

F. LAWACZECK.
TURBINE PUMP OR COMPRESSOR.
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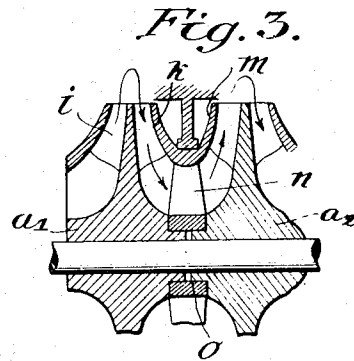
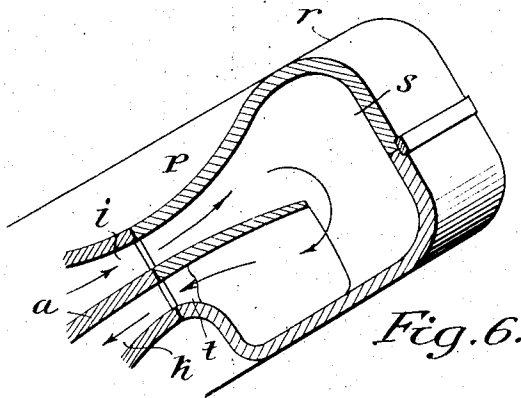
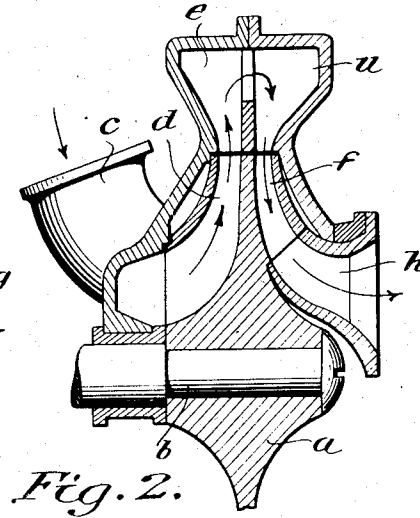
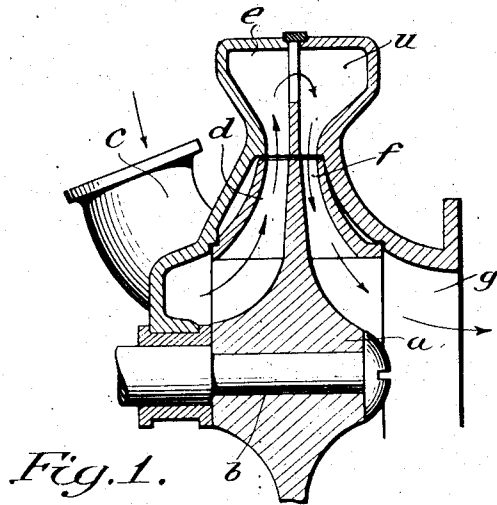
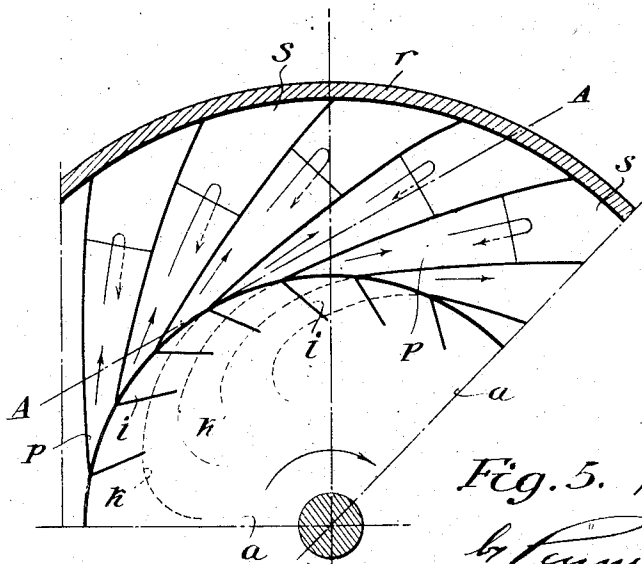
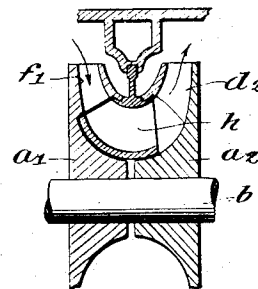


Fig. 4.



