F. MARBURG, Jr.

AXIAL IMPELLER PUMP AND THE LIKE.

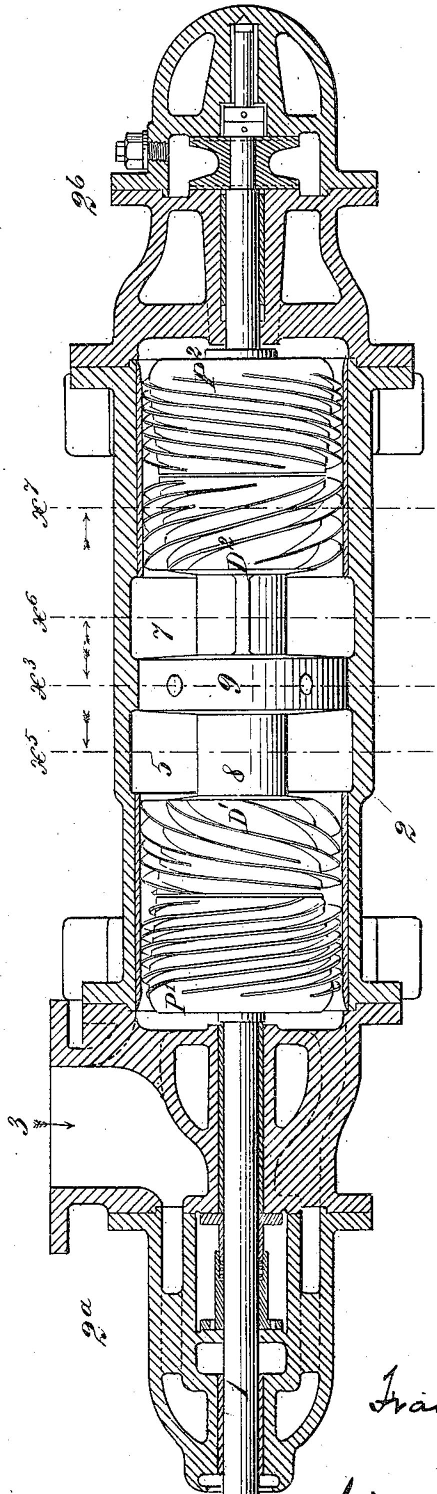
APPLICATION FILED MAY 25, 1906.

1,046,092.

Patented Dec. 3, 1912.

4 SHEETS—SHEET 1.

Fig. 1.



Witnesses

F. W. Hinman

A. F. Cornett

Franz Marburg Jr.

Inventor

By his Attorney Henry Connett

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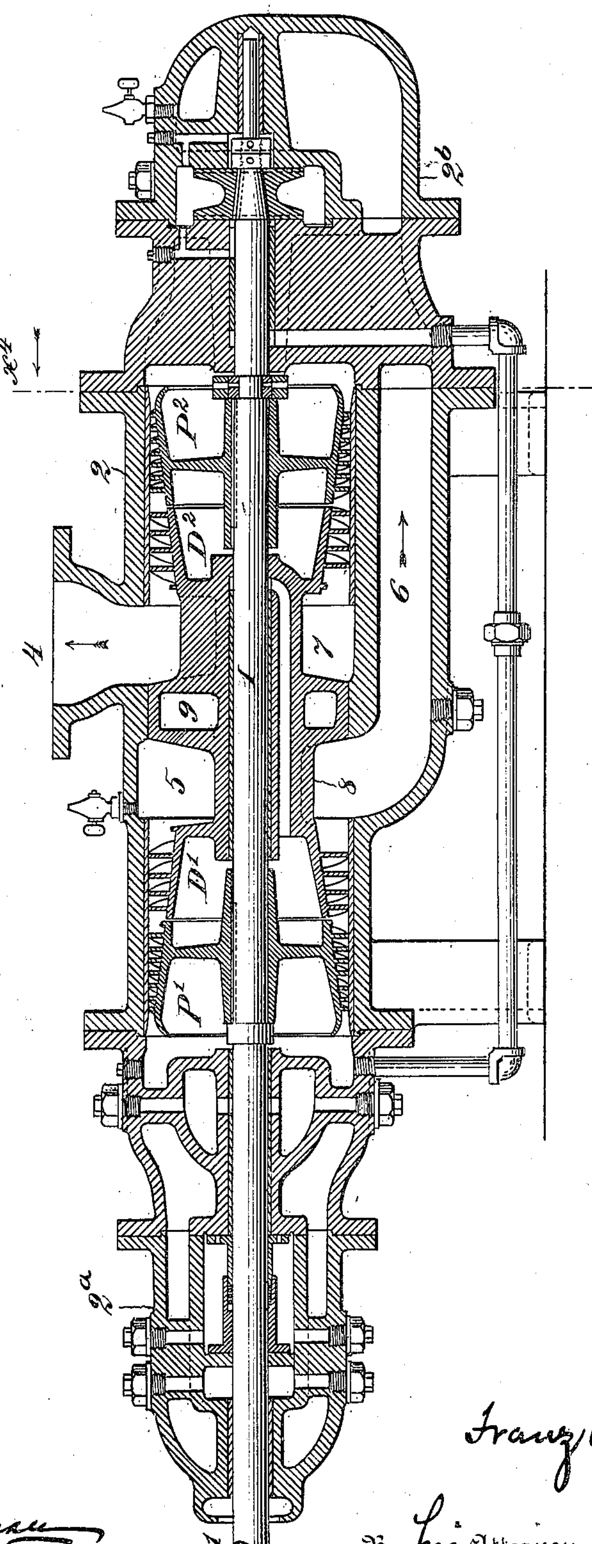
4 SHEETS—SHEET 2.

