED STATES PATENT OFFICE.

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CENTRIFUGAL PUMP.

1,026,101.

Specification of Letters Patent.

Patented May 14, 1912.

Application filed December 23, 1910. Serial No. 599,036.

To all whom it may concern:

Be it known that I, ELON A. MARSH, a citizen of the United States, residing at Detroit, county of Wayne, State of Michigan, have invented a certain new and useful Improvement in Centrifugal Pumps, and declare the following to be a full, clear, and exact description of the same, such as will enable others skilled in the art to which it pertains to make and use the same, reference being had to the accompanying drawings, which form a part of this specification.

This invention relates to centrifugal pumps and its object is an improved pump of this class in which the duty performance per unit of power employed is much greater than has heretofore been realized. By reason of the great frictional resistance characteristic of this type of machine, centrifugal pumps have not, in the past, shown a sufficiently high rate of mechanical efficiency as to supersede other types of greater bulk and complication of parts and that are more costly both in construction and maintenance. If this frictional resistance can be reduced without a corresponding reduction in the amount of useful work, it seems evident that a great gain in efficiency may be realized. One of the best types of centrifugal pumps, and generally speaking, the one showing the highest efficiency is the closed or box impeller type in which the impeller wheel rotates in a chamber formed by the cylinder heads and the cylindrical wall of the discharge channel. This chamber fills with water during the operation of the pump and the skin friction produced by the rapid rotation of the impeller wheel in this water packed chamber is the principal cause of the low output per unit of power employed.

The principal feature of the invention herein disclosed is in the novel means employed in keeping the impeller chamber filled with air under pressure practically equal to the discharge pressure of the pump and in so arranging said means that the air pressure varies in accordance with variations in the discharge pressure caused by variations in the speed of the impeller wheel or in the volume of discharge.

Other novel features are in the means employed to prevent the escape of air from the chamber and in the means for removing

water from the chamber that may accumulate therein by seepage.

These and other objects and novelties of the invention are hereinafter more fully described and claimed.

In the drawings—Figure 1 is a side elevation of a centrifugal pump embodying my invention. One of the cylinder heads and inlet pipe connecting therewith being removed to more clearly show the impeller wheel. Fig. 2 is a plan view of the pump showing the inlet chamber in section. Fig. 3 is a vertical longitudinal section of the pump, the dotted lines diagrammatically showing the relation of some of the parts. Fig. 4 is an enlarged sectional detail of a part of the impeller wheel and chamber in which it rotates. Fig. 5 is a detail showing the method and means employed in packing the shaft to prevent a leakage of air into the inlet chamber of the pump. Fig. 6 is a detail of the shaft bearing. Fig. 7 is a detail showing one of the outlet orifices in the wall of the discharge channel.

Similar letters refer to similar parts throughout the drawings and specification.

A indicates an impeller wheel of the closed or box type which is keyed to the shaft S mounted in bearings b, b carried by the cylinder heads C, C. The cylinder heads are bolted to the discharge channel B in the usual manner. The discharge channel B is spiral in form as shown in Fig. 1 and has a circular, central opening within which is located the impeller wheel whose periphery is practically in contact with the inner circular wall of the channel. This circular wall has a passageway p through which the water from the impeller wheel enters the channel B. The impeller wheel A is provided with vanes v and hubs h, h integral with the side walls w. The hubs form the inlet orifices into the wheels as shown in Fig. 3. The cylinder heads are each provided with central openings into which the hubs h extend and surrounding the hubs are circular channels c, c in the cylinder heads. The walls of the cylinder heads conform somewhat closely to the shape of the impeller wheel and the cubical contents of the chamber surrounding the wheel is consequently small. Each cylinder head is provided with a chamber c' into which the inlet pipes I, I lead. The inlet pipes

are connected to the main supply pipe M as shown in Fig. 2. The shaft S may be belted or otherwise connected to a source of power and rotation of the shaft and the impeller wheel attached thereto draws water from the source of supply through the suction or inlet pipes I, I into the suction chamber c^1 of the pump and into the impeller wheel as shown by arrows in Fig. 3. The water is discharged from the wheel through the passageway p into the spiral discharge channel B in a manner usual with this type of machine.

