M. W. JOHNSON, JR.

TURBINE.

APPLICATION FILED DEC. 19, 1912.

1,142,882.

Patented June 15, 1915.

2 SHEETS—SHEET 1.

Fig 1

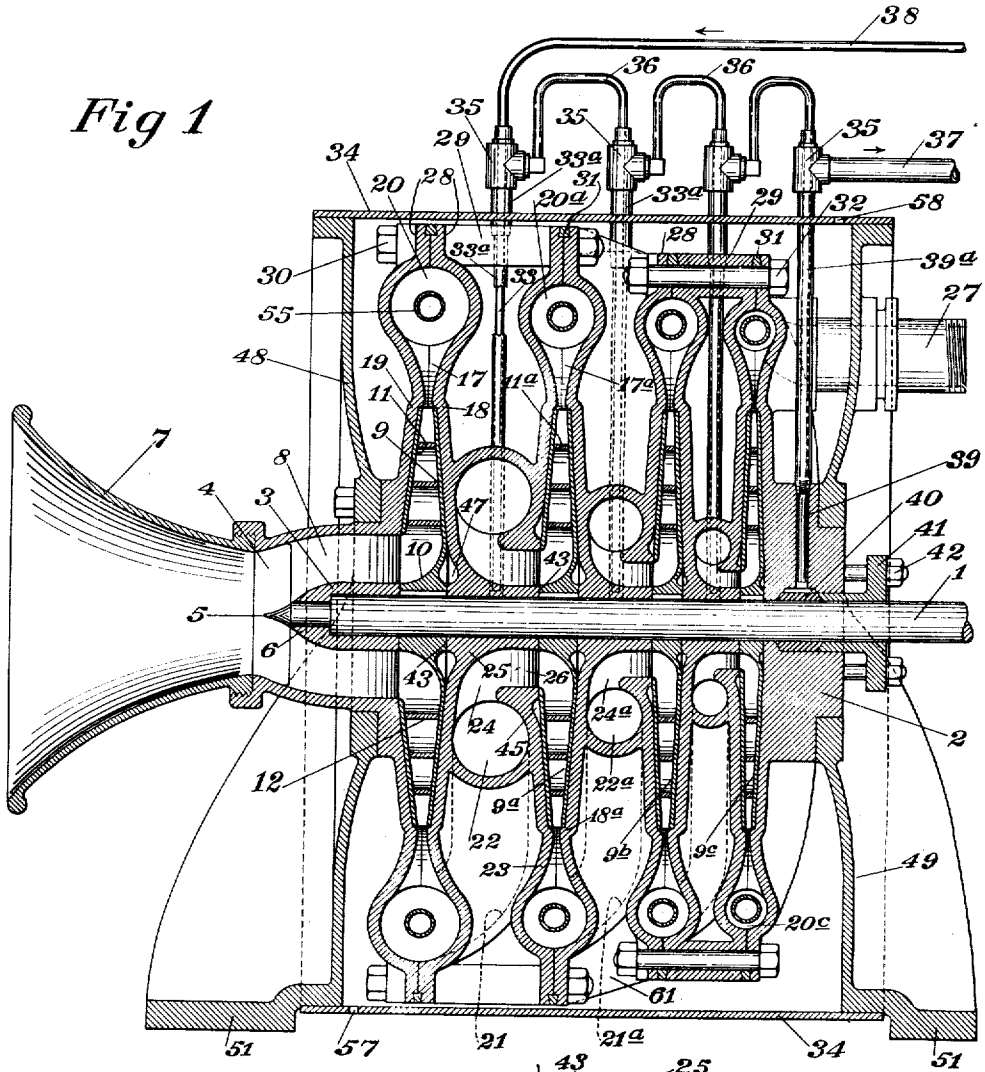
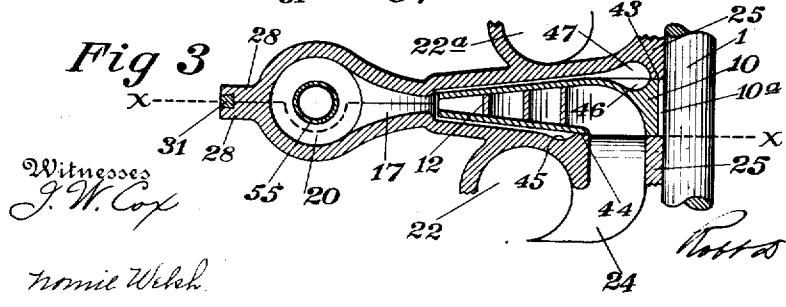


