No. 858,599. PATENTED JULY 2, 1907.

S. T. HOLLY.

STEAM TURBINE.

APPLICATION FILED SEPT. 13, 1904. RENEWED FEB. 21, 1907.

4 SHEETS—SHEET 1.

Fig. 1

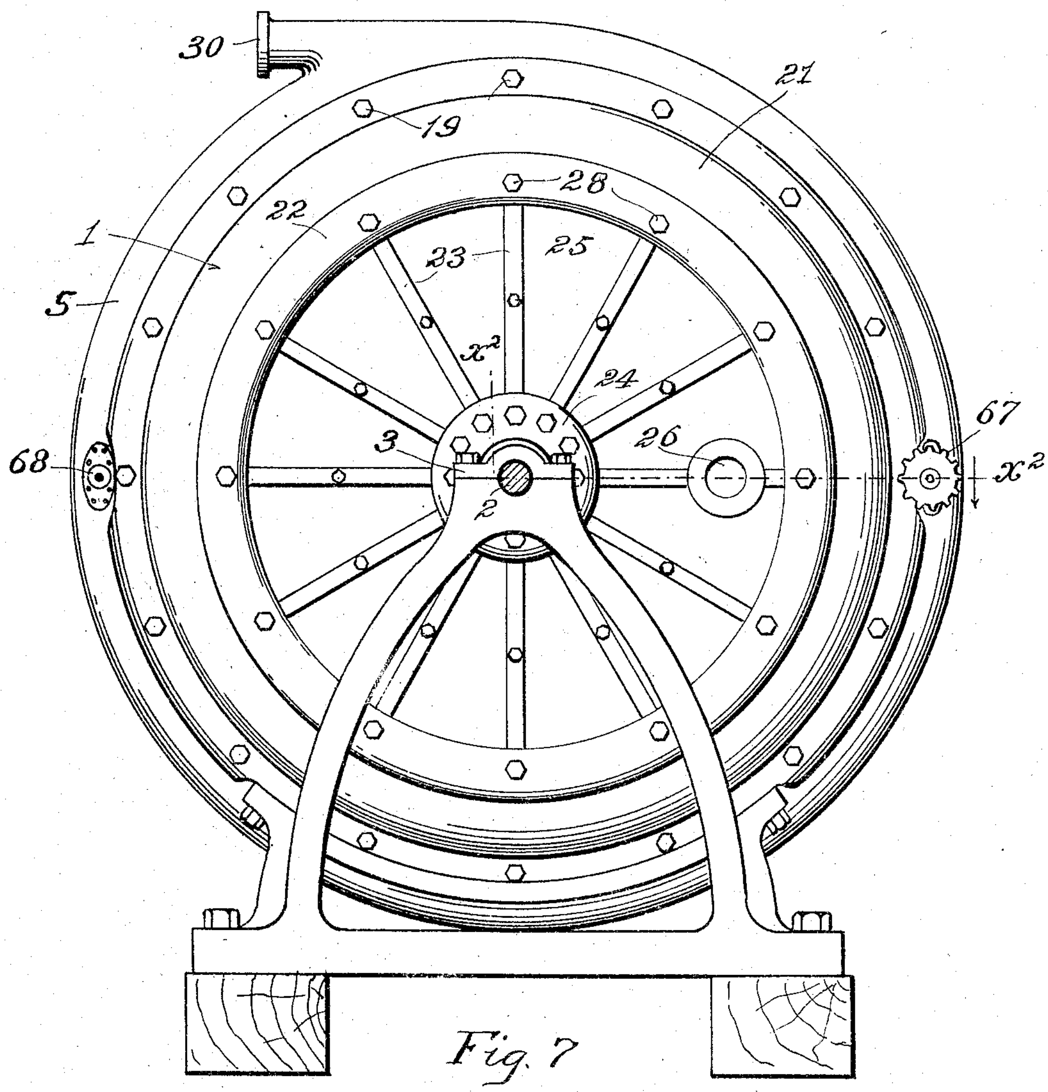
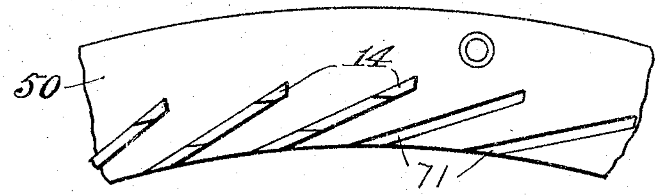