In order that the chamber s surrounding the impeller wheel may at all times be filled with air under pressure equal to the discharge pressure of the pump, I have arranged a tank or cistern T on the same foundation with the pump but at such a height than an imaginary line passing through the shaft center of the pump would divide the tank into two practically equal parts. Connected with the top of the tank is a pipe q which leads to the chamber s surrounding the impeller wheel. Connected to the bottom of the tank is a pipe q^1 which leads to the discharge channel B. Consequently whatever the discharge pressure of the pump is, it is communicated, by means of the pipe q^1 , to the water in the tank T and therefore to the air in the upper part of the tank and in the chamber s surrounding the impeller wheel. As the pressure in the discharge channel increases or diminishes, due to variation in speed of the impeller or other cause, the air pressure in the tank and the chamber s varies accordingly.

In order that the relative quantity of air and water in the tank may be observed and the conditions known under which the pump is working, the tank T is provided with a gage glass g . If the water stands much above the center of the tank, too small a quantity of air is indicated for the pressure at which the pump is working. If the water is much below the center of the tank, too great a quantity of air is indicated for the pressure at which the pump is working. To keep the conditions described in equilibrium, the tank T is provided with a pipe p^1 leading thereinto provided with a valve v^1 to which is connected the pipes p^2 and p^3 . The pipe p^2 is to be connected with an air compressor or other source of supply and the pipe p^3 is open to atmosphere. If too small a quantity of air is indicated in the system, the valve v^1 is turned to allow air from the compressor or storage tank to flow into the tank T. If too great a quantity of air is indicated, the valve v^1 is turned to allow an escape of the desired quantity through the pipe p^3 . The system, however, would be practically self sustaining and the above described means of establishing equilibrium would only be utilized at the time of start-

ing or to overcome excess leakages that might occur. The cubical capacity of the tank T should be greater than that of the impeller chamber s . By filling the chamber s with air under pressure as described, the impeller wheel rotates without frictional resistance on the side walls w thereof and the cost of operation will be so reduced that the output per unit of power employed compares very favorably with that of pumps of the reciprocating type.

Any very perceptible leakage of air from the chamber is undesirable, therefore the channels c, c heretofore described as surrounding the hubs h of the impeller wheel, are connected to the discharge channel B by means of the pipes k, k as shown in Fig. 3 and thereby filled with water under pressure. To preclude the possibility of the escape of air from the chamber s into the suction chamber c^1 , the pressure of water in the channels c, c should be slightly greater than the air pressure in the chamber so that water will leak into the chamber. To accomplish this, the passage o in the wall of the channel B, to which the pipe k connects as shown in Fig. 7, should pass therethrough at an acute angle to the direction of flow through the channel with the inner end of the passage facing, as nearly as possible, the flow in the channel. The pressure in the pipes k, k and the channels c, c will thus be augmented by the velocity of the flow through the channel B. The hubs h run very nearly in contact with that part of the cylinder heads C which surrounds them as heretofore described, consequently leakage of water from the channels c, c into the chamber s and suction chamber c^1 will not be very great. A leakage into the chamber c^1 will occur as there is no pressure in said chamber to counteract the pressure in the channels c, c .

To prevent a leakage of air from the impeller chamber into the passageway p in the discharge channel, the circular wall W of the channel B is provided with grooves u, u in alinement with the peripheral edge of the side walls w, w of the impeller wheel. The grooves fill with water under pressure and prevent any serious leakage of air from the chamber. These grooves would as effectually perform their function if they were formed in the peripheral edge of the side walls w of the impeller and might also be of other shapes than as shown without departing from the spirit of this invention.

As heretofore described and as shown particularly in Fig. 1 and diagrammatically by dotted lines in Fig. 3, the center of the tank T is practically in line with the shaft of the pump. The pressure of water in the discharge channel B at this level is greater than the pressure at the top or highest point of the impeller wheel and is less than the pressure at the bottom or lowest point

