No. 833,482. PATENTED OCT. 16, 1906.

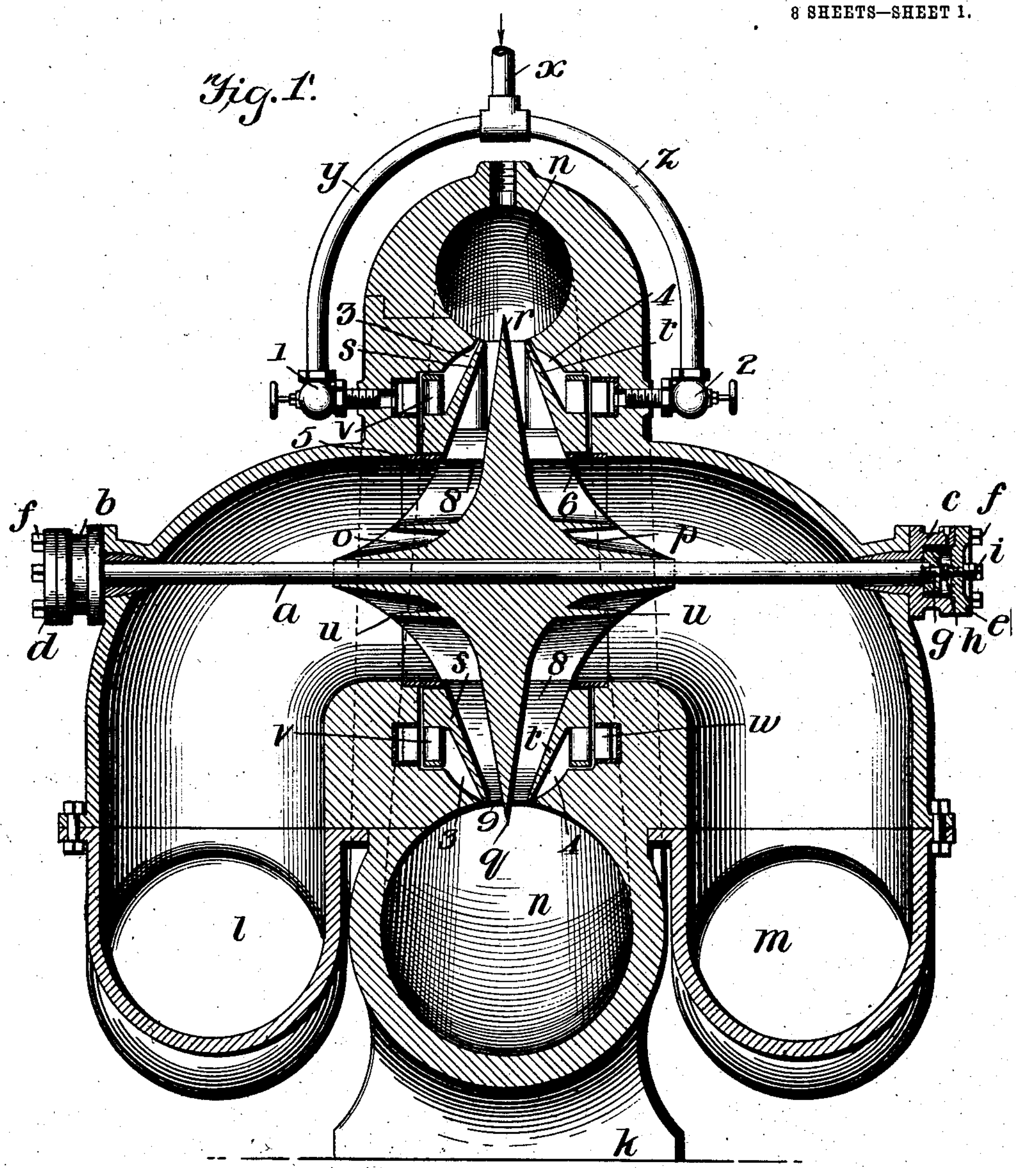
R. S. PRINDLE.

SELF CONDENSING TURBINE.

APPLICATION FILED MAR. 5, 1902.

8 SHEETS—SHEET 1.

Fig. 1.



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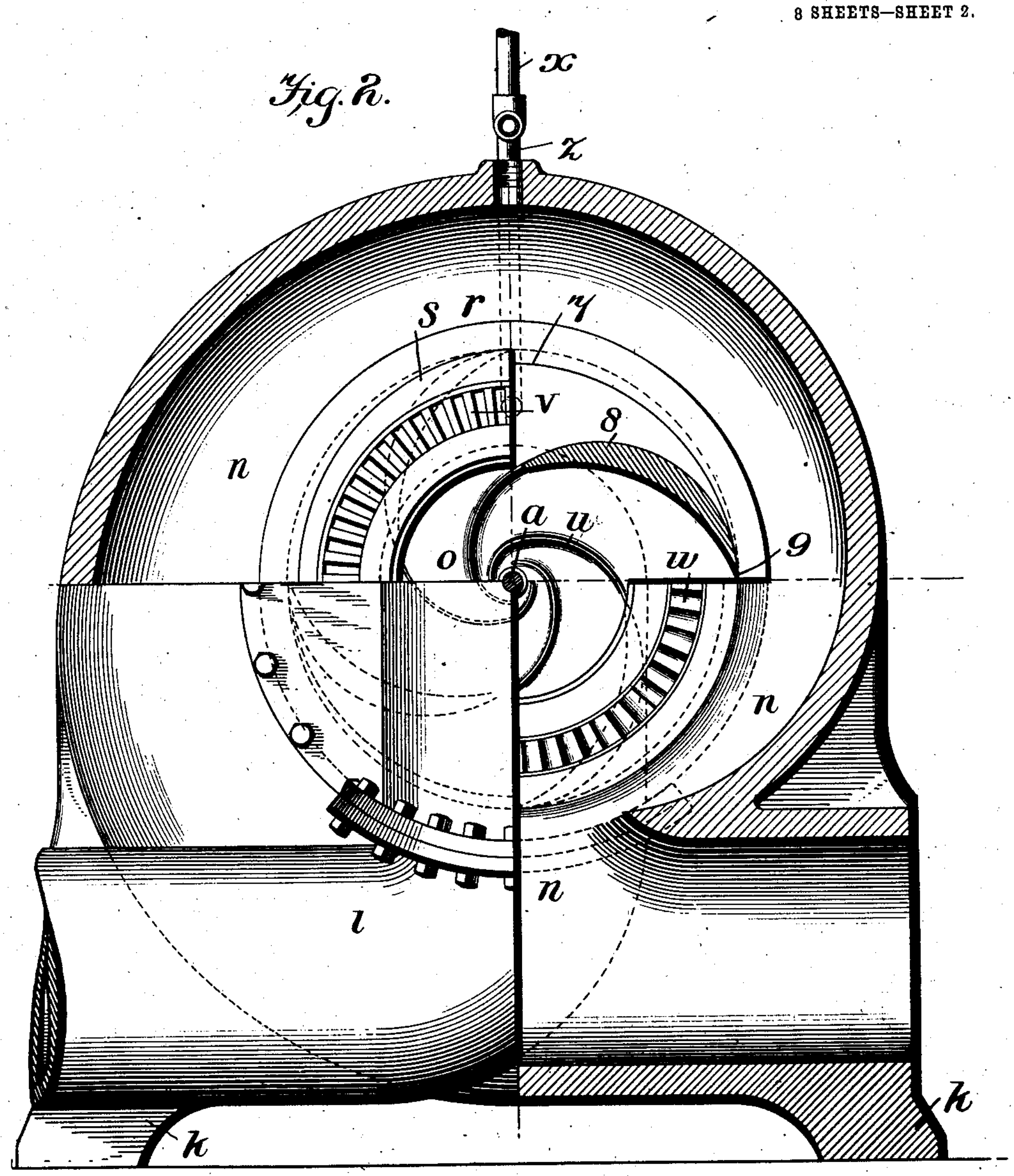
8 SHEETS—SHEET 2.