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FRANZ LAWACZECK, OF HALLE-ON-THE-SAALE, GERMANY.

TURBINE PUMP OR COMPRESSOR.

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Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, FRANZ LAWACZECK, a subject of the King of Prussia, and residing at Halle-on-the-Saale, Germany, have invented certain new and useful Improvements in Turbine Pumps or Compressors, of which the following is a specification.

Experience in the building of turbine pumps shows that the efficiency of a rotor, or blade wheel, is much better in proportion as a greater part of the total energy transferred to the water (or other pumped fluid) by means of the rotor, exists in the form of potential energy at the outlet of the wheel, that is, the smaller the proportion of kinetic energy at the outlet of the rotor, because comparatively great losses are incident to the transformation of velocity into pressure outside of the rotor wheel by means of the so-called distributor or diffuser. It is because of this fact that the impeller blades of centrifugal pumps are commonly bent backward so as to reduce the outlet velocity, although this shape, as compared with forward-bent blades, necessitates for a given discharge head, an increase of peripheral velocity of the rotor and an increase of the so-called outer wheel friction losses.

The structure of the present invention attains great proportional potential energy at the outlet of the pump, and at the same time relatively small outer wheel friction losses. Fundamentally this structure is characterized by admission of the fluid at the periphery of the rotor wheel and its central discharge, the impeller blades of the pump being so arranged as to increase the energy of the centripetally flowing impelled fluid. In such a pump the absolute value of the outlet velocity can always be very small, since the most essential component of this velocity,—the inner tangential velocity of the wheel—is always much smaller than the outer. Because of this reduced outlet velocity, the kinetic energy of the discharge stream is likewise small, and a relatively simple diffuser suffices to transform the remaining kinetic energy of the stream into pressure. Indeed the diffuser may be dispensed with altogether, in machines constructed according to the invention if the stream leaving the wheel is directed radially.

The extent to which the characteristic peripheral admission feature of the invention makes it possible to lessen the wheel friction

will be apparent from the following considerations: Let w denote the absolute velocity of the fluid at the periphery of the blade wheel (whether directed inwardly or outwardly does not matter), and let its inclination to the tangent to the periphery be denoted by a , the peripheral velocity of the wheel by u , the effective head by H , the efficiency by η , the reciprocal of the efficiency, or $1/\eta$ by e and the force of gravity by g . Then according to the fundamental equation of the turbine under the condition of a radially directed (inward or outward) absolute velocity of the fluid at the inner circumference of the wheel opening.

$$egH = u.w. \cos. a.$$

In the normal pump with central admission $w. \cos. a$ is always dependent to a very considerable degree upon the circumferential velocity u ; for the design of the pump there is not much room left for the choice of the size of $w. \cos. a$. Practically speaking, $w. \cos. a$ is about equal to u ; greater than u with forward curved wheel blades and smaller with backward curved blades. In any case, however, and that is important, in the design of a pump having peripheral discharge, the velocity w can not be chosen independently of u ; a high circumferential velocity u has as condition also a high velocity w . This is quite different in the peripheral inlet pump wheels of the present invention. Here $w. \cos. a$ can be freely chosen, for instance, so, that the velocity u has a small value. In other words, the outer wheel friction, (mainly that of the front surfaces of the wheel) may be diminished at will without any loss of head. This effect can also be explained as a consequence of the opposing motion of the incoming stream and the circumferential velocity of the wheel. By the opposing motion of the stream entering with the velocity w the circumferential velocity of the wheel seems to be increased in relation to this stream, whereas the water particles streaming along the outside of the wheel can only produce a friction which corresponds to the real circumferential velocity u . Naturally also for low heads the values u and $w. \cos. a$ can be chosen entirely independent of each other. The advantages of this and altogether those of the principle of the outer admission are especially noticeable in cooling