Fig. 2.



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4 SHEETS—SHEET 3.

Fig. 3.

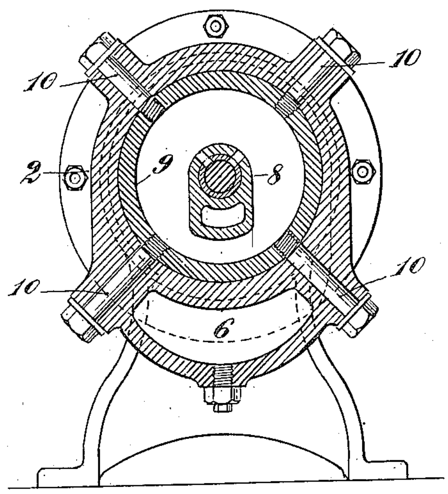
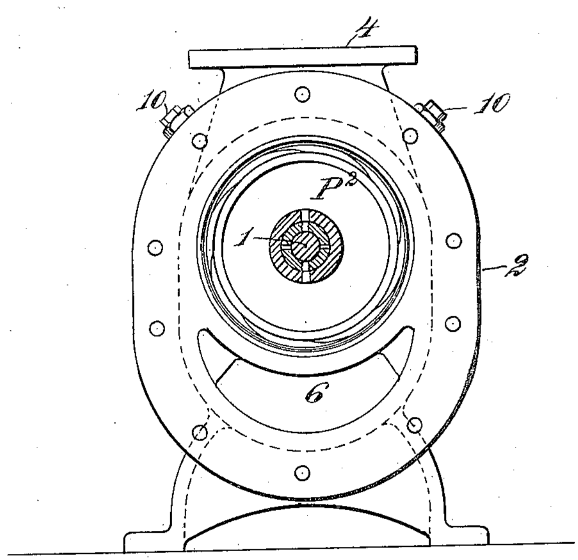


Fig. 4.



Witnesses

F. W. Wiman

A. F. Connell

Franz Marburg Jr.

Inventor

By his Attorney Henry Connett

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4 SHEETS—SHEET 4.

Fig. 5.

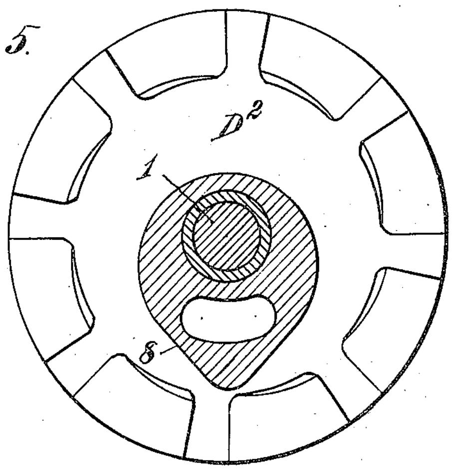


Fig. 6.