Fig. 2.



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8 SHEETS—SHEET 3.

Fig. 3.

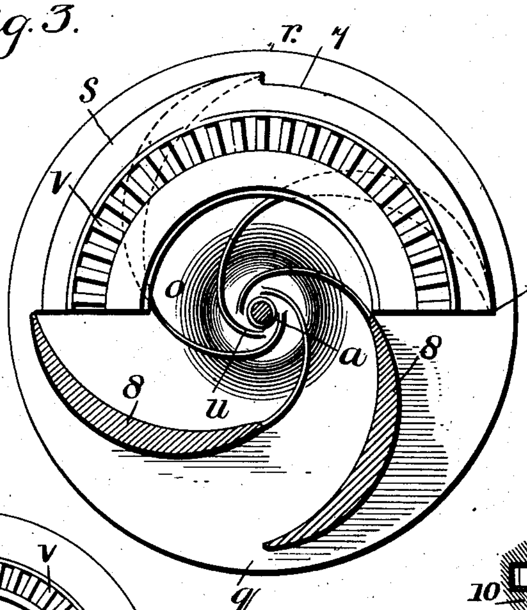


Fig. 4.

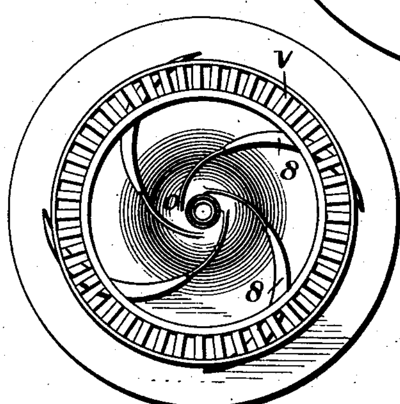


Fig. 5.

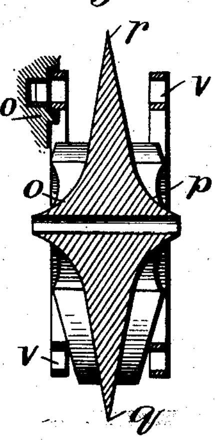
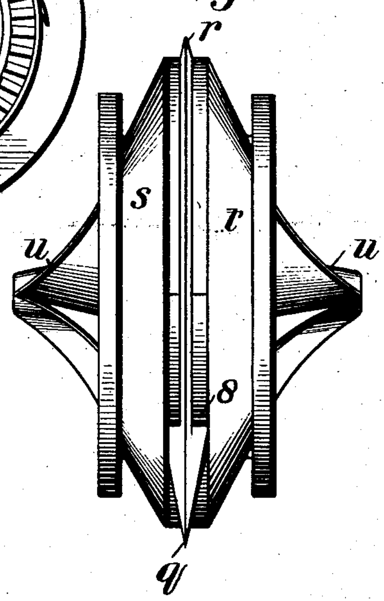


Fig. 6.



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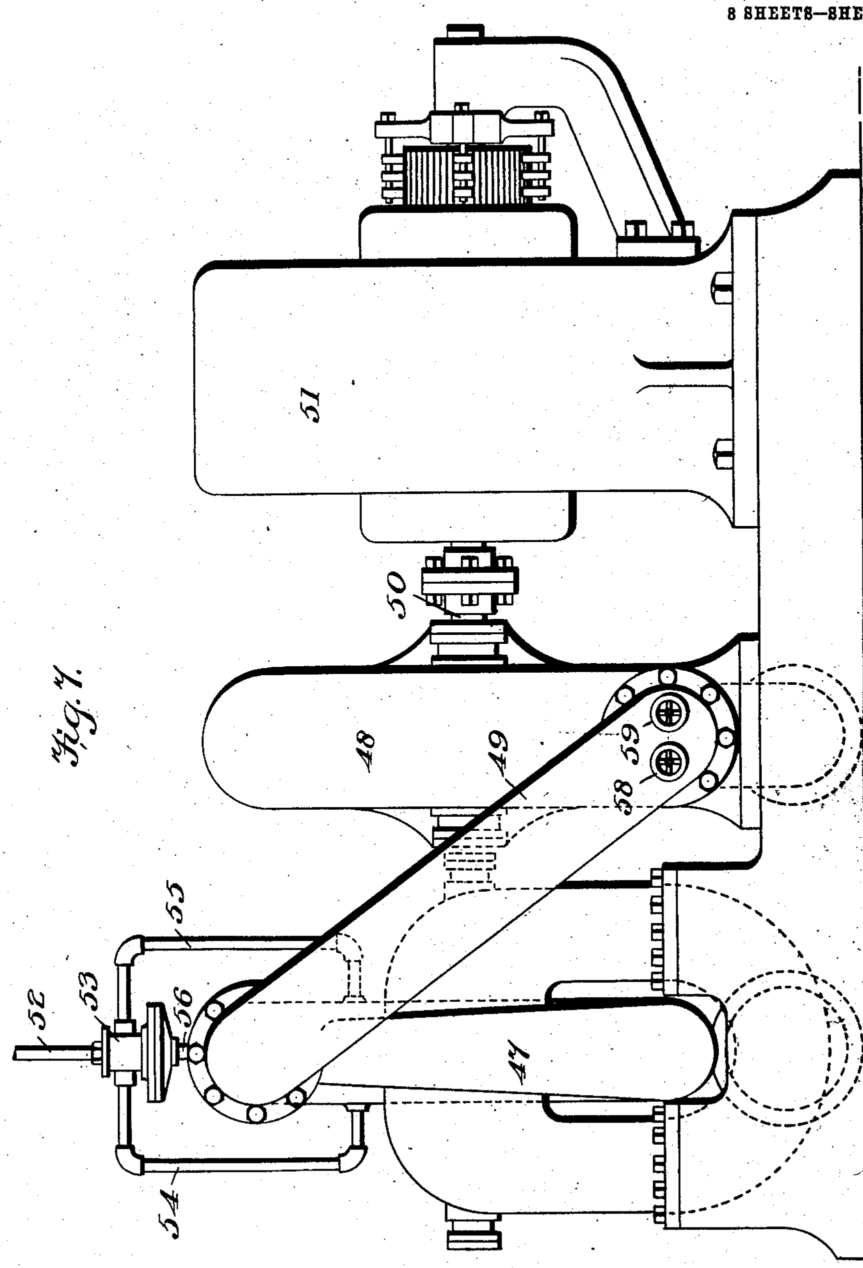
8 SHEETS—SHEET 4.