of the impeller wheel. This is due to the difference in hydrostatic head between the several points. The pressure in the tank T is the pressure due to the combined discharge pressure of the pump and the hydrostatic head at the center line. This is also the pressure of the air in the chamber *s*. It will thus be seen that the pressure of air in the impeller chamber is greater than the pressure of water at the top of the impeller wheel and is less than the pressure of the water at the bottom of the impeller wheel. There is, therefore, a tendency for the air in the top of the impeller chamber to leak through the interstice between the edges of the impeller wheel and the wall W of the channel B into the passageway *p*. There will also be a tendency for the water to leak into the chamber *s* through the space between the wall and the impeller at the bottom of the wheel. As the impeller fits closely in the circular opening in the spiral casing, the leakage of water into the impeller chamber is of little importance because of its small volume. The leakage of air from the chamber, however, is of greater importance and it is to effectually prevent this that the grooves *u, u* are provided. These grooves fill with water at the bottom of the wheel due to the greater pressure of water at this point as heretofore described. The water thus accumulated revolves with the impeller wheel by reason of its frictional contact therewith but not at the same speed because of its contact with the non-rotative surface of the wall W of the channel B. Air will also accumulate in the groove at the top of the impeller wheel, as heretofore shown, and will be carried around with the wheel. As indicated in Fig. 4 at *z*, the air that may accumulate in the grooves *u, u* at the top of the wheel will be on the air chamber side and in contact with the periphery of the impeller wheel to a greater extent than with the groove itself. The reason for this is that the centrifugal force of the water revolving in the groove will tend to keep the groove filled, and, at the point where the air pressure may be great enough, the air will tend to seep out of the chamber in contact with the peripheral surface of the impeller. As the air revolves with the impeller, it will, in its travel therewith, be gradually forced back into the chamber *s* as it approaches the bottom thereof and be entirely removed from the groove and the interstice between the impeller and its casing when it has arrived at the bottom of the chamber where the water pressure is the greatest.

The volume of water which may escape through the interstice is proportional to the area of said interstice modified by its length and the difference in hydrostatic pressure between the air chamber *s* and the groove

u respectively at each extremity of the interstice. Whatever the difference in hydrostatic pressure is between the two extremities of the interstice, it is intermittent and reversible when the impeller revolves, so that, as the direction of leakage alternates, its volume is lessened by said reversal and is entirely abated when the impeller runs at high speed. To illustrate, let it be supposed that, at some certain, slow speed of the impeller wheel, water leaks through the interstice into the impeller chamber at the bottom of the wheel at a speed of fifty feet per second; the air in the impeller chamber having a corresponding tendency at the top of the wheel. As the air and water in the interstice revolve with the impeller wheel, as heretofore stated, the differences in hydrostatic pressure encountered by the air and water in their travel with the impeller will alternate the direction of flow of both the air and water so that the volume of leakage in either direction is proportionate to the duration of said alternation, which is determined by the speed of revolution of the impeller wheel. When the speed of the impeller has become so great that the direction of the flow of water through the interstices is reversed at a rate of speed equal to said flow of fifty feet per second divided by the length of the interstice, the leakage is entirely abated and a state of equilibrium produced which is automatically maintained as long as the impeller runs at the proper speed. Any speed of the impeller wheel greater than that above described will lessen the distance of travel of the water during said alternation in the direction of flow through the interstice. If, when a state of equilibrium is reached, the water travels the entire length of the interstice and back during an alternation in the direction of flow therethrough, then, if the speed of reversal is increased, the water can only travel a part of said distance and back as the time during which it may travel in either direction is lessened.

To remove the water that may seep into the chamber *s* at the periphery of the impeller and at the hubs *h*, as heretofore shown, a trap L is provided connected, by means of the pipe *m*, to the chamber *n* at the bottom of the discharge casing B. This chamber is connected to the air chamber *s* by channels *i, i* shown clearly in Fig. 3 and indicated by dotted lines in Fig. 1. The trap is provided with a float *f* pivoted to the side wall of the trap chamber and connected to a valve in the pipe *t* which leads to one of the suction pipes I. The pipe *t* and the valve therein are below the water level in the trap and are thus effectually water sealed which prevents an escape of air from the chamber *s*. Any excess of water in the chamber *s* will flow into the

trap through the channels i, i and the pipe m and raise the float f . The raising of the float opens the valve in the pipe t and the pressure of the air in the chamber s and the upper part of the trap chamber will force the water out of the trap into the suction pipe I through the pipe t . As the water passes out of the trap, the float drops and closes the valve in the pipe t . The removal of water from the chamber s is, therefore, entirely automatic and requires no attention other than to keep the trap in proper working condition.