Fig 3



Witnesses
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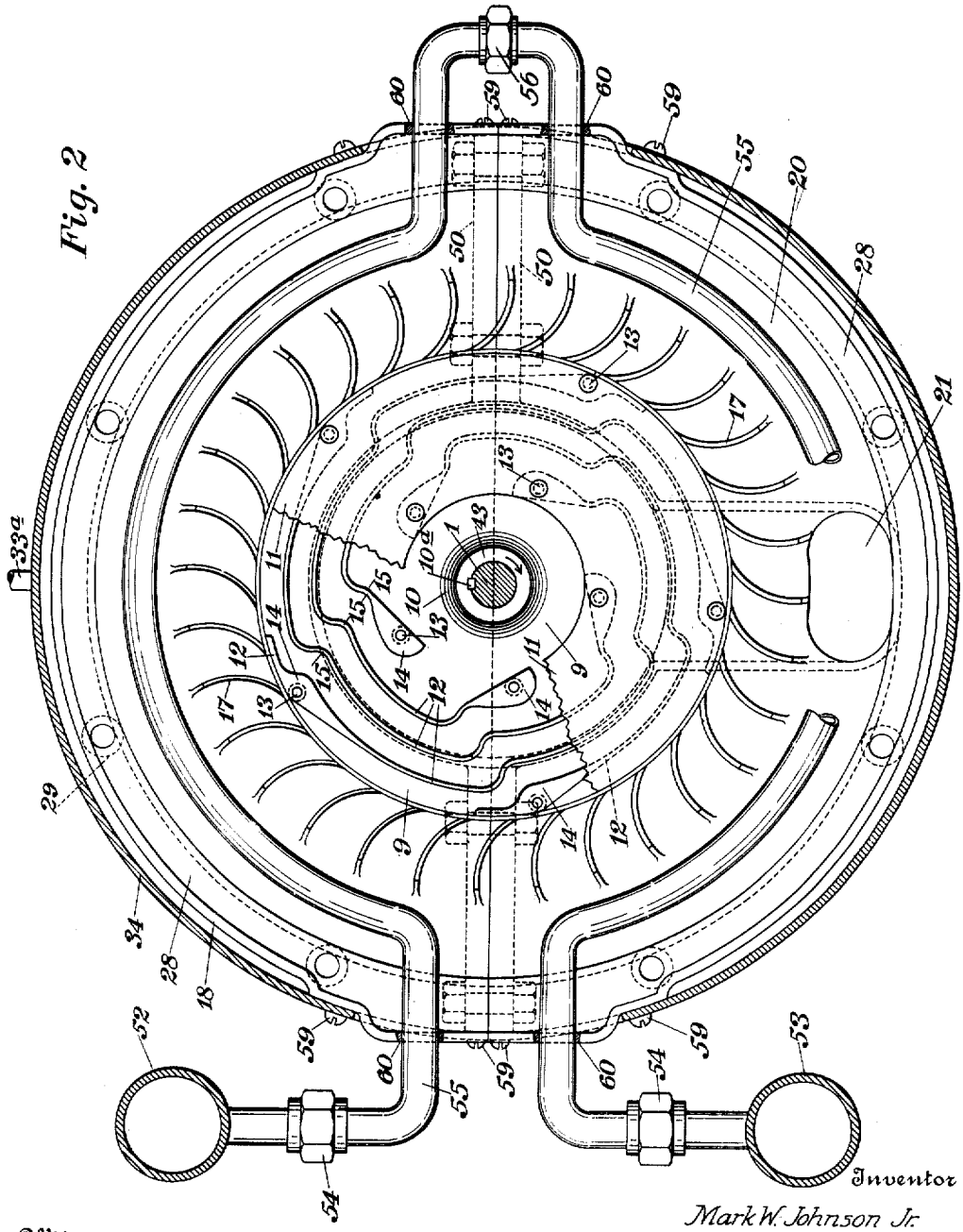
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2 SHEETS—SHEET 2.

Fig. 2



Witnesses

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TURBINE.

1,142,882. Specification of Letters Patent. Patented June 15, 1915.

Application filed December 19, 1912. Serial No. 737,748.

To all whom it may concern:

Be it known that I, MARK W. JOHNSON, Jr., a citizen of the United States of America, residing at Atlanta, Fulton county, Georgia, have invented certain new and useful Improvements in Turbines, of which the following is a specification.