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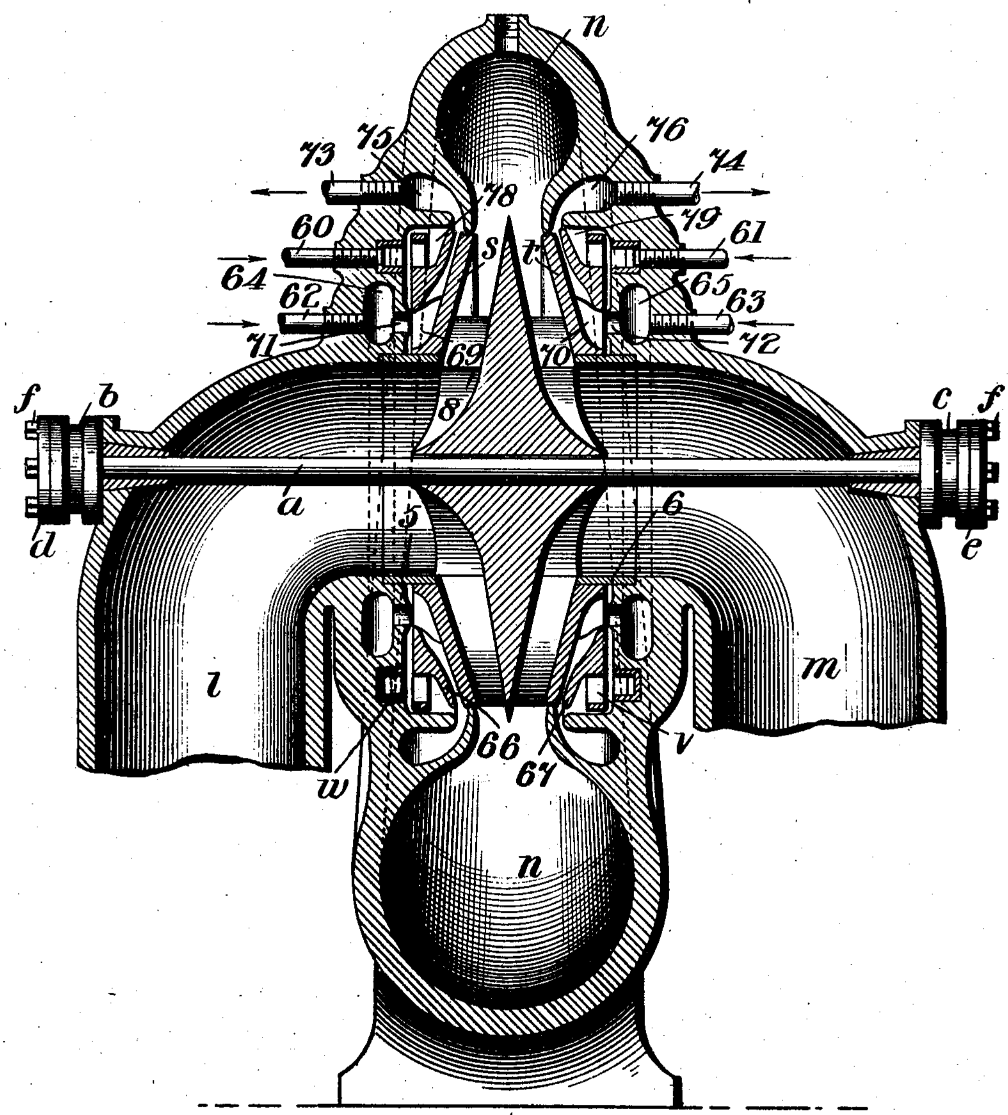
8 SHEETS—SHEET 5.

Fig. 8.



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8 SHEETS—SHEET 6.

Fig. 9.

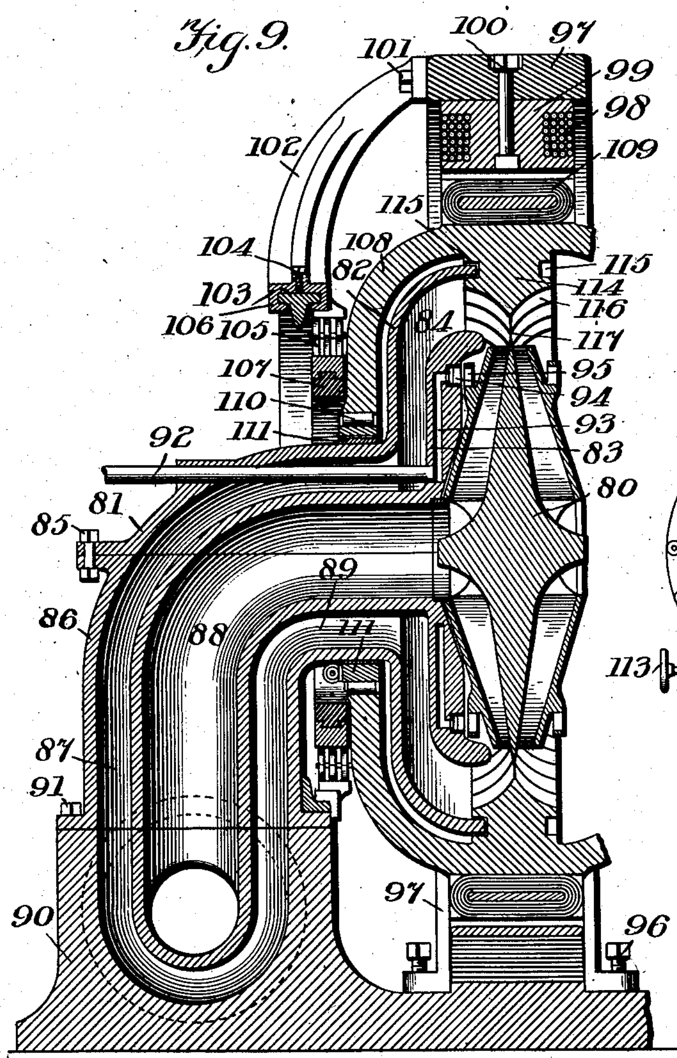
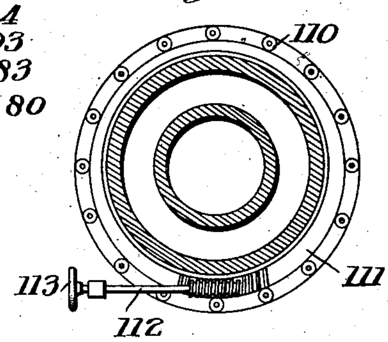


Fig. 10.



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8 SHEETS—SHEET 7.

Fig. 12.

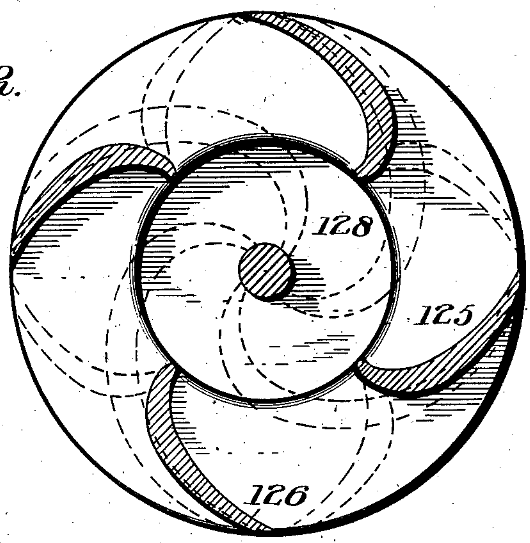
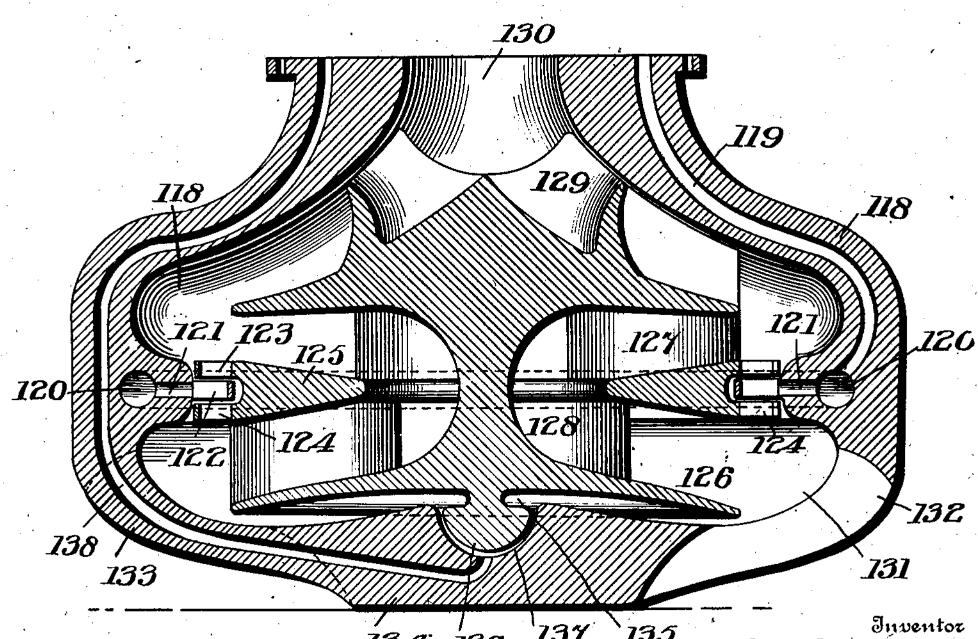


Fig. 11.