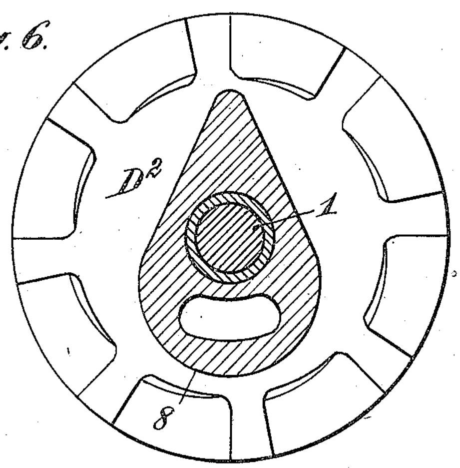
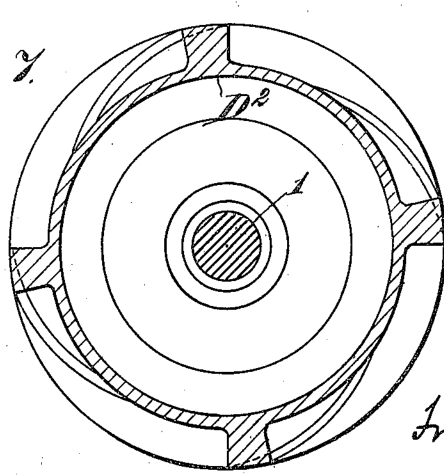


Fig. 7.



Witnesses

F. W. H[illegible]

A. F. Cornell

Franz Marburg Jr.

Inventor

By his Attorney Henry Connett

UNITED STATES PATENT OFFICE.

FRANZ MARBURG, JR., OF WIESBADEN, GERMANY.

AXIAL IMPELLER-PUMP AND THE LIKE.

1,046,092. Specification of Letters Patent. Patented Dec. 3, 1912.

Application filed May 25, 1906. Serial No. 318,747.

To all whom it may concern:

Be it known that I, FRANZ MARBURG, Jr., a citizen of the United States, at present residing in Wiesbaden, Germany, have invented certain new and useful Improvements in Axial Impeller-Pumps and the Like, of which the following is a specification.

This invention relates to axial-flow impeller pumps, blowers, and the like, and its main object is to increase the efficiency and to make the apparatus capable of operating against high pressure.

The principal difficulty is to construct a pump of this type in such a manner that the fluid passes through the impeller, or through the pump, as free as possible from shock and whirling. In an impeller of constant theoretical capacity throughout the impeller, as commonly used at present, great shocks and whirling are experienced at the impeller-inlet, as the actual fluid capacity; consequently the slip, that is the relative backflow within the impeller in the direction of the impeller blades, amounts to fifty per cent. or at very high pressure even to seventy-five per cent. of the theoretical capacity of the impeller.

It is not the object of the present invention to prevent this slip nor even to reduce it, but to take up the slip gradually from the impeller inlet toward the impeller-outlet. At a high peripheral velocity, say from one-hundred to one-hundred and fifty feet per second, which is necessary to produce high pressure, it is essential that the fluid should enter into or be drawn into the impeller with a velocity as nearly as possible equal to the theoretical velocity of the axial component of the spiral motion of the impeller blade, which I will hereinafter term the axial velocity of the impeller-blade, and that the difference between such axial velocity of the impeller-blade and the corresponding axial velocity of the fluid, which on account of the slip is unavoidable, should take place only very gradually within the impeller. This result is herein accomplished by constructing the impeller-inlet so small that the theoretical inlet capacity is the same as the actual capacity of the impeller while operating against a given pressure. By increasing the theoretical capacity of the impeller very gradually from twice to four times the theoretical inlet capacity, according to different pressures to be produced, a very gradual increase of the slip and of the pressure takes place toward the impeller outlet. If the unavoidable slip is one-half the theoretical impeller-outlet capacity, then the latter should be twice as great as the theoretical impeller-inlet capacity. If the slip is three-fourths of the theoretical impeller-outlet capacity, then the latter should be four times as great as the theoretical impeller-inlet capacity. In other words, the theoretical impeller-inlet capacity should always be the difference between the theoretical outlet capacity and the unavoidable slip. The slip is to be determined by the pressure and by the peripheral velocity of the impeller-blades.

To understand more fully the principle of this impeller, it is necessary to state that as the slip, and consequently the difference between the axial velocity of the impeller-blades and the axial velocity of the fluid, increases gradually the fluid attains without shock a very great forward velocity which increases rapidly and reaches its maximum at the impeller-outlet.

The purpose of the present invention is to overcome the difficulties set forth above, as will be hereinafter set forth with reference to the accompanying drawings, which fully illustrate an embodiment of the invention.

In these drawings:—Figures 1 and 2 are longitudinal axial sections of the pump or device, the former being a horizontal section and the latter, a vertical section. In Fig. 1 the impellers and diffusers are seen in plan. Fig. 3 is a cross-section at x^3 in Fig. 1; and Fig. 4 is a cross-section at x^4 in Fig. 2. Figs. 5, 6 and 7 are cross-sections of the diffusers taken respectively at lines x^5, x^6 and x^7 in Fig. 1.