Fig. 7



Witnesses:

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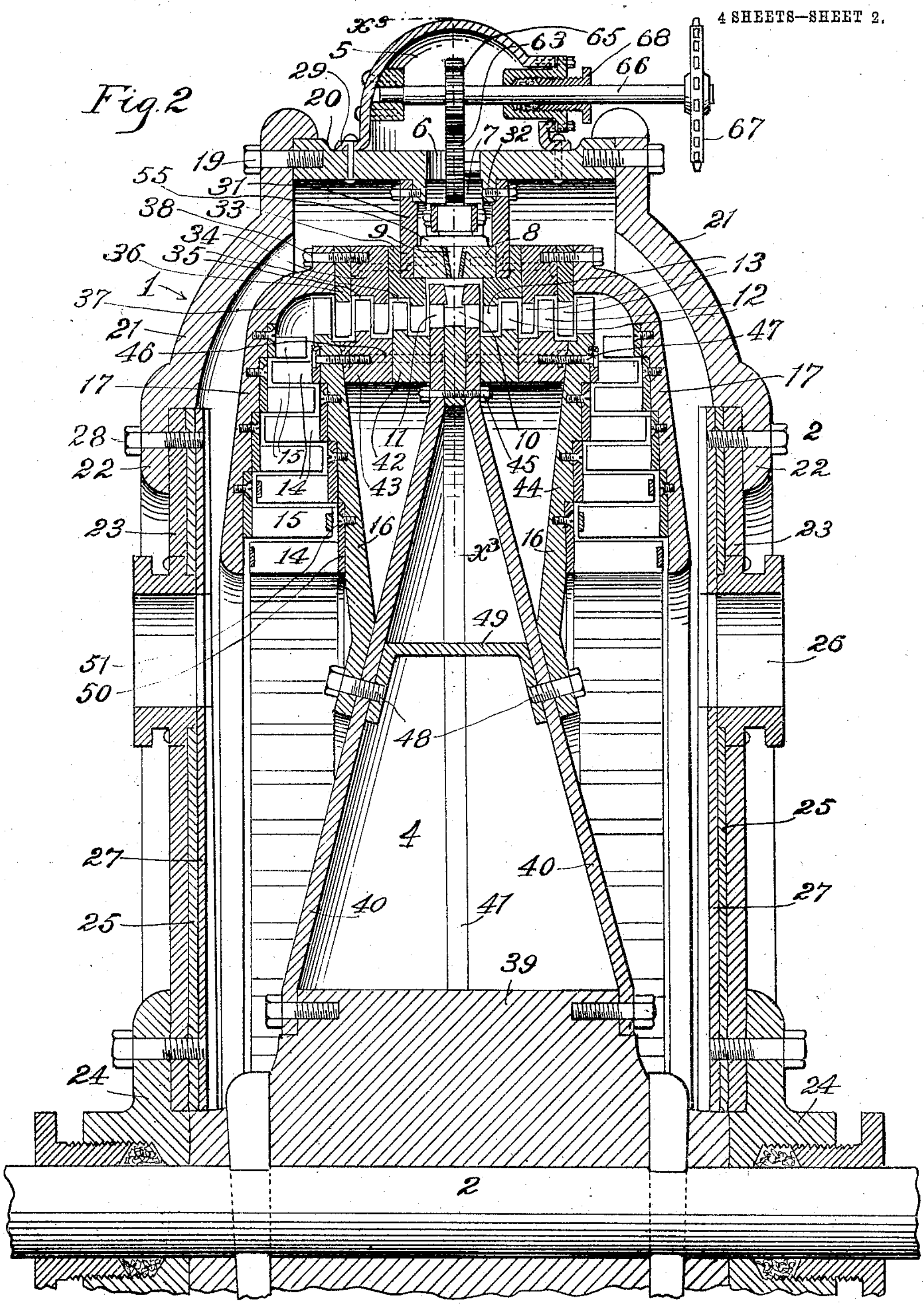
4 SHEETS—SHEET 2.

Fig. 2



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4 SHEETS—SHEET 3.