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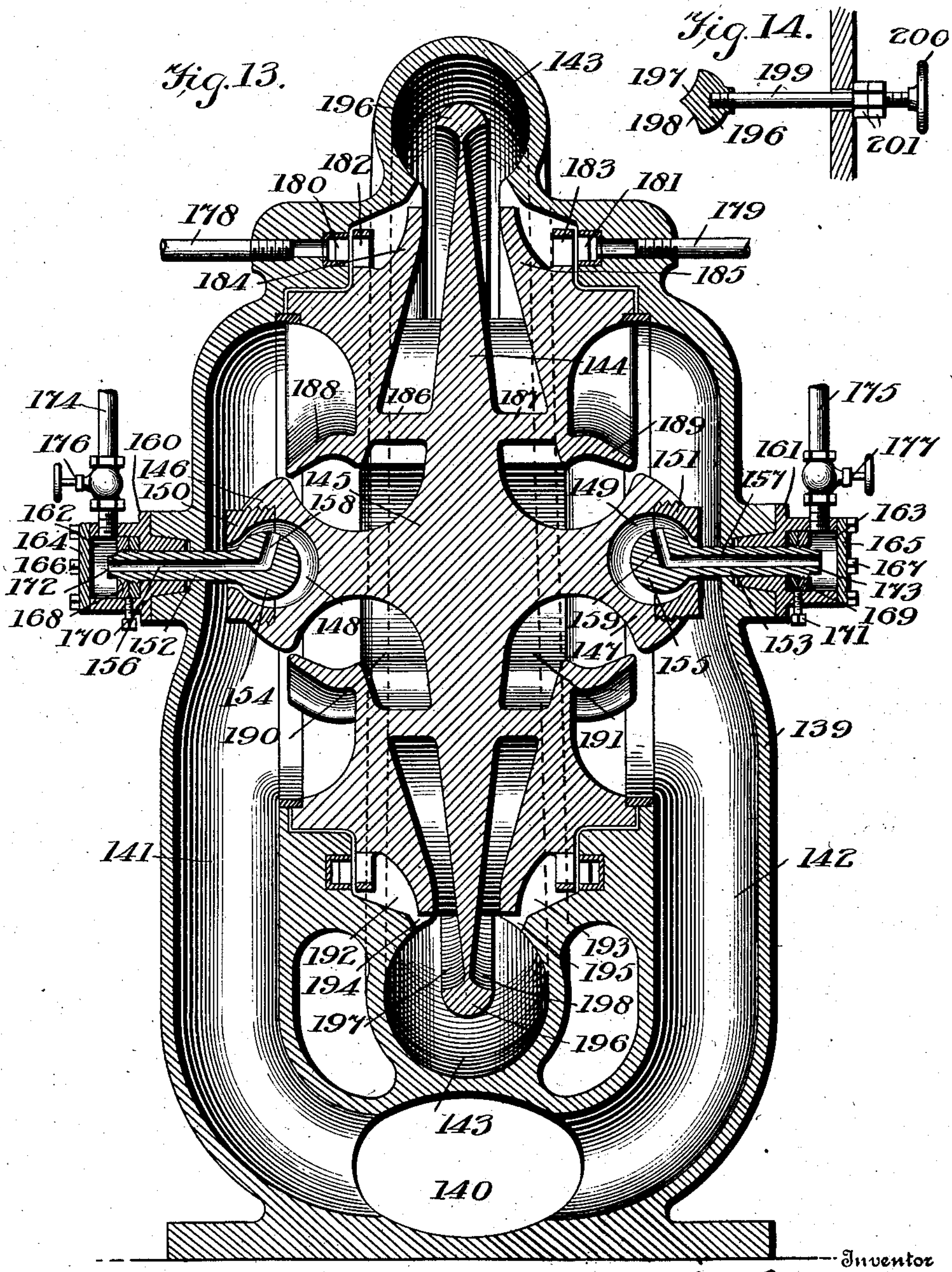
8 SHEETS—SHEET 8.



Inventor

Witnesses

UNITED STATES PATENT OFFICE.

ROSCOE S. PRINDLE, OF NEW YORK, N. Y., ASSIGNOR OF ONE-HALF TO CHARLES H. TOMPKINS AND VINCENT C. TOMPKINS, OF NEW YORK, N. Y.

SELF-CONDENSING TURBINE.

No. 833,482. **Specification of Letters Patent.** **Patented Oct. 16, 1906.**

Application filed March 5, 1902. Serial No. 96,828.

To all whom it may concern:

Be it known that I, Roscoe S. Prindle, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Self-Condensing Turbines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in steam-turbines; and the objects of my invention are to produce a device of this character which may be driven at the very highest possible speeds dependent only on the tensile strength of the material, to practically do away with friction, to have the running parts accurately and automatically balanced, and to have them so arranged that when in rotation they will be supported on practically nothing but fluid.

A further object is to have the apparatus self-condensing and free from torsional strains, the power which the apparatus produces being utilized as hereinafter described.

With these objects in view my invention consists in the constructions and combinations of parts, as hereinafter described, and particularly pointed out in the claims.

In the accompanying drawings, Figure 1 represents a cross-section of a steam-turbine and a centrifugal pump combined. Fig. 2 is a side view of the same, partly in section, the section being taken on three different planes. Fig. 3 is a side view, partly in section, of the rotating part or runner, the section being taken in two planes. Fig. 4 is a side view of a modification, the rotating part or runner shown therein being of the open type. Fig. 5 is a cross-sectional view of the runner or rotating part shown in Fig. 4. Fig. 6 is an end view of the rotating part or runner of the closed type, such as is shown in Fig. 3. Fig. 7 is an elevation showing the means whereby power is taken from the steam-turbine and utilized. Fig. 8 is a cross-section of a modification, showing separate condensing means. Fig. 9 is a broken cross-section of a modification, showing a self-condensing steam-turbine, a pump, a liquid-motor, and an electric generator, all in one structure; and Fig. 10 is a detail view, partly in section, of one of the bearings. Fig. 11 is a cross-section of another modification; and Fig. 12 is a bottom plan view, partly in section, of the runner shown in Fig. 11. Fig. 13 is a cross-section of another modification, showing a steam-turbine and combined centripetal and centrifugal pump; and Fig. 14 is a detail view showing the means for supporting and adjusting the pressure-ring.