My invention relates to centrifugal and centripetal engines and motors, such as turbines, blowers, air compressors and pumps, wherein the fluid or gas acts upon or is acted upon by a rotor and which are characterized by having the high pressure fluid chambers at the periphery of the rotor and the low pressure chambers at or near the center of the rotor which is so designed as to act efficiently as a prime mover or as a fluid compressor or pump.

One object is to design the rotor to conform more nearly to the natural flow or, in other words, the line-of-least-resistance-flow of any fluid moving in a path that changes from central to peripheral, or vice versa, according to the type of engine or motor. In the case of turbines driven by air or other gases, the rotor is usually driven at a very high velocity. Since the force of friction created by the flow of the motor fluid in restricted passages and across or along the faces of blades, vanes, etc., varies as the square of the velocity, friction losses in such machines are obviously great. To reduce such friction losses in the most effective way, I propose to reduce the velocity of flow of the motor fluid without however decreasing the requisite rotating speed of the rotor. I accomplish this result by causing the fluid to flow through the rotor in the same direction as it turns and at a velocity but slightly at variance with that of the rotor. This causes the force of friction of the fluid to be exerted against the rotor in the direction of its travel and hence is not lost but utilized. Obviously this reduces the friction losses because the actual rate of flow of the fluid through the rotor passages is equal only to the difference between the actual velocity of the fluid and that of the rotor and I find that the relative velocity of the fluid may be controlled by varying the cross-sectional area of the rotor passages through which it flows. I obtain the desired flow of the fluid by providing a rotor subdivided by vanes which provide small tangential openings at its periphery and larger central openings through one or both of its sides near its center. In the case of a steam or air turbine rotor, the motor fluid is injected into the peripheral openings at a high velocity (which is slightly greater than the peripheral velocity of the rotor) and since it would naturally tend to move about in the rotor, were the latter made hollow and without vanes in a spiral, I cause the vanes to conform to the aforesaid natural flow of the fluid in the revolving rotor and therefore shape them in the form of a spiral or a practical approximation thereto. According to this design the smaller the peripheral openings the greater the number of vanes and the longer the spiral length thereof. The greater the number of vanes and the greater their length the less will be the shock or impact from the fluid, since the spiral vanes present a gradually and uniformly increasing resistance to the flow of the motor fluid. While I have described these conditions in connection with the turbine, if the shaft be revolved, carrying with it the rotor, reversed conditions are set up and the result is an air compressor, blower or pump possessing the same advantages as have been pointed out with reference to the turbine. The speed of rotation of the rotor should be such that the centrifugal force set into action should be approximately equal to the high pressure of the fluid at the periphery of the rotor. In the case of a motor, centrifugal force should be slightly less, while for a compressor or blower it should be slightly greater, the difference being determined by the velocity of influx and efflux of the fluid at the main point or points of entrance and exit. If it be impracticable for a single rotor to operate at a speed sufficient to carry out the above conditions, the results may be accomplished in stages by utilizing two or more rotors connected in series or multiple stages.

Another object of my invention is to materially improve the design of the stator to increase the efficiency of the machine as a whole. To this end I make two essential changes in the present design of stator, one consisting in providing vanes for directing the gas or fluid which the rotor, acting as a blower or pump, will discharge into the peripheral or high pressure chamber, so as to prevent the loss due to uninterrupted flow at high velocity therethrough, or to idle whirling therein, of its kinetic energy of velocity and convert such energy into poten-

tial energy of pressure. My design is based on the principle that the opposing of resistance to a fluid in motion creates energy of pressure and to this end the vanes are designed to receive the tangentially out-flowing gas or fluid from the rotor and gradually change its line of travel from tangential to radial, causing it to impinge directly against the peripheral wall of the high pressure chamber, thus most effectively presenting a resistance to its flow, and as a result most efficiently converting its energy of velocity into energy of pressure. The design is equally available for turbine motors as the vanes will act to efficiently convert the energy of pressure of the motor fluid in the high pressure chamber into energy of velocity before directing it against the rotor.

A further object of my invention is to provide vanes in the central or low pressure chamber of a turbo blower or pump, for directing the fluid discharged thereinto so that its direction of flow is the same as that of the rotor and its velocity nearly equal to the velocity of the rotor opposite the low pressure chamber. The fluid in this chamber tends to flow therein in the form of a helix and I provide vanes curved to gradually change the motion of the fluid in the required manner and arrange them to form gradually restricted passages so that the velocity of flow of the fluid is increased until it is slightly in excess of that of the rotor where it flows into the latter. In the case of the turbo motor the design of the vanes is such that they will receive the fluid from the wheel and act after the fashion of the vanes in the high pressure chamber to convert its energy of velocity into energy of pressure.