water pumps for the condensation of large steam power plants. It is a criterion of those cooling water pumps that they have to deliver large quantities of water at small heads (30 to 40 ft.) In such cases it is very desirable that these pumps should not be driven by an electric motor, but, for instance by a steam turbine, so that their working remains independent of the current generated by the power plant. In view of the high number of revolutions of the steam turbine and of the low head demanded, the diameters of the wheels, with central admission, must be chosen so small that the surplus of head, arising in any case with wheels with central admission, becomes as small as possible. As a rule, this surplus of head, which must be throttled, is economically quite inadmissible; besides the inner mouth of the wheel becomes so small on account of its necessarily small outer diameter, that in view of the low suction velocity, restricted because of the danger of tearing the suction column, only a very little quantity of water can be delivered by each wheel, and for this reason several blade wheels (as a rule about 10) must be connected in parallel to handle the usually very great quantities of water. This circumstance has until now made it simply impossible to make use of the steam turbine, so that it has usually been necessary to use three phase induction motors with not more than 1450 R. P. M., in which case because of the still comparatively very large number of revolutions as many as 5 wheels may have to be connected in parallel. The peripheral admission of the invention does away in one stroke with all these difficulties. Independently of the peripheral velocity u any desired head, no matter how small, can be obtained without throttling. Above all, however, the quantity of water which can be delivered by one wheel is practically unlimited, since the suction section, which now lies in the outer circumference of the blade wheel and therefore can be made of any desired size, may always be so chosen that the suction velocity does not overstep the admissible value; whereas the quantity of water passing through the blade wheel can leave the small section of the inner mouth at any desired speed generated at will in the blade wheel. In the case of the usual blade wheels with central admission, as has been mentioned, the conditions in the case of large quantities of water are on the contrary as unfavorable as possible, for in this case the comparatively small inlet mouth of the blade wheel is available to the incoming necessarily slow flowing water in the suction section, whereas at the same time the very rapidly outflowing water passes through the largest section of the wheel. Whereas until now it has been extremely difficult, if not impossible, to build centrifugal pumps, and es-

pecially the blade wheels for them, for large quantities of water at small resistance heads and high number of revolutions, with the new wheel with the peripheral admission the quantity of water which a single wheel can deliver independently of the pressure head to be generated is practically unlimited.

The wheel friction depends not only upon the velocity u but also, as we know, upon the size of the moistened outer surface of the wheel. This surface is mainly composed of the outer front surfaces of the rotor wheel. In the usual form of the wheels these surfaces cannot be diminished. If, however, a wheel of the so far usual form, *i. e.*, one working with central admission, be combined with a wheel which according to the invention has peripheral admission, the one front surface of the usual wheel producing the friction is thus made somewhat smaller, at the same time, however, the head attainable with such combination wheel is about doubled. In this arrangement the water is inverted after having passed through the familiar wheel with central admission and is led from the outside to the second set of blades fixed on the same wheel body. In this manner the harmful surface of the wheel becomes, as mentioned, a little reduced, the useful work, however, is at the same time essentially increased. In consequence, the efficiency of the rotor as a whole is also considerably raised.

In the drawings, which illustrate single stage and multistage pumps embodying the invention and in which blade wheels having central admission are combined with the characteristic wheels having peripheral admission, Figure 1 is a section through a turbine pump according to the invention with a single wheel of combination form. Fig. 2 shows a section through a pump with an inner diffuser, Fig. 3 shows one mode of execution of a multistage pump wheel without inner diffuser, and Fig. 4 another similar form with inner diffuser. Fig. 5 is a radial section through a pump with a special form of the outer diffuser, and Fig. 6 is a section on A—A of Fig. 5.