Referring to Fig. 1, *a* represents a shaft on which the rotating runner is supported while at rest. In motion it is practically balanced so that there is very little friction between the shaft and the casing, or said shaft may be supported on water-bearings, as shown in my companion application of even date, entitled "Method of transmitting power." This shaft is mounted in boxes *b c*, supported in extensions upon the casing, said boxes having removable heads *d e*, which are fastened thereto by bolts *f*. In each end of the shaft a set-screw *g* is inserted, and a washer or spacing-block *h* is held between the head of said screw and the end of the shaft. Another set-screw *i* passes through the head *e* and contacts with the head of the screw *g*. By this arrangement the shaft may be adjusted or may be allowed a slight lateral play. The casing shown is the casing of one type of centrifugal pumps supported on a standard *k* and provided with inlet-pipes *l* and *m*, which deliver to opposite sides of the rotating part or runner. This rotating part or runner discharges into a discharge-chamber *n*, made in the form of a volute and shown as largest at the bottom, where the discharge takes place, although I do not restrict myself to this arrangement, either of suction or discharge, as the inlet-pipes might come in from the side or the top and the discharge-orifice may be placed in any desired position. The rotating part or runner secured to the shaft *a* in any desired manner is composed of two oppositely-coned portions *o* and *p*, which are united by two oppositely-coned portions *q* and *r*, arranged at right angles to the first coned portions and constituting a guiding-vane. Substantially parallel to this guiding-vane and on either side thereof are two wings *s* and *t*, and the water discharged by the rotation of the runner passes through the passages between the wings *s* and *t* and the vanes *q* and *r*, these wings being of course cut away at the center to allow the liquid to freely enter the central and inclosed part of the runner. From points near the central part of the runner curved spiral webs *u* run to the periphery of the runner. The parts of these webs which pass between the wings *s* and the central vane are enlarged and extended to form arms completely connecting the vane and side wings. I do not restrict myself, however, to the number of webs and arms shown, nor to having them made exactly in the form of a true spiral, the number, pitch, and throw of the webs and arms depending upon the volumes, speeds, and powers of the combined turbine and pump. On each of the wings *s* and *t* and symmetrically arranged in regard to the central vane are rings of impeller blades or vanes *v*. In Fig. 1 I have shown these rings arranged about midway of the wings *s* and *t*; but it is obvious that they may be arranged either nearer the inner periphery or nearer the outer periphery thereof, as may be desired. These blades and vanes are made of any desired size, shape, and thickness. Parallel with these impeller-blades and mounted in recesses in the casing or attached thereto are similar rings of deflecting blades or vanes *w*. *x* represents a steam-pipe for the delivery of steam to said rings or blades and vanes which is split up into branch pipes *y* and *z*, provided with hand-valves 1 and 2, delivering to each side of the casing, respectively. I prefer to use four of these inlet-pipes on each side spaced equally apart; but I do not restrict myself to any number or position thereof. Steam may be conveyed by an annular passage cored out of the casing, if desired. In fact, any of the usual and well-known means for supplying steam to the impeller-blades may be used, and, moreover, I so arrange the apparatus that different pressures of steam may be applied to different parts of the rings of the impeller-blades, the pressures on either side of the runner being, however, balanced. In this way I am enabled to practically support the weight of the runner by the pressure of the steam used to drive it and also to cause the runner to be automatically and perfectly balanced in the center of the casing. In this figure I have shown on either side of the central vane a single row of impeller-blades and a single row of diverting-vanes. It is obvious that I am not restricted to such an arrangement. I can use as many rings of impeller-blades (provided the same number is used on the same side of the central vane) and as many rings of reacting or diverting blades as I desire, which latter series of rings will be fixed to the casing, such arrangements being well known in steam-turbines. In this way I am enabled to obtain energy from the steam by impact, reaction, expansion, or any combination thereof. Between the wings *s* and *t* and the casing are passages 3 4, into which the steam emerges after passing through the impeller-blades. These passages 3 and 4 are contracted at their outer ends, the result being that when the rotating part is driven the water or other fluid passing out between the wings *s* and *t* and the central vane into the discharge-chamber *n* draws along with it the steam through these narrow passages out of the passages 3 and 4 and condenses it, also at the same time drawing out any air that there may be in the casing or entrained in the steam. In this way the steam is jetted against a moving column of water, and condensation is practically instantaneous. Moreover, there is a steady current of water passing through the discharge-chamber in a circular direction, and the exposure of the exhaust-steam to this moving column of water causes instant condensation, as in a jet-condenser, the result being that the water driven by the runner carries with it the condensed steam and any air that may be present and discharges them all through the exhaust-opening. This, in effect, allows the rotating part or runner to run in a vacuum, rendering it possible to run the apparatus at high speeds with a comparatively small quantity of steam. This instantaneous condensation greatly reduces the power necessary to operate the apparatus. 5 and 6 represent circular annular guide-plates secured to the casing and overlapping the inner peripheries of the rings *s* and *t*, but not in contact therewith, it being one of the essential features of my invention that the rotating part or runner shall be compelled to rotate entirely free from the casing, thereby diminishing friction and permitting no slip of the liquid column. The purpose of these guide-plates 5 and 6 is to direct the water coming in from the pipes *l* and *m* into the spaces between the rings *s* and *t* and the central vane.

As shown in Fig. 2, the side wings *s* and *t* are cut away, as shown at 7. This cut-away portion is in the form of a spiral, commencing at the outer edge of one of the arms 8 and gradually depending until just behind the next succeeding arm, being approximately in the form of a reversed spiral, the deepest part being behind the runner-arm at the point of vacuum, since the pressure generated by each one of the arms is greatest at the point 9, and behind the arm 8 there is a vacuum when the apparatus rotates in a liquid.

In Figs. 1, 2, and 3 the centrifugal pump shown is of the closed runner type—that is to say, it has wings *s* and *t*, between which and the central vane the water passes. I may use, however, a rotating part of the open runner type, as shown in Figs. 4 and 5, in which the side plates are eliminated and the rings of impeller-blades are attached directly to the arms.

For the purpose of preventing the water from being thrown out and condensing the steam before it passes through the impeller-blades the rings let into the casing which inclose the diverter-blades may be made to overlap the rings carrying the impeller-blades, this arrangement being shown in Fig. 5, and the inclosing rings being numbered 10. Moreover, I prefer to make the impeller-blades mounted upon the runner concaved, so that the steam coming in strikes the bottom thereof and is thrown out at an angle thereto, which angle is directed toward the discharge-chamber, whereby the tendency of the water and the steam is to flow outward into said discharge-chamber in the same direction, the speed of rotation of the runner not permitting the water to enter the impact-space.

In Fig. 7 is shown a side elevation of my combined steam-turbine and pump, which drives a Pelton wheel or other water-motor, which motor in turn supplies power for any desired purpose—such, for instance, as the shaft for a dynamo, to which in Fig. 7 the shaft of the water-motor is coupled. In practice it would not do to couple a dynamo-shaft directly to the axle of a turbine for several reasons. In the first place, very high speeds are necessary to obtain the highest efficiency from a steam-turbine. Fifty thousand revolutions a minute is not an excessive number. This is far in excess of any rate of speed at which the shafts of dynamos have up to the present time been driven. Commercial dynamos are never driven more than five thousand revolutions a minute, and the average is considerably less than this. It is evident, therefore, that it is impracticable merely from considerations of speed to couple the shaft of a dynamo directly to the shaft of my steam-turbine runner. Another reason is that I desire to make the steam-turbine small in size and cheap in construction, which could not be done if it were coupled directly to the shaft of a dynamo, for which purpose, among others, my improved apparatus has been designed. Moreover, dynamos have been driven commonly at much higher speed than other kinds of machinery, so that in the latter case the objection would be still greater. Another reason is that if the dynamo were coupled directly to the shaft of the runner a torsional strain would be set up in said shaft, which is one of the things I desire to avoid, since this strain would result in a tendency to destroy the balance of the turbine, deflecting the shaft and binding the gears, and making very carefully arranged and elaborate bearings necessary. Moreover, if such a torsional strain existed it would be exceedingly difficult, if not impossible, to cause the combined turbine and runner to float upon the liquid—a thing which is one of the especial objects of my invention and which results in special and very great advantages. In my construction the very lightest kind of turbine, compared with the amount of power obtained therefrom, can be used on account of its exceedingly high speed and because it practically does away with friction of both air, liquid, and metallic contact. Of course there is a slight amount of skin-friction of the liquid in the pump; but this is so small compared with the amount of friction in ordinary turbines that it is practically negligible. In my construction nearly all the strains are practically applied at the point of impact of the steam upon the impeller-blades and usually near the periphery, the result being that these strains are comparatively slight, are equally distributed without shock, and therefore do not interfere with the working of my apparatus. For these reasons I prefer to use a small steam-turbine, as described, to run that at a very high speed, and by means of the water discharged to run a Pelton wheel or some other suitable construction of water-motor at a much lower speed, from which motor the power for driving the dynamo or other machinery is directly obtained. By means hereinafter described the speed of the turbine itself and of the water-motor may be regulated as desired.