In the drawings, 1 designates the shaft, 2 the main and middle portion of the casing, 2^a the end-portion of the casing seen at the left in Figs. 1 and 2, and 2^b the end-portion of the casing seen at the right in these figures.

As shown in the principal views there are two duffusers D^1 and D^2, connected together rigidly, and non-rotative in the casing, and two impellers P^1 and P^2, disposed adjacent thereto in series; but the invention is not limited to this duplication.

The fluid-inlet 3 is seen best in Fig. 1, and the outlet 4 is seen in Fig. 2.

Referring to the principal views, the fluid enters the pump at 3, flows first through the rotating impeller P^1, then through the non-rotating diffuser D^1, and thence into the chamber 5; from this chamber it flows by a conduit 6 to the other end of the middle section of the casing where it enters the other impeller P^2, flows through it to the other adjacent diffuser D^2, through the latter to the central chamber 7, and thence off at the pump outlet 4.

As herein shown the two diffusers are connected integrally by a sleeve 8, through which the shaft 1 extends. On this sleeve is a hollow hub 9 which fits snugly in the casing and is secured thereto by screws 10, as best seen in Fig. 3. This hub forms a cross partition in the main section 2 of the casing.

Certain features of the invention shown herein, are only claimed specifically as the same features are claimed more broadly in my former Patent 872,361.

The core of the impeller has in the present case, a relatively large diameter, which should not be less than about four-fifths of the corresponding diameter of the outer contour of the impeller-blades. If the radial width of the impeller-blades is too great in proportion to the diameter of the said outer contour, a great slip, or even absolute back currents result at the radially inner portions of the blades while the pump operates against high pressure. The fluid pressure produced in similar pumps is proportional to the square of the velocity of the blades, or of any sections thereof, and as the velocity is least near the axis, the pressure is least near the axis; therefore with a small core-diameter the fluid will, under certain back pressure, flow backward at the radially inner portions of the impeller-blades, thus causing great loss in the efficiency of the pump. Through higher rotative speed the backflow could be reduced or prevented, but the radially outer portions of the blades would in such a case have too high a peripheral velocity for the given pressure, whereby losses of a different nature would occur. Through experiments I have found that for a given pressure a certain velocity of the impeller-blades gives the best efficiency and this velocity of said blades can only be approximately reached by the radially outer as well as by the radially inner portions of the blades, if the radial width of the blades is about one-tenth or less of the diameter of the corresponding outer contour of the propeller. This again is the case if the core of the propeller is at least about four-fifths of the diameter of the corresponding outer contour of the impeller-blades.

A clear distinction must be made between slip, or relative backflow, and absolute backflow. The former reduces the capacity only but does not cause a loss in the efficiency of the pump if it be taken up gradually, while the latter constitutes a loss both in the capacity and in the efficiency of the pump.

The drawings also show the gradual increase of the radial width of the impeller-blades at the impeller-inlet until they reach their full radial width, and the gradual decrease from their radial width at the impeller-outlet. The object of this feature is also to reduce shock at the impeller-inlet and to reduce suction and whirling at the impeller-outlet. By full radial width is herein not to be understood the maximum radial width of the impeller-blades but only their radial width at any portion where it reaches in close proximity to the cylinder or the surrounding wall, which may also be a rotating outer ring.

The purpose and construction of the diffuser will now be explained. In all similar pumps, the fluid under a head, on account of the unavoidable slip in the impeller, is carried around with the impeller and has therefore at the impeller-outlet a high peripheral velocity in the direction of the turning motion of the impeller. To utilize this high peripheral velocity of the fluid at the impeller-outlet, or rather the high absolute velocity of which the high rotary velocity and smaller axial velocity are components, a diffuser is employed adjacent to the impeller-outlet. The characteristic feature of the diffuser, is a gradually increasing capacity in the direction of the flow of the fluid and at the same time a gradual deflection of the fluid toward the pump-outlet. The blades of the diffuser must therefore be of opposite angle or pitch to the blades of the impeller and must be inclined at the angle at which the fluid leaves the impeller, that is in the direction of rotation and at a small angle to the vertical plane through the propeller-axis. The smaller the angle of the impeller-blades the smaller must be the angle of the diffuser-blades; also the angle of the diffuser blades becomes smaller with greater increase of the theoretical capacity within the impeller. The fluid pressure at the diffuser-outlet, is directly opposed to the motion of the fluid, and as the capacity of the diffuser increases gradually, the velocity of the fluid will be thereby gradually reduced. The amount of the kinetic energy which can thus be changed to useful pressure may be calculated by the formula

$$h=\frac{v^2}{2_g};$$

wherein h equals head in feet, v equals velocity in feet per second, and g equals 32.16.