The single stage pump of Fig. 1 has a blade or rotor wheel a driven in usual manner by the shaft b . The water or any other form (even gaseous) fluid is admitted to the pump by the stand pipe c and in the example shown flows first into the usual set of blades d in direction of the arrow, *i. e.*, from the inside or center of the wheel. The water or other fluid, after having been inverted in the diffuser e whereby its velocity, as hereinafter will be more fully explained, may have been partly transformed into pressure, is admitted from the outside, *i. e.* to the periphery of the wheel, to the set of blades f fixed on the other front surface of the body g of the wheel. The water or other

fluid now flows through these blades f from the outside to the central outlet and leaves the pump by the pressure stand-pipe g . If an especially high head is to be attained by such single stage pump, then the set of wheel blades with peripheral admission must be so chosen that the water or other fluid does not flow out radially. In this case, the kinetic energy remaining in the discharged water is converted into pressure in a centrally situated diffuser h (Fig. 2). For the rest the form of the pump shown in this Fig. 2 does not differ from that of Fig. 1. Naturally the pump shown in Fig. 1, as well as that shown in Fig. 2, can be constructed as multistage pumps, so that the water or other fluid to be delivered flows through several blade wheels. One example of this multistage form of a pump according to Fig. 2 is partially shown in Fig. 4. On a common shaft b are situated the different blade wheels a_1, a_2 , and so on, which are alternately arranged for central and peripheral admission. Between each set of blades with peripheral admission and the following set of blades with central admission there is placed a diffuser h , which transforms the kinetic energy, inherent in the fluid as it leaves the blades f_1 into pressure and which at the same time deflect the fluid in the desired manner to enter the blades d_2 .

As the wheel with peripheral admission always occupies the space which in the form of pumps at present generally used is necessary for leading back the water from the diffuser of one wheel to the suction mouth of the following wheel, the head generated by a pump built according to this invention of equal total length with the usual pumps will be about double that of the latter; or else for the same results the total length of the pump is reduced to about half by using the new sets of blades with peripheral admission.

The multistage pump of the invention has special advantages in those cases in which, instead of producing the highest possible pressure head per blade by means of the usual diffuser, this diffuser is omitted and the wheels with alternately central and peripheral admission are united to one single wheel drum, for instance, in the manner shown in Fig. 3. This form has the advantage in spite of the use of a very weak shaft of giving a wheel body so strongly braced that its critical speed is an extremely high one.

A further advantage of this construction will be seen in that the blade wheels at i and k (Fig. 3) can be cast open and consequently can be easily tooled. The two sets of blades then are covered by the double-cone m , which can also be very easily and completely tooled. If such wheel body is to

turn with very high peripheral velocity, it is suitable to use radially placed bars n fixed on a sleeve o uniting two neighboring wheel-bodies (a_1, a_2) and which increase considerably the strength of the double cone m . These bars n also can have helically formed surfaces and so distribute the total work done by the double bladed wheel to the blades k and i , according to the inclination of the helical surface. If this inclination of the helical surface equals 90 degrees this surface becomes an axial plane; then more work is transferred to the water by the blades k before it reaches the bar than by the blades i following the bar.

It is a further advantage of this construction that by the omission of sleeves which till now have been placed between the several stages and which have the tendency to strike the turning shaft, the safety of working is essentially increased. If the clearance-pressure, as will be now fully described, on the outer periphery of the wheel-bodies a is made constant for both sets of blades i and k of each wheel, then the number of spaces to be tightened is reduced to half of that of usual pumps. For this purpose the outer diffuser e (see for instance Figs. 1 and 2) simply could be formed so that the velocity of the water produced in a set of blades with central admission is inverted without transformation into pressure, and is transferred immediately into the second wheel. This procedure would, however, sometimes be impractical, since, as experience shows, the greatest losses usually occur in those places where water flowing with high velocity is to be entirely inverted in a narrow space. To avoid this loss it is advantageous to convert the kinetic energy inherent in the water leaving the blades with central admission into pressure and to then invert the water after its velocity has become small enough. If this water, being under pressure, should be directed immediately to the following set of blades (f or k), the inconvenience of a considerable clearance pressure at the periphery of each wheel a would arise. The invention avoids this inconvenience by bringing the pressure of the inverted water before its entrance at the periphery of the wheel, as closely as possible to the pressure of the water leaving the wheel (d or i) with central admission. The outwardly situated diffuser of this kind may be so constructed, that the diffuser, for instance, e of the drawing, first transforms in the usual manner the water velocity into pressure, and then leads around the water circumferentially before its entrance into the second ring space u (Figs. 1 and 2). Before the passage of the water to the wheel with peripheral admission, a further deflection of the water to the desired entrance-direction takes place in the space u and at