In Fig. 7, 47 represents a steam-turbine of the construction already described and shown, for example, in Fig. 1. 48 represents a Pelton wheel or other desired form of water-motor. The steam-turbine and wheel are connected by a pipe or waterway 49, which connects with the discharge-chamber of the steam-turbine and delivers the impelling fluid to the motor 48. To the shaft 50 of the water-motor is coupled the shaft of a dynamo 51. If desired, however, this shaft 50 could be used to run any form of machinery in any of the usual ways. The means for governing the rate of speed for the steam-turbine will now be described. In Fig. 7, 52 represents a steam-inlet pipe which delivers into a chamber 53, from which branch pipes 54 and 55 conduct the steam to the steam-turbine. A pipe 56 is connected with the discharge-chamber of the centrifugal pump and at its other end is connected with the casing 57, in which is a diaphragm or piston. This is connected to a valve in the chamber 53 and is so arranged that the varying pressure in the discharge-chamber of the pump actuates the diaphragm or piston and thereby the valve, admitting or cutting off the steam to the pipes 54 and 55 as desired. The variations may be adjusted as desired by a hand screw and spring, as common in pressure-regulators. Thus it will be seen that the pressure in the discharge-chamber of the combined turbine and pump automatically regulates the speed. Of course the water-moter 48 is liable to run at different speeds, according as the load is increased or diminished. This is regulated in the usual way by means of the valves 58 and 59, which control the fluid-jets which drive the water-motor, which is preferably made with double sets of buckets in the usual way. The speed of the water-wheel can be regulated by any usual form of governor, such as a centrifugal governor. If the speed is increased above a certain limit, the amount of water passing through the jets is automatically diminished by this governor. This results in a greater pressure in the pipe or waterway 49, which in turn increases the pressure in the discharge-chamber of the combined steam-turbine and pump, which, by the means already described, acts to cut off part of the supply of steam to said turbine, thereby reducing the speed. This regulating action is practically instantaneous, and this establishes a positive and extremely close speed regulation, dependent simply upon the speed to which the water-motor 48 is set.

In Fig. 8 another modification of my apparatus is shown, in which the condensation is effected by some other liquid than that which is discharged into the chamber *n*. In pumping beer, for example, it would not be desirable to have the steam condensed by the outflowing stream of beer, since this would dilute the beer too much. In Fig. 8, therefore, the condensation is effected by separate means. The apparatus shown in this figure is practically the same as shown in Fig. 1, with the exceptions hereinafter mentioned. 60 and 61 represent the steam-inlet pipes, and 62 and 63 represent the inlet-pipes for the water which is used to condense the steam used as a motive power. These inlet-pipes deliver into circular chambers 64 and 65. Outside of the rings *s t* and mounted on the runner are other wings 66 and 67, nearly parallel to the wings 62, but separated therefrom by passages. The wings 66 and 67 are of considerable less width than the rings *s t*, whereby open spaces 69 and 70 are formed. Orifices 71 and 72 connect the chambers 64 and 65 with these open spaces 69 and 70. In this modification the rings of the impeller-blades are mounted on the wings 66 and 67 instead of upon the rings *s t*. 73 and 74 represent outlet-pipes for the water after it has been used to condense the steam. These water-pipes connect with circular chambers 75 and 76, cut out of the casing, there being a free passage between the rings *s t* and the wings 66 and 67 into these chambers 75 and 76 for the water used for condensing purposes and there being other passages from the spaces 78 and 79 just inside of the rings of impeller-blades for the passage of steam into the chambers 75 and 76. The water coming in through the pipes 62 and 63 may be under considerable pressure, if desired. The result of this arrangement is that the steam is condensed and carried with the water through the pipes 73 and 74 without being mingled with the beer or other liquid which is forced into the the discharge-chamber *n*.

In Fig. 9 is shown a steam-turbine, a centrifugal pump, a water-motor, and an electric generator, all in one unitary structure, Fig. 10 showing details thereof. 80 represents a centrifugal pump of the closed-runner type, similar to that shown in Fig. 1, provided with curved impeller-arms, side wings, and rings of impeller-blades mounted thereon. The casing of all these structures may be divided into either vertical or horizontal sections. 81 represents the upper part of the stationary casing, which is cored out, leaving plates 82 83, with a passage 84 therebetween. This fits upon another stationary part 86, being united thereto by bolts 85. The part 86 is cored out, leaving passages 87, 88, and 89, the passage 88 being the water-inlet and the passages 84, 87, and 89 being the water-outlets. The part 86 rests upon the stationary base 90, being united therewith by bolts 91, which base is also cored out to form passages, which are continuations of the passages 87, 88, and 89. Steam is admitted through a pipe 92 (shown in dotted lines) and through a passage cut in the casing 81 into an annular space 93, cut out in the casing 81, from whence it passes from between the diverter-blades 94 and against the impeller-blades 95, causing the pump-runner to revolve, as already described. These blades may be compounded or used in multiple, if desired, thereby utilizing the principles of impact, reaction, expansion, or any combination whereof, and the water-motor hereinafter described may also be compounded or used in multiple, if desired. Secured adjustably to the base 90, by means of bolts 96, is a metal ring 97, which supports the field-coils of an electric generator. In this case a generator of direct current is used; but I may of course use a generator of alternating currents, if desired. The coils 98 are supported on cores 99, united to the ring 97 by bolts 100. Secured by bolts 101 to the ring 97 are one or more bracket-arms 102, in which is supported a sliding brush-supporting ring 103, which may be fastened in said brackets in any desired position by screws 104. Brushes 105 are carried in brush-holders 106, supported by the ring 103, and may be adjusted in a circle around the commutator as desired. The commutator 107 is of the usual type and mounted on the shell or casing 108, which supports the armature-coils 109, made in the usual way. These coils of course revolve in close proximity to the field-coils, but do not touch them. The shell or casing 108 is supported on antifriction-rollers 110, preferably mounted in spacing-rings in the usual manner to form a cage. These antifriction-rollers are supported on a ring 111, preferably made of hardened steel annular in its general form, but thickest at the bottom, as shown in Fig. 10, this ring 111 being mounted on the stationary casing 81 86. The ring 111 is, in fact, an eccentric bearing-ring, and by means of a screw-bolt 112 and hand-wheel 113 this ring may be adjusted around the periphery of the casing 81 86, thereby adjusting the armature structure in relation to the field-coils and pump-runner. The object of this adjustment is to vary the reaction-pressure from the buckets 116 upon the pump-runner 80, so that when running this pump-runner will be automatically balanced, the line 117 being eccentric to the central vane of the pump-runner 80, as already described in connection with Fig. 4. After this adjustment is made the frame supporting the field-coils is adjusted so that these coils will be concentric with the armature-coils in the usual manner by means of the adjusting-screws 96, for example, commonly used in alining engine-type generators. The armature structure is driven by means of buckets secured on the interior thereof, against which the liquid discharged by the pump-runner directly impinges. On the interior of the movable casing 108 is a ring 114, cut away on each side, as shown at 115, for the reception of the part 82 of the stationary casing. On the inside of this ring 114 are mounted buckets arranged in a double series, so as to split up the current of water thrown against the same after its energy has been utilized and to divert it on either side into the discharge-passages. These buckets 116 are concaved and also curved reversely to each other, as shown in Fig. 9, coming to a line 117 in the center, which line is outside of the central vane of the runner and in the same plane. The admission of the water to the water-wheel may be controlled in any desired way—for example, by means similar to that shown in Fig. 7 or any of the common ways of controlling volume and angle of impact of the stream of water. Moreover, I do not restrict myself in any way to the exact details of construction. The pump-runner, for example, may be of the open type instead of the closed type. It may be simple, compound, or multiplex. The means for driving the runner by means of steam may also be simple, compound, or multiplex. The particular shape and arrangement of the buckets against which the water is thrown by the centrifugal pump may also be varied. Instead of a direct-current generator an alternating-current generator may be used, and, in fact, all the details may be varied greatly, the central idea of this form of the invention being the making of a steam-turbine, a pump, and motor driven by said pump, and an electric generator all in one unitary structure. Moreover, this apparatus can be used directly as an engine, all that is necessary to do being to take off the field-coils, commutators, &c., making the casing 108 a pulley instead of having it carry the armature-coils. Power can also be taken from a shaft torsionally by a slight modification.