My invention embodies many other improvements in the design and construction of turbine motors or engines, all of which are hereinafter more fully explained with reference to the accompanying drawings which form a part of this specification, and in which:—

Figure 1 is a longitudinal vertical sectional view of my invention as embodied in a four stage turbo-compressor. Fig. 2 is a vertical cross-sectional view taken along the line x—x of Fig. 3, and Fig. 3 is an enlarged detail view showing more clearly the construction of the rotor and the chamber in which it works.

Similar reference numerals refer to similar parts throughout the drawings.

It being understood that the principles underlying my invention are equally applicable to various forms of turbine motors or engines utilizing a rotor to act on or be driven by a body of gas or fluid, I have chosen to illustrate my invention as embodied in a four stage air compressor. The several rotors in the multi-stage compressor are mounted upon a common shaft 1 which is connected to any suitable rotary engine or turbine, not shown, and which passes through a bearing head 2 formed integral with the high pressure stage of the blower and at its other end is seated in a bearing 3 formed integral with the low pressure stage of the turbine and disposed concentric with the opening in the port 4. The end of the shaft is reduced to a point 5 which projects through the tapered end portions 6 of the bearing 3. An air intake nozzle 7 is suitably threaded into the outer end of the port 4 and a series of curved vanes 8 connect the bearing 3 with the side walls of the port. These vanes are designed to direct the entering fluid tangentially into the annular low pressure fluid inlet port 16 of the rotor 9 disposed in the first stage, giving it the same direction of flow as the rotor and a velocity slightly greater than that of the rotor opposite the vanes. This rotor has a hub portion 10 keyed on the shaft 1 and an annular body portion which has mounted thereon and spaced therefrom a ring plate 11 extending from the outer edge of the inlet port to the periphery of the rotor.

I interpose a series of spiral vanes 12 between the rotor and plate 11 and the several ports are suitably connected together by bolts or countersunk rivets 13. These vanes may, if desired, be provided with enlargements 14 to receive the rivets 13. I illustrate the wheels as provided with only five vanes, though it will be understood that there may be any number of such vanes according to the size and diameter of the rotor and the use for which it is intended. The greater the number of vanes the greater will be their length and the smaller the cross-sectional area of the spiral fluid passages in the rotor, which contract gradually as they approach the rotor's periphery. As illustrated, the vanes, due to the enlargements 14, and the necessity of avoiding contracting the passages opposite such enlargements, do not follow a true spiral but are provided with a number of curved offsets 15 which offer impact faces against which the fluid will impinge as it flows through the working passages between the vanes. The rotor and plate 11 are set at an angle to each other gradually converging toward their peripheries and providing gradually contracting passages from the inlet port 16 to the periphery of the rotor. The fluid is discharged from the peripheral end of the rotor passages at a high velocity and at a tangent. I provide a series of curved vanes 17 which are formed in halves, one-half being integral with each of the annular sections 18 and 19 forming part of the stator and being designed to inclose between them the first or low pressure stage of the compressor. This stage is divided on a vertical plane at right angles to the shaft and the vanes 17

are therefore formed in halves opposite the center line of the circumferential orifice of the rotor. The sections 18 and 19 are so designed that they furnish a gradually increasing passage for the fluid as it flows between the vanes 17 which are designed to convert the tangential direction of flow of the fluid gradually to a radial line of flow and discharge it radially against the outer peripheral wall of the annular high pressure passage 20 of the first stage. The flow of the fluid is thus arrested and its energy of velocity immediately converted into energy of pressure. The fluid is conducted by a pipe or by-pass 21 and discharged tangentially into a circular passage 22 formed integrally with that portion of the stator embodying the section 18 of the first stage and the adjacent section 23 of the second stage. I term this passage 22 the low pressure chamber for the second stage and provide it with a series of vanes 26, the inner ends of which are disposed tangentially to the fluid whirling in the chamber. These vanes are disposed in an annular lateral outlet port 24 formed in the hub portion 25 of the stator which makes a close running fit with the shaft 1. Since the port 24 curves from a radial to an axial direction, the blades 26 are similarly curved and in addition their outer ends toward stage 2 are curved so as to direct the fluid tangentially to the face of the rotor 9^a in the second stage and give it a velocity slightly greater than that of the rotor. This rotor 9^a is similar to 9 except that its plate 11^a is set closer to it to further restrict the area of the fluid passages between the vanes proportionately to the increased density of the fluid. This fluid is again subjected to the action of the spiral vanes 12^a in the rotor 9^a and is centrifugally ejected therefrom against the vanes 17^a of the high pressure chamber 20^a of the second stage, which is similar to 20, and connected by a by-pass 21^a to the low pressure chamber 22^a of the third stage, where it is diverted by the vanes 26 through a port 24^a into the wheel 9^b of the third stage in which the fluid passages are still smaller. The fluid thus flows from stage to stage, the design of which is similar but gradually decreases the cross-sectional area of the fluid passages until having compressed it to the desired extent it is delivered by the rotor 9^c of the last high pressure chamber 20^c from which it is discharged through the outlet pipe 27 to the point of use.