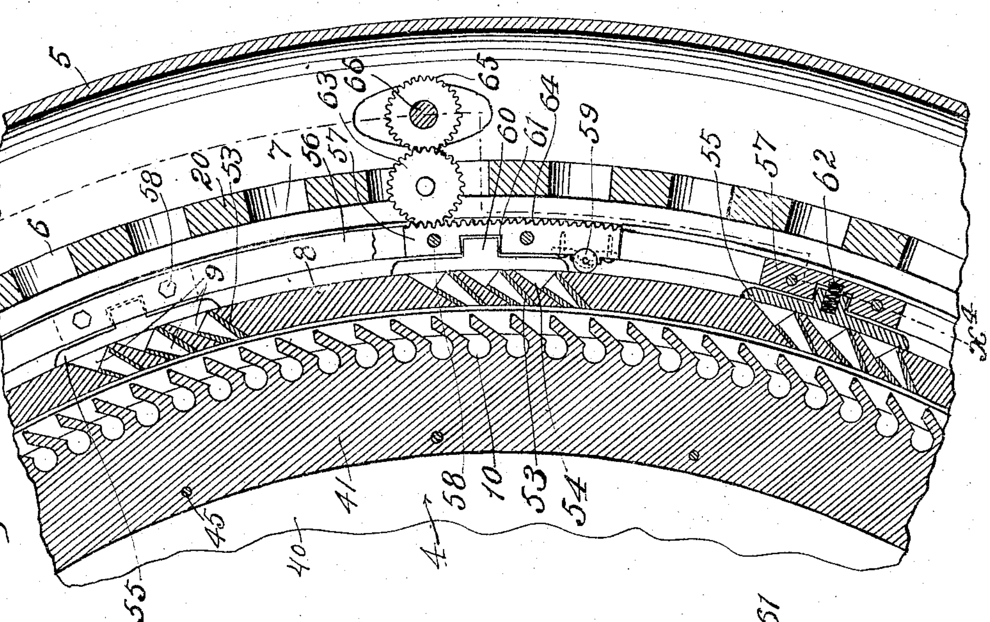

Fig. 3.

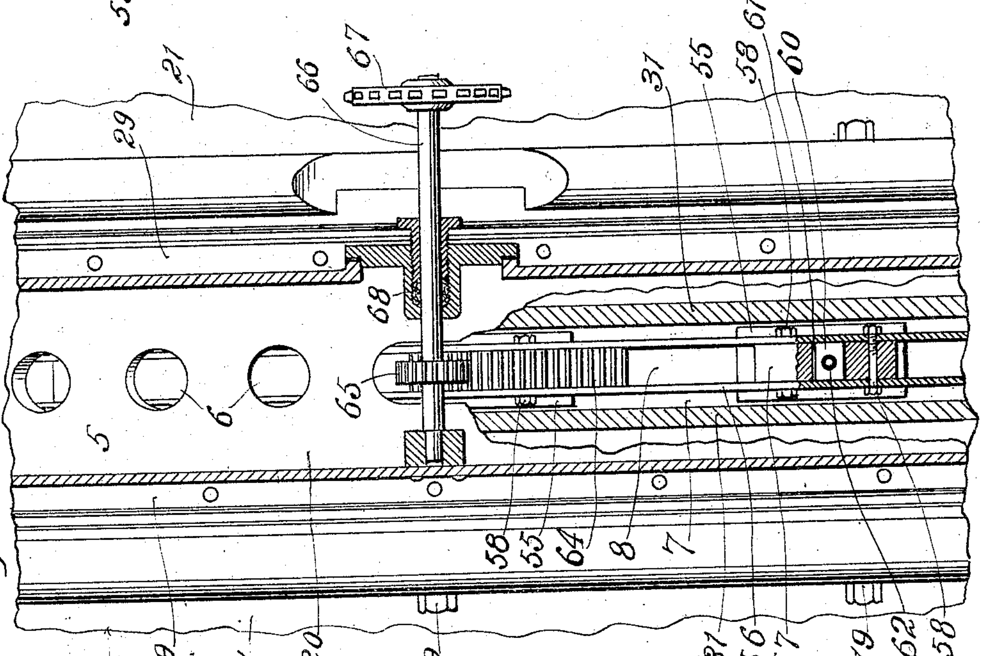

Fig. 4.

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4 SHEETS—SHEET 4.