In Fig. 9 I have shown a very small turbine-wheel and pump-runner combined which I desire to run at very high speeds. It is not feasible or desirable that the casing carrying the armature-coils should be run at the same high speed, and by a proper proportioning of the parts this will not be the case. It will be understood that the speed of the turbine-wheel and pump-runner may be anywhere from ten to one hundred times as fast as the speed at which the armature is driven, thus illustrating one of the important points of this invention, the flexibility of the transmitting medium rendering it possible to use very small amounts of water moved at a very high speed and pressure to obtain large amounts of power. As already described in connection with Fig. 7, the speed to which the armature is set in the beginning may be used to govern the speed of the whole apparatus.

In Figs. 11 and 12 I have shown still another modification of my apparatus in which a vertical pump is used—that is to say, a pump whose runner runs in a horizontal plane and whose axle, if one were used, would be in a vertical plane. This modification, like all vertical centrifugal pumps, may, if desired, be submerged when in use, thereby obviating the necessity of priming the pump. If, however, this modification were used in connection with a suction-pump, priming would be necessary before starting the pump, as is usual. 118 represents the casing, which may be made either in the form of a shell or in sections, if desired. In one part of the casing a steamway 119 is cored out, connecting with a steam-pipe at any desired point. This delivers into a circular passage 120, which passage is connected by ports 121 with the diverter-blades. The regulation of the speed may be accomplished by variations in the pressure affecting the amount of steam conducted, as already described in connection with Fig. 7. After passing through the parts 121 the steam impinges upon the diverter-blades 122, which are curved in opposite directions. These blades may be made in one piece or separate, as desired, and by means of said blades the steam is divided into two columns or continuous jets, which jets pass between the impeller-blades 123 and 124, secured on either side of the diverter-blades 122, said impeller-blades being mounted on the central vane 125 of the pump-runner. These blades are shown as exposed to the moving column of water on their outer edges after impact, as described in connection with the open type of runner, (see Fig. 5,) or, if desired, they may be housed, as in the closed type of runner. (Shown in Fig. 1.) On the sides of the central vane 125 in the runner is located an inlet-passage 126 and an outlet-passage 127, which passages are joined together by a continuous open space 128, extending around the central portion of the pump-runner. In these passages 126 and

127 are located reversely-covered arms, as shown in Fig. 12, the arms in the passage 126 serving to draw the liquid toward the center centripetally and the arms in the passage 127 serving to throw the same out from the center centrifugally. The top of the pump-runner is curved upward, as shown at 129, approximately in the form of a cone, and this top is provided with curved arms, which aid in drawing the liquid up through the discharge-passage 130, 131 representing the inlet, which is a continuous orifice with the exception of the arms 132 and 133, which are supported on the base-plate 134. The lower central portion of the pump-runner is cut away, as shown at 135, and outside of this cut-away portion is an enlargement or boss 136, located in a correspondingly-shaped depression 137 in the base, whereby a bearing for the pump-runner is formed. Connecting with the depression 137 is a waterway 138, (or a separate pipe may be used, if desired,) which waterway or pipe is connected with the discharge chamber or passage 130, the result being that after the runner is set in motion water is forced through the pipe or way 138 into the depression 137 and around the boss 136, after which the water passes out between one side of the pump-runner and the base. This arrangement furnishes a convenient and effective water bearing for the combined pump-runner and turbine-wheel, whereby said combined structure is supported on fluid during its rotation, any tendency to wabble or oscillate being corrected by the balanced columns of water and steam which act upon the combined turbine-wheel and pump-runner. Moreover, the outflowing current between the lower side of the pump-runner and the base will tend to steady the pump-runner in its rotation, requiring very little initial pressure on account of the large area exposed to overcome any downward thrust when the pump is working under high pressure. It is obvious that if I desire to force the water to any considerable height this may be accomplished by using in connection with a single discharge-pipe a number of these pumps located one above the other with a continuous steam-supply for all of said pumps, each one of which can be regulated independently of the others by the means already described in connection with Fig. 7. If the pump is to be used submerged, the inlet pipes or ways for the steam are made double to avoid condensation, there being an air-space between the pipes or a suitable non-conducting material being placed between said pipes.

While I have shown in Figs. 11 and 12 a combined centrifugal and centripetal pump, it is obvious that I could use a centrifugal pump alone, a centripetal pump alone, or any combination thereof, and, further, that the water inlets and outlets may be placed in any desired position within or without the casing.

In cases where it is desirable the steam-turbine may be mounted separately from the pump-runner—for example, where the pump-runner is submerged—and yet furnish a stream of water whereby the pump itself may be driven, as already illustrated in connection with the water-motor, as shown in Fig. 7, which water is conveyed by impact to the pump-runner itself.

In several of the modifications the casing is shown as stationary and the runner rotatable therein. It is obvious that this arrangement could be reversed and that the casing could be made rotatable and the inner part stationary.

In Fig. 9 I have shown a water-motor directly coupled to the shaft of a dynamo. It is obvious that this shaft could be used in various other relations to transmit power. In some instances it is desirable to reverse the motion of the shaft, as in marine work. This reversal may be quickly and easily effected in the following manner: The water-motor may be provided with two sets of buckets curved in opposite directions and with separate sets of corresponding jet-nozzles. A balanced valve located in the main water-supply pipe leading from the pump to the water-motor is provided in connection with said oppositely-arranged jet-nozzles. By simply moving this valve the water-jets are directed to one or the other set of reversibly-arranged buckets, depending on the direction of rotation of the motor-shaft. This reversal acts as a brake on the water-motor, quickly stopping it and then reversing it, all without interrupting the motion of the steam-turbine wheel or interfering with its control, which depends, as stated before, on the pressure in the discharge-chamber of the pump. Moreover, by moving this valve so that it will direct jets of varying and unequal power upon the oppositely-arranged sets of buckets the speed and direction of rotation of the motor-shaft may be exactly and almost instantaneously regulated. This valve may of course be operated either pneumatically, hydraulically, electrically, or by any desired mechanical devices from a distant point. For example, the valve in the engine-room of a ship may be directly operated from the pilot-house thereof. This is an important feature, inasmuch as the reversal of the operating-shaft does not necessitate the slowing down, stopping, and starting again of the prime mover, as is the case with all motive devices known to me. Moreover, the prime mover is maintained at all times in its highest state of efficiency and readiness to transmit its energy in my invention.

My invention is especially designed to reduce to a minimum the weight, space, cost, and vibration of the device and at the same time to increase its simplicity and durability and economy in the use of fuel. In marine work it furnishes a central power-station for all uses to which power is applied on board ship.