The stator sections forming the several stages have circumferential flanges 28. The adjacent sections of two adjoining stages are connected together by web portions 29 which are integral with the flanges 28 and both are drilled to receive bolts 30 which lock the sections of the stage compartments together. Suitable packing 31 is interposed between the flanges to prevent leakage from the high pressure chambers 20 and 20^a, etc. The sections of the several high pressure stages have similar parts which are similarly numbered though the sections are shown of shorter diameter and having their respective flanges 28 connected by bolts 32. To prevent leakage along the shaft between the several stages, I provide means to pack the clearances between the shaft and hubs 25 by oil under pressure which is delivered by pipes 33 which are inclosed in return circulation pipes 33^a shown broken away in the low pressure stage of Fig. 1. These pipes pass through the low pressure chambers 22 and the hub portions 25 to the shaft opposite the center of each hub portion, the pipes 33 delivering a circulating body of oil to the bearing and the oil flowing back out of the casing through pipes 33^a, which pass out of the outer casing 34 surrounding the stator and connect each with couplings 35. These couplings are connected by pipes 36 to form a manifold to which oil is applied under pressure by a pipe 38 and drawn off through a pipe 37. Similar oiling arrangements are provided for the high pressure shaft packing, the oil being delivered through to the packing box 40 in the head 2, and flows back through pipe 39^a. A packing gland 41 is connected by screws 42 to the head 2 and is removable for replacing the packing. No packing is required for the low pressure end of the shaft.

It will be noted that the several rotors are designed to have a running contact with the casing sections only at the hub portions of the rotor, as at 43, and at the point 44 (see Fig. 3) surrounding the outer edge of the fluid inlet to the rotor. These points of running contact are turned smooth and are adapted to make a fluid tight running fit. At other points a sufficient running clearance is provided between the rotors and their casing to avoid frictional engagement. With the exception of the section 19 of the low pressure stage, the other similar sections are each provided with an annular groove 45 surrounding the running contact face 44 in which any fluid leaking between the rotor and casing is caught. The lower portion of the rotor is circumferentially grooved at 46 opposite a groove 47 surrounding the casing sections 18 of the several stages excepting the high pressure stage where only the groove corresponding to 46 is used.

The stator is surrounded by a metal jacket 34 and both stator and jacket are divided into halves on a horizontal central plane and the jacket sections are suitably flanged and bolted together. The jacket is bolted to a low pressure head 48 through which the nozzle 4 passes with a pressure tight fit. I also provide a high pressure head 49 for the

jacket and it fits pressure tight about the bearing 2. These heads are divided on horizontal central planes like the jacket and have flanges 50 by means of which they are adapted to be bolted together. The lower sections of the heads form the base supports 51 for the machine.

In the case of air compressors where it is necessary to keep down the temperature of the air, I provide a water cooling system comprising manifolds 52 and 53 and to each I connect a series of pipes 55 which have couplings 54 near the manifolds and are suitably packed at 60 where they pass between the sections of the stator. There are two pipes 55 for each stage and they are connected together without the jacket by a coupling 56. The portions of the pipes within the stages are curved and pass centrally around through the high pressure chambers 20, 20^a, etc. A cooling medium is circulated through the manifold system and in addition to this cooling means I may admit water into the jacket at 57 and draw it off through port 58 after it has circulated about the stator or stage walls. No cooling means would be required in the case of a pump, or a turbine motor. The stator sections are enlarged opposite the points of entrance and exit of the cooling pipes, and the jacket sections cut away to make a tight fit about such enlargements, being connected to the same by screws 59. The stator construction into half sections on both vertical and horizontal transverse planes makes it easy to open up the machine for inspection and repairs.