the same time its velocity is increased to the required value. This double deflection of the water can be avoided, as shown in Figs. 5 and 6, by transforming the absolute velocity of the fluid leaving the wheel having central admission, into pressure, deflecting the fluid and again transforming pressure into the initial velocity, all in the same plane. The absolute velocity of the fluid leaving the set of blades i of the blade wheel a is transformed into pressure in the nozzle-like part p of the diffuser r . The deflection is effected in the part s , the fluid preferably being still under the guidance of the directing blades used in the part p . Thus the fluid keeps its low velocity to the point t shortly before its entrance into the blades k of the wheel a . At this point t , where short guiding blades may be placed for securing the direction of entrance again, it is expedient that the fluid regain the same velocity it had at entrance into the diffuser r . To guide the water entirely in the same plane situated in the direction of the absolute outlet velocity at the periphery of the wheel gives the lowest losses.

The pump of the invention may naturally also be used for delivering or compressing gaseous media after having been correspondingly altered.

I claim:—

1. A turbine pump or compressor having a rotor with one set of impeller blades associated in the usual manner with a central inlet and peripheral outlet, another set of impeller blades arranged between a peripheral inlet and central outlet and adapted to increase the energy of the centripetally impelled fluid and a diffuser adapted to receive the discharge from the first set of blades, transform kinetic energy thereof into pressure, and subsequently invert the fluid for passage into the inlet of the second set of blades.

2. A turbine pump or compressor having a rotor with one set of impeller blades associated in the usual manner with a central inlet and peripheral outlet, another set of impeller blades arranged between a peripheral inlet and central outlet and adapted to increase the energy of the centripetally impelled fluid and a diffuser adapted to receive the discharge from the first set of blades, transform kinetic energy thereof into pressure, subsequently invert the fluid, and then increase the velocity and reduce

the pressure of the fluid as it passes into the inlet of the second set of blades.

3. A turbine pump or compressor having a rotor with one set of impeller blades associated in the usual manner with a central inlet and peripheral outlet, another set of impeller blades arranged between a peripheral inlet and central outlet and adapted to increase the energy of the centripetally impelled fluid and a diffuser adapted to receive the discharge from the first set of blades, transform kinetic energy thereof into pressure, subsequently invert the fluid, and then increase the velocity and reduce the pressure of the fluid as it passes into the inlet of the second set of blades, and directing vanes in the diffuser adapted to direct the entering water in the manner described.

4. A turbine pump or compressor having a rotor with one set of impeller blades associated in the usual manner with a central inlet and peripheral outlet, another set of impeller blades arranged between a peripheral inlet and central outlet and adapted to increase the energy of the centripetally impelled fluid, and a diffuser adapted to receive the discharge from the first set of blades, transform kinetic energy thereof into pressure, subsequently invert the fluid in the same plane, and then increase the velocity and reduce the pressure of the fluid as it passes into the inlet of the second set of blades, and directing vanes in the diffuser adapted to direct the entering water in the manner described.

5. A turbine pump or compressor having a rotor with one set of impeller blades associated in the usual manner with a central inlet and peripheral outlet, another set of impeller blades arranged between a peripheral inlet and central outlet and adapted to increase the energy of the centripetally impelled fluid, a stationary chamber arranged to receive the discharge from the first set of blades and invert it for passage into the inlet of the second set of blades, and vanes in said chamber adapted to direct the fluid as it passes into the said inlet.

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

FRANZ LAWACZECK.

Witnesses:

N. R. SNYDER,
DORIS KRAHL.