Fig. 5

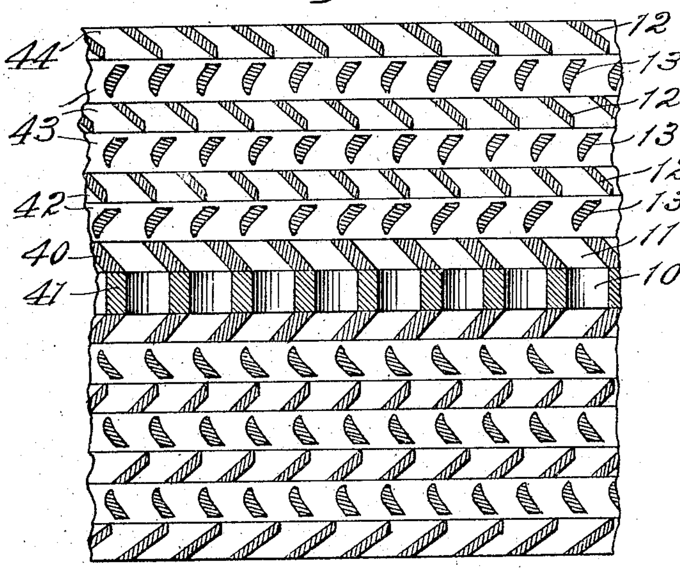
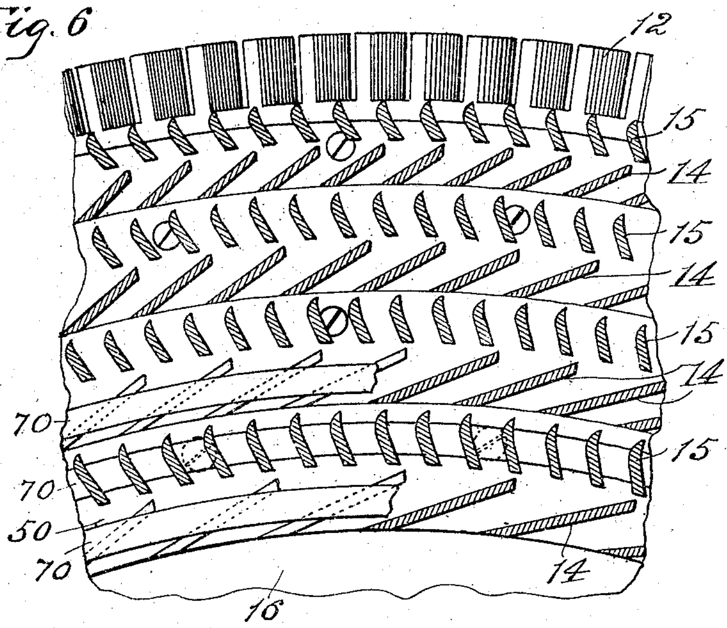


Fig. 6



Witnesses:
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UNITED STATES PATENT OFFICE.

SOLOMON TOWNSEND HOLLY, OF LOS ANGELES, CALIFORNIA, ASSIGNOR OF ONE-FOURTH TO LUTHER M. MARSTON, ONE-FOURTH TO ANNA MAY MARSTON, AND ONE-FOURTH TO CARRIE C. HOLLY, ALL OF LOS ANGELES, CALIFORNIA.

STEAM-TURBINE.

No. 858,599. **Specification of Letters Patent.** **Patented July 2, 1907.**

Application filed September 13, 1904. Renewed February 21, 1907. Serial No. 358,723.

To all whom it may concern:

Be it known that I, SOLOMON TOWNSEND HOLLY, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles and State of California, have invented a new and useful Improvement in Steam-Turbines, of which the following is a specification.

This invention relates to the general class of turbines illustrated in my application Serial Number 166,966, filed July 25, 1903, wherein the expansive fluid is first directed upon a turbine wheel at the periphery thereof and midway between the ends, and is then caused to flow each way from the middle plane of the wheel and to successively impinge upon the wheel in such manner as to give a compounding effect.

An important object of the present invention is to utilize as far as possible all of the energy contained in the expansive fluid. In doing this I prefer to operate in such manner that at or before its first impact against the turbine wheel the fluid will be allowed to attain to substantially the full velocity due to its initial pressure so that the power and energy developed by this first impact is brought to a maximum thereby producing conditions for highest efficiency inasmuch as there are substantially no losses due to friction, etc., preliminary to this first impact. It is not, however, possible in turbines of practicable size and speed to utilize all of the power or energy of the expansive fluid, such as steam at the initial pressures required in practice, and it is therefore necessary to provide means for utilizing the energy remaining in the expansive fluid after this first impact.