In order that air may be prevented from being drawn into the suction chamber c^1 through the stuffing box in the cylinder head in which the shaft S is located, a packing for the shaft is provided as shown in Fig. 5. The shaft is provided with a bushing j and surrounding this is the packing material J in the stuffing box J^1 . The stuffing box is provided with a gland j^1 of the ordinary type. At or near the center of the box and encircling the shaft are two flat rings r, r^1 between which is a coiled spring r^1 . The spring holds the rings apart and leading to the annular channel thus formed is a passageway r^2 in the stuffing box to which a pipe r^3 may be connected, which communicates with the discharge channel B at any convenient point as shown by dotted lines in Fig. 3. The channel between the rings r, r^1 is thereby filled with water under pressure and the packing thus compressed to such degree as to preclude the possibility of air leaking therethrough into the suction chamber.

By reason of the great internal pressure developed in this type of pump, the cylinder heads are subjected to severe strain which may tend to bind the shaft in the bearings d, d carried by the cylinder heads. To obviate this difficulty, the bearings are formed with an annular channel q^1 in which the ring q^2 of the journal Q loosely fits. The journal is thus swiveled in the bearing and any irregularities in the alinement of the bearing, due to excessive strain on the cylinder head, is compensated for and the shaft may revolve without binding. The shaft may be oiled by ring oilers of the ordinary type as shown.

The tank T , instead of being arranged as shown, may be formed in the cylinder heads as a separate compartment but integral with them.

Various other departures from the structure herein shown may be made without departing from the spirit of this invention.

Having thus briefly described my invention and its method of operation, what I claim is—

1. In a centrifugal pump, an impeller wheel of the closed or box type, a chamber in which the impeller wheel revolves, means

for filling said chamber with air under pressure, means for preventing a leakage of air from the chamber, and a trap for removing liquid from the chamber.

2. In a centrifugal pump, an impeller wheel of the closed or box type, a chamber in which the impeller wheel revolves, means for filling the chamber with air under pressure corresponding with the discharge pressure of the pump, means for preventing a leakage of air from the chamber.

3. In a centrifugal pump, an impeller wheel of the closed or box type, a chamber in which the impeller wheel revolves, means for filling the chamber with air under pressure, and means for preventing a leakage of air from the chamber.

4. In a centrifugal pump, an impeller wheel of the closed or box type, a chamber in which the impeller wheel revolves, means for filling the chamber with air under pressure, means for preventing a leakage of air from the chamber and of producing a leakage of water into the chamber, and means for removing the water from the chamber.

5. In a centrifugal pump, an impeller of the closed or box type, a chamber in which the impeller revolves, means for filling the chamber with air, said means including an external source of supply, means whereby the discharge pressure of the pump is communicated to the air in the chamber, and means for preventing a leakage of air from the chamber.

6. In a centrifugal pump, an impeller wheel of the closed or box type, a chamber filled with air under pressure in which the impeller wheel revolves, automatic means for varying the air pressure, and means for preventing a leakage of air from the chamber.

7. In a centrifugal pump, an air chamber in which the impeller wheel revolves, and a tank or compartment exterior of the pump in communication with both the air chamber and the discharge channel of the pump whereby the pressure in the discharge channel is communicated to the air in the chamber.

8. In a centrifugal pump, an air chamber in which the impeller wheel revolves, an air tight compartment in communication with the air chamber, and means for producing pressure therein corresponding with the discharge pressure of the pump.

9. In a centrifugal pump, an air chamber in which the impeller revolves, an air tight compartment in communication with the air chamber, and means for producing pressure therein automatically varying in accord with the discharge pressure of the pump.

10. In a centrifugal pump, an impeller wheel of the closed or box type, an air chamber in which the impeller wheel revolves, an air tight compartment in communication

with the air chamber, means for altering the volume of air in the compartment and chamber, and means for compressing the air in the compartment and chamber to correspond with the discharge pressure of the pump.

11. In a centrifugal pump, an impeller wheel of the closed or box type, a chamber in which the impeller wheel revolves, means for filling the chamber with air under pressure, means for preventing a leakage of air from the chamber and of producing a leakage of water into the chamber, and means for removing the water from the chamber; said means including a water sealed, float operated valve controlling the outlet from the chamber.