In Fig. 13 is shown a cross-section of a combined centrifugal and centripetal pump and steam-turbine. In this figure, 139 represents the casing provided with a water-inlet 140, which is divided into two branches 141 and 142, which deliver to opposite sides of the pump-runner. 143 represents the discharge passage or chamber, preferably in the form of a volute largest at the bottom. I have shown the water-inlet pipes as coming from below and the discharge-passage at the bottom. It is obvious, however, that these passages may be located in any desired position. The upper part of the volute is provided with a passage into which is fitted a steam-ejector pipe used for priming the pump in the usual way, as has already been described in connection with the other modifications. The pump-runner itself is provided with a central vane 144, made in the form of a circular cone. This is mounted upon a central part 145, which part is provided with extensions 146 and 147, in which the supporting-shafts are mounted. These extensions are cut away, as shown at 148 and 149, for the reception of the hollow shafts, which are confined therein by nuts 150 and 151. The supporting-shafts 152 and 153 are hollow and provided with enlargements 154 and 155 at their inner ends. The passages 156 and 157 in said shafts are turned upward and inward at their inner ends, as shown at 158 and 159, for the purpose of discharging streams of water upwardly and inwardly against the pump-runner to sustain the weight and overcome any lateral thrust thereof. These shafts pass through bearings 160 and 161, located in extensions in the casing, and into boxes 162 and 163, which are provided with removable heads 164 and 165, secured to said boxes by bolts 166 and 167. Lock-nuts 168 and 169 engage these shafts, and bolts 170 and 171 secure these lock-nuts in position. The outer ends of the shafts are squared, as shown at 172 and 173, for the purpose of receiving the head of a wrench, whereby said shafts may be adujsted in order to perfectly balance the pump-runner. 174 and 175 represent pipes connected with the discharge-passage 143 or with any source of water under pressure for the purpose of providing water bearings for the pump-runner. 176 and 177 are valves located in these pipes for controlling the pressure and volume of the water therein. 178 and 179 represent inlet-pipes for the steam, which passes between diverter-blades 180 and 181 and thence into the impeller-blades 182 and 183, which are mounted on the pump-runner. I have shown one ring of impeller-blades and one ring of diverter-blades on each side of the central vane; but it is obvious that more may be used, the diverter-blades being secured upon the casing and the impeller-blades upon the pump-runner, whereby I am enabled to utilize the principles of impact, reaction, and expansion. Indeed, the whole apparatus may be used either simple, compound, or multiplex, as desired. The pump-runner itself is provided with wings 184 and 185, approximately parallel to the central vane 143. Between these wings and the central vane are curved impeller-vanes 186 and 187, so arranged as to drive the liquid out into the discharge-passage 143. Another set of curved arms 188 and 189 are mounted on the outer sides of the runner. These arms are curved in the opposite direction from the arms 186 and 187 and serve to draw in the liquid centripetally and deliver it into the pump-runner near the center, from whence it is discharged centrifugally. These arms of course do not extend up to the central portion of the runner, as it is necessary to leave a passage there for the influx of the water. Moreover, the runner itself is cut away from the center, as shown at 190 and 191, to afford a free passage for the water or other liquid. By this construction I am enabled to run the apparatus at a very high speed without using a separate pump to feed the centrifugal part of the runner, as is common in apparatus of this type, the vacuum being established and maintained at all times. Between the wings 184 and 185 and the casing are passages 192 and 193, which connect with the discharge-passage 143 by narrower passages 194 and 195, the result being that the liquid thrown out by the centrifugal action of the pump-runner draws with it the steam after it has passed through the impeller-blades into the discharge-passage 143, where said steam is condensed, the apparatus thus acting as a most efficient self-condenser. Moreover, any air that there may be in the apparatus or that is brought in along with the steam is also drawn out and discharged in the same way. This form of the apparatus, like the other forms, is self-balancing, owing to the reason that it is built symmetrically and that the moving columns of liquid and gas impinge upon its opposite sides with equal pressure, thereby insuring a perfect balance. To aid in this action, especially if on account of the defects of the material the plane of gravity should not exactly coincide with the plane of rotation or for other reasons, the central vane 144 is made large enough so as to extend some distance into the discharge-passage 143. Any tendency to wabble or oscillate will be automatically corrected by reasons of the variations in liquid-pressure which would be caused by the oscillation of this vane. To still further aid in and insure this automatic balancing action in reference to the weight or running thrust of the runner itself, a ring 196 is mounted on the outer rim of the vane 144. This ring is provided with two oppositely-arranged curved faces 197 and 198, whereby by means of the central vane and the ring attached thereto the liquid thrown out by centrifugal action into the discharge-passage 143 is divided temporarily into two moving columns or streams. Any tendency of the runner to vary from its proper position of rotation—by settling, for example—will result in diminishing the area of the water-passage and will immediately diminish the pressure at that point and increase the pressure at the opposite side of the runner, whereby this tendency will be automatically corrected. This results from the fact that the stream of water is divided into four different moving streams or columns, two on each side of the central vane, through the different inlets and outlets common to each set. This ring 196 may, however, be separated from said central vane, although located in proximity thereto, and in Fig. 14 I have shown means for supporting and adjusting it. 199 represents a rod passing through the casing and provided with a hand-wheel 200. This rod is secured in position by lock-nuts 201. As many of these rods as desired may be used; but I prefer to use at least three, preferably spaced at equal distances apart, two below the center of the casing and one above it. It may also, if desired, be supported eccentrically upon lugs arranged in the volute passage 143. This ring 196 may be adjusted so that it will be eccentric to the central vane 144, preferably nearest to said vane at the bottom, the result being that the pressure of the discharged liquid being greatest at the bottom reacts against the runner, thereby overcoming its weight and the thrust due to its rotation. It can be determined whether the runner is running in its proper position by the means described in connection with the runner shown in Fig. 5 or in any other convenient way—for example, by having ports fitted with glass covers cut in the casing at suitable points.

While I have thus described my invention, I wish it to be distinctly understood that I do not limit myself in the slightest degree to the details of construction shown and described. The motive fluid, for instance, may be gas, air, water, or other liquid or any combination thereof. The apparatus may also be used as a condensing or non-condensing apparatus, although I prefer to use it as a self-condenser. The main point of my invention is the production of a combined runner and impeller in a single structure, which structure is capable of running freely without contact with the casing and without any support except fluid support, noiselessly and without vibration or wear, and with practically no friction. Moreover, in this way I am enabled to get the highest possible speeds and efficiencies with a minimum of cost, weight, and space occupied by the apparatus.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The combination of a steam-turbine and a centrifugal pump, the steam-turbine wheel and pump-runner being made in a single unitary structure and including pump-vanes and turbine-vanes located symmetrically with respect to a central plane, said combined structure being provided with steam-vanes and pump-vanes on each side of said central plane, whereby a perfect balance is maintained.

2. The combination of a casing, a steam-turbine, and a centrifugal pump, said casing being provided with steam and water inlets and outlets, the steam-turbine wheel and pump-runner being made in a single unitary structure, said structure being provided on each side of a central plane with curved pump-vanes, and a ring of steam-vanes located outside of said pump-vanes, whereby a perfect balance is maintained.

3. In a steam-turbine, a movable part or runner, composed of a central portion, curved arms, wings substantially parallel thereto and rings of vanes attached thereto on either side.

4. In a steam-turbine, the combination of a steam-turbine wheel and runner, made in a single unitary structure, and a casing surrounding the same, passages being left between said structure and said casing, whereby the water discharged by the runner exhausts the steam and condenses it and also entrains any air within the casing along with it.

5. In a steam-turbine, a rotating part or runner, consisting of a double-coned central portion, a double-coned vane secured thereto, curved arms, wings substantially parallel to said arms, and rings of vanes or blades secured on the outer side of each of said wings.

6. The combination of a casing, having rings of blades or vanes, steam-inlets therefor, a combined steam-turbine wheel and centrifugal pump-runner, supported within said casing and made in one unitary structure, said structure being adapted to rotate freely in said casing without touching it and circular guide-plates secured to said casing and extending close to the inner edges of the wings of said structure, but not touching them.

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

ROSCOE S. PRINDLE.

Witnesses:

CLARENCE A. BATEMAN,
GUSTAVE R. THOMPSON.