I prefer to curve vanes 17 in the high pressure chamber so that the outer or discharge ends do not stand in a radial line but are inclined slightly backward as I find this arrangement is most effective in bringing the fluid to rest in the high pressure chamber.

What I claim as new and desire to secure by Letters Patent, is:—

1. In a turbine, a stator comprising an outer circumferential high pressure chamber and an inner circumferential low pressure chamber, a rotor, a compartment in the stator inclosing the rotor and communicating with said chambers, said rotor having fluid passages which lead in a spiral direction from its center to its periphery the expansion of the spiral being continuously in the direction of its rotation, and guide vanes in the high pressure chamber of the stator forming curved passages which at their inner ends are inclined substantially in line with the passages of the rotor to change the direction of the flow of the fluid from radial to tangential, or vice versa.

2. In a turbine, a stator comprising an outer circumferential high pressure chamber and an inner circumferential low pressure chamber, a rotor, a compartment in the stator inclosing the rotor and communicating with said chambers, said rotor having fluid passages which communicate with said chambers and which lead in a spiral direction from its center to its periphery the expansion of the spiral being continuously in the direction of its rotation, guide vanes in the high pressure chamber of the stator which are curved to change the direction of the flow of the fluid from radial to tangential, or vice versa, and curved guide vanes for the low pressure chamber to cause flow of the fluid entering or leaving it to be in the form of a helix.

3. In a turbine, a rotor having a hollow circular body portion and fluid ports near its center and periphery, and long spiral guide vanes in the rotor leading from its central to its peripheral ports and forming gradually contracting fluid passages which are disposed in a spiral about the axis of rotation of the rotor, the expansion of the spiral being continuously in the direction of its rotation, in combination with a stator having fluid passages communicating with the central and peripheral ends of said fluid passages.

4. In a turbine, a rotor provided with a series of laterally disposed spaced vanes which pass in a spiral direction for approximately a half turn about its axis of rotation, the advance of the spiral being in the same direction as the direction of rotation, in combination with means to confine the fluid growing between said vanes to provide spiral fluid passages, and curved guide vanes having their inner ends disposed tangentially to the periphery of the rotor and inclined in the direction in which the fluid leaves the rotor's periphery, substantially as described.

5. In a turbine, a stator comprising an annular chamber for the low pressure fluid and a wheel chamber into which said low pressure chamber opens, a rotor in said wheel chamber, curved vanes on the stator to direct the fluid in a helical form as it flows axially to or from said low pressure chamber, long spiral vanes on the rotor advancing in the same direction as the direction of rotation, a circumferential high pressure chamber communicating with the periphery of the wheel chamber, and curved guide vanes in the passage between the wheel chamber and high pressure chamber which are curved to change the direction of the flow of the fluid from radial to tangential, or vice versa, as it flows between the wheel chamber and high pressure chamber, substantially as described.

6. A multi-stage turbine comprising a series of stage compartments, a rotor operating in each compartment, high pressure ring-shaped chambers which surround and com-

municate each with the periphery of a stage, low pressure ring shaped chambers which surround the hub between stages and have each a port which leaves the chamber radially and curves to enter a stage compartment axially and adjacent to a side wall of the rotor therein, and guide vanes 24, 26, in said port which cause the line of the flow of the fluid in passing therethrough to be in the form of a helix toward the rotor and in the direction of its travel, and spiral vanes in the rotor against which vanes the fluid impinges in passing between the high and low pressure chambers of a stage, substantially as described.

7. A rotor having a series of overlapping vanes which wind in a long spiral about its center of rotation, the advance of the spiral being in the same direction as the direction of rotation, said vanes having bolt receiving enlargements and all vanes being curved opposite enlargements to provide passages which gradually and uniformly contract from center to circumference of the rotor.

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

MARK W. JOHNSON, Jr.

Witnesses:
Nomie Welsh,
R. D. Johnston, Jr.

Correction in Letters Patent No. 1,142,882.

It is hereby certified that in Letters Patent No. 1,142,882, granted June 15, 1915, upon the application of Mark W. Johnson, Jr., of Atlanta, Georgia, for an improvement in "Turbines," an error appears in the printed specification requiring correction as follows: Page 4, line 101, for the word "growing" read *flowing;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 27th day of July, A. D., 1915.

[SEAL.]

R. F. WHITEHEAD,

Acting Commissioner of Patents.