In the form of turbine here contemplated this energy will be mostly in the form of *vis viva*,—in other words the available residual energy in the fluid will be due to its velocity rather than to its pressure. It is apparent, that at each successive impact the velocity of the fluid will, according to the above principle of operation, be diminished, and the important object of my invention is to so construct the directing and impact-receiving surfaces of the turbine as to allow for this progressive decrease in velocity and render the fluid equally available for driving the turbine notwithstanding its diminished velocity. This I obtain in part by causing the expansive fluid to pass successively from portions of the turbine of greater diameter to portions of less diameter so that the speed of the impact-receiving portions is diminished progressively, it being, of course, necessary that the impact-receiving surface should travel slower than the impinging fluid in order that there shall be any propelling effect. In practice, however, this difference in speed will not be sufficient for most purposes, and it is necessary to further compensate for the decreasing speed of the fluid by arranging the impact-receiving surfaces in such manner that as the speed of the fluid is diminished the surface will be presented thereto in a direction to render the reduced velocity thereof fully available. This I obtain by progressively decreasing the angle of the impact-receiving blades relatively to their direction of movement.

This invention further relates to improvements on the valve mechanism of the class shown in my application above referred to wherein a ring valve member controls simultaneously a series of ports circumferentially arranged around the turbine wheel, the object of the present invention in this connection being to facilitate the operation of the valve, especially in machines of large diameter.

This invention also relates to structural features particularly designed for use in machines of large size and of great power.

The accompanying drawings illustrate the invention.

Figure 1 is a side elevation of the turbine. Fig. 2 is a horizontal section on the line x^2—x^2 in Fig. 1. Fig. 3 is a vertical section on line x^3—x^3, in Fig. 2. Fig. 4 is a fragmentary section on line x^4—x^4 in Fig. 3. Figs. 5 and 6 are respectively plan and side views of a section of the impact-receiving and directing members of the turbine. Fig. 7 is a fragmentary view of part of one of the vane-carrying rings.

The machine comprises a casing or frame member 1, a shaft 2 extending axially through said casing and mounted on suitable journals indicated at 3, and a turbine-wheel or rotary member 4 mounted on said shaft. A steam-chest or distributing trunk 5 extends around the casing 1 and communicates through openings 6 with an annular valve chamber 7 formed interiorly of the casing and closed on its inner face by a ring or wall 8 having valve ports 9.

The turbine wheel 4 has a central series of buckets 10 arranged in the same plane as ports 9 and adapted to receive the steam therefrom. These buckets extend inwardly and forwardly in the direction of the rotation of the wheel and communicates at each side with outlets 11 extending rearwardly at an angle to the direction of the rotation so as to discharge the steam in a backward direction. A plurality of series of vanes 12 are secured on the turbine wheel at each side of the outlets 11, and a corresponding plurality of directing blades 13 are secured in fixed position adjacent to said series of vanes on the turbine, one series of blades 13 being adjacent to the outlet 11 to receive the steam therefrom, and directing the steam against the first series of vanes 12 and the succeeding series of blades 13 receiving the steam from each preceding series of rotating vanes and directing it against the next succeeding series of rotating vanes. To further increase the compounding action thus obtained a similar series of moving and fixed vanes 14 and blades 15 are secured respectively to the two faces or ends 16 of the turbine and to fixed supports 17.

In order to provide for the continual expansion or increase in volume of the steam the length of the moving and fixed vanes are progressively increased. A special feature of the present invention, however, as regards the vanes, is that the angle of said vanes relatively, to the direction of movement, is progressively varied, each series of vanes making a more acute angle with the direction of the movement than the preceding series of vanes, as shown in Figs. 5 and 6. I prefer to make the moving vanes 12 and 14 flat or straight so that all portions thereof will present the most favorable angle to the impinging fluid. I also prefer to arrange the directing blades 13 and 15 in such manner that they will direct the fluid substantially perpendicular to the movable vanes, and in order that said directing blades shall receive and deflect the steam in the most efficient manner from the preceding series of moving vanes, it is desirable to curve them somewhat, as shown.