The diffuser-blades increase gradually to their full radial width at the diffuser-inlet in a manner similar to the impeller-blades. The object of this construction of the diffuser-blades is to permit the fluid to enter more easily into the diffuser. Another feature of the diffuser is the shorter blades which are, as shown in the drawing, about half the length of the longer blades and are located toward the outlet end of the diffuser. These shorter blades may be called "auxiliary blades" and they serve the purpose of further reducing eddy-currents, while the longer blades may be called "main blades."

It is self-evident that the impeller as well as the diffuser can have one or more blades and each blade can have part of a turn, or one or more turns. The producing line of the blade or blades of the impeller as well as of the diffuser is not necessarily a line vertical to the axis of the shaft, but may be inclined to the axis; also it could be instead of a straight line a line having any desired curve. In a pump of this character one or more impellers and diffusers could be used. The construction shown has two impellers operating in series, but a larger number could be employed in series, to produce a higher pressure at a more moderate number of revolutions, which may be desirable in special cases.

It is clear that the details of construction of the pump can be changed very much, while the main principles of the invention remain the same *i. e.* gradually increasing capacity of both the impeller and the diffuser combined.

To summarize shortly, the object of the invention is to increase the unavoidable slip gradually from the inlet toward the outlet of the impeller. As a consequence the fluid pressure and the high peripheral velocity of the fluid increase gradually within the impeller, whereby shocks and eddy-currents are as much as possible prevented. The diffuser having gradually increasing capacity, has the purpose to gradually change the kinetic energy of the fluid to useful pressure.

Obviously the device may be used for receiving and forcing any fluid whether liquid or aeriform.

Having thus described my invention, I claim—

1. In an axial impeller pump, an impeller, and adjacent thereto a diffuser, the impeller and diffuser having each substantially spiral blades and having each gradually increasing capacity toward its outlet, said increase of the impeller capacity being produced by a gradual increase of the radial width of said spiral blades toward the impeller outlet.

2. In an axial impeller pump, an impeller, and adjacent thereto a diffuser, the impeller and diffuser having each substantially spiral blades and having each gradually increasing capacity toward its outlet, said increase of the diffuser capacity being produced by a gradual increase of the radial width of said spiral blades toward the diffuser-outlet.

3. In an axial impeller pump, an impeller, and adjacent thereto a diffuser, the impeller and diffuser having each gradually increasing capacity toward its outlet, said increase of the diffuser capacity being produced by a gradual increase of the radial width and of the angle or pitch combined of said spiral blades, toward the diffuser outlet.

4. In an axial impeller pump, an impeller, and adjacent thereto a diffuser, the impeller and diffuser having each substantially spiral blades and having each gradually increasing capacity toward its outlet, said increase of the capacity being produced in each by a gradual increase of the radial width of the spiral blades toward its outlet.

5. In an axial impeller pump, an impeller, and adjacent thereto a diffuser, the impeller and diffuser having each substantially spiral blades and having each gradually increasing capacity toward its outlet, said increase of the capacity being produced within the impeller by a gradual increase of the radial width of the spiral blades toward the impeller-outlet and said increase of the capacity being produced within the diffuser by a gradual increase of the radial width and the pitch combined of the spiral blades toward the diffuser-outlet.

6. In an axial impeller pump, an impeller, and adjacent thereto a diffuser, the impeller and diffuser having each substantially spiral blades and having each gradually increasing capacity toward its outlet, the angle or pitch of the diffuser-blades being opposite or reverse to the angle or pitch of the impeller blades, the latter increasing gradually to their full radial width at the impeller outlet.

7. In an axial impeller pump, an impeller, and adjacent thereto a diffuser having each substantially spiral blades, and having each gradually increasing capacity toward the outlet, the angle or pitch of the diffuser blades being opposite or reverse to the angle

or pitch of the impeller blades, said impeller blades and diffuser blades having their greatest radial diameter at their end approaching the outlet, said impeller blades and diffuser blades gradually decreasing in their radial width in a direction toward the inlet.

8. In an axial impeller pump, an impeller, and adjacent thereto a diffuser, the impeller and diffuser having each substantially spiral blades and having each gradually increasing capacity toward its outlet, the angle or pitch of the diffuser-blades being opposite or reverse to the angle or pitch of the impeller-blades, the diffuser-blades increasing gradually to their full radial width at the diffuser outlet.

In testimony whereof I affix my signature in presence of two witnesses.

FRANZ MARBURG, Jun.

Witnesses:
RICHARD MARBURG,
WALTER HÄUSING.