12. In a centrifugal pump, an impeller wheel of the closed or box type, an air chamber in which the impeller revolves, an air tight compartment in communication with the air chamber and with the discharge channel of the pump whereby the air in the chamber has a pressure corresponding to the discharge pressure of the pump, and means for altering the volume of air in the compartment and chamber.

13. In a centrifugal pump having an impeller wheel which operates in a chamber containing air under pressure, hubs for said impeller wheel extending through the walls of the impeller chamber, circumferential grooves in the walls of the chamber facing and surrounding the hubs of the impeller wheel, and channels connecting said grooves with the discharge chamber of the pump; the orifices in the discharge chamber which form the inlets to the channels being arranged to face the flow in the discharge chamber whereby said grooves have a pressure head greater than the hydraulic head, substantially as and for the purpose described.

14. In a centrifugal pump having a closed or box impeller wheel mounted in an air chamber formed by the cylindrical wall of the discharge chamber and the walls of the cylinder heads, circumferential grooves in said cylindrical wall facing the peripheral edges of the side walls of the impeller wheel said grooves forming reservoirs for water that may accumulate therein by leakage from the discharge chamber and acting as secondary impellers which receive and discharge said leakage by reason of the differences in hydrostatic head encountered by the water in its travel around the impeller wheel, substantially as shown and described.

15. In a centrifugal pump having an impeller wheel which operates in a chamber containing air under pressure, said chamber being formed by the cylindrical wall of the discharge chamber of the pump and the walls of the cylinder heads, hubs for said impeller wheel extending through the walls of the impeller chamber, grooves surround-

ing said hubs, and grooves surrounding the impeller wheel at the periphery thereof; both sets of grooves being in communication with water in the discharge chamber of the pump, substantially as shown and described.

16. In a centrifugal pump having an impeller wheel operating in a chamber containing air under pressure, a shaft for said impeller wheel projecting through the walls of said chamber, a stuffing box for the shaft carried by each of said walls, packing material in each box, a centrally disposed circumferential channel in said packing, means for maintaining said channel in opposition to the pressure produced on the packing by the gland with which the stuffing box is provided, means for filling said circumferential channel with water under pressure, and swiveled bearings for said shaft carried by said chamber walls.

17. In a centrifugal pump, an air chamber in which the impeller revolves, and an air tight compartment in communication with both the air chamber and the discharge channel of the pump, whereby the pressure in the discharge channel is communicated to the air in the chamber.

18. In a centrifugal pump, a chamber in which the impeller revolves, means for filling the chamber with air under pressure, and means for automatically counteracting said pressure at the periphery and hub of the impeller thereby preventing a leakage of air from the chamber.

19. In a centrifugal pump, an impeller of the closed or box type, a chamber filled with air under pressure in which the impeller revolves, means whereby the pressure of the air is determined by the discharge pressure of the pump, said means comprising an air tight compartment in communication with both the air chamber and the discharge channel of the pump, and means external of the pump for introducing air into said air tight compartment.

20. In a centrifugal pump, an air chamber in which the impeller revolves, means for producing pressure therein automatically varying with the discharge pressure of the pump, and means for preventing a leakage of air from the chamber.

21. In a centrifugal pump, an impeller wheel of the closed or box type, a chamber in which the impeller wheel revolves, means for filling the chamber with air under pressure, and means for preventing a leakage of air from the chamber comprising water packing grooves or channels surrounding the hub and the periphery of the impeller in communication with the discharge channel of the pump.

22. In a centrifugal pump, an impeller of the closed or box type, a chamber in which the impeller revolves, means for a trap for removing liquid from the chamber, and

means for filling the chamber with air under pressure.

23. In a centrifugal pump having an im-
peller of the closed or box type rotatable in
a chamber, means for freeing the chamber
5 of liquid by a volume of air under pressure,
and means for maintaining air in the cham-
ber under a pressure equivalent to and vary-
ing with the discharge pressure of the pump,
10 said means including a means for preventing
a leakage of air from the chamber.

24. In a centrifugal pump having an im-

peller of the closed or box type rotatable in
a chamber, means for filling the chamber
with air under pressure, and means inde- 15
pendent of the air pressure for freeing the
chamber of liquid.

In testimony whereof I sign this speci-
fication in the presence of two witnesses.

ELON A. MARSH.

Witnesses:

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HENRY P. HART.