The above described principles may be carried out in various forms of apparatus, the construction shown in the drawings being especially adapted to turbines of large size. In this construction the casing or frame 1 is formed as two side members or shelves 21 and interposed ring 20, said side members being clamped to said ring by screw 19. The side members 1 are desirably formed as of dished rings and are provided at their inner edges with shouldered flanges 22. upon which are clamped arms 23 forming a spider or frame on each side of the machine, a gasket 24 being supported centrally in said spider to receive the shaft 2. The web or disk 25 may be attached to said arms 23 to close the casing at each side and one of the arms 23 may be formed with an outlet or exhaust opening 26. 27 indicates arms located opposite the arms 23 on the inside of the plate 25, the arms 23—27 forming conjointly a spider frame between which the plate 25 is clamped and the same screws 28 serving to fasten all these parts to one another and to the side member 21 and the gasket member 24.

The steam distributing trunk 25 is desirably formed as a hollow annulus, semi-circular in cross section and having flanges 29 at each edge whereby it is bolted or riveted to the main ring 20 of the frame. Said annulus is formed with a steam inlet 30. Two rings 31 screwed or bolted to flanges 32 projecting inwardly from the ring 20, form the side walls of the valve chest 7 aforesaid, and embrace between them another ring forming the inner wall 8 of the valve chest.

On the outer side of each ring 31 is secured a ring 33 which is shouldered to engage and extend within the rings 31 and the ring 8, leaving between the rings 33 an annular space for the reception of the central part of the turbine wheel, hereinafter described. These rings 33 carry the first or innermost series of deflecting blades 13. On the outer side of rings 33 are secured similar rings 33 carrying the next series of blades 13, each of said rings 33—34 being provided with annular channels 35 for the reception of the rotating vanes 12 of the piston. On the outer side of the rings 34 are secured flat rings 36 carrying the outermost series of blades 13, and to the outer rings 36 are secured two side members or inwardly projecting webs 37, which carry a plurality of series of vanes 15.

Each of the members 33—34—35— and 37 are secured by screws 38 or other suitable means to the members next within the same, so that the machine may be taken apart from either side, one member after the other being removed, and giving access to the one next below; and the whole series of said blades carrying members is supported by the inwardly projecting rings 31 from the main frame ring 20.

The turbine wheel 4 is carried by a suitable hub 39 on an axle 2 and comprises two webs or plates 40, secured by screws to said hub at their outer edges and dishing or inclining inwardly toward another at their peripheral portions, which are sufficiently close to one another to embrace between them the central ring 41 wherein are formed the central series of buckets 10 aforesaid. The inclined lateral outlets of said buckets are formed in said peripheral portions of the plates 40, and these portions together with the ring 41 form the central part of the piston which works within the central channel formed between the fixed rings 33 aforesaid.

On the outside of each peripheral portion of plates 40 is secured a ring 42 and on the outside of that a ring 43, the side members 44 of the turbine wheel on each side being secured to the outer ring 43, and carrying the vanes 14 aforesaid.

Plates 40 of the turbine wheel are secured to central ring 41 by bolts 45 and the rings 42—43 are secured to plates 40 by screws 46. The outer members 44 are secured by screws 47 to the ring 43, and by screws 48 to plates 40. Braces 49 may extend across between the plates 40 and be secured thereto by the screws 48.

The movable vanes 14 and the fixed blades 15 may be detachably supported on the members 44 and 17, as by forming them as projections on rings 50, secured by screws 51 to the said member.

The turbine wheel constructed as described can be taken apart from either side, similarly to the supporting frame. Valve means are arranged within the valve chest 7 to progressively close the ports 9 to regulate the operation of the engine. These ports are desirably arranged in groups as shown in Fig. 3, each group comprising a plurality of ports. The ports are each desirably formed with a taper from the valve chest to the discharge port or outlet end of the port, and each port may be provided with a thimble 53 having a bore tapering as described, and said thimbles tapering on the outside to fit in correspondingly formed sockets 54 in the valve chest ring 8.

The valve means may comprise a plurality of sliding valves 55 which slide on and around the ring or wall 8 to close or open the respective ports 9, each group of ports having a valve 55 of sufficient length to cover all of the ports of that group simultaneously. These valves are operated by annular operating means which extends around the entire machine and is connected to all of the valves 55 in such a manner as to cause reciprocation of the said valves on their seats, but not to interfere with the free movement of the valve towards its seat under the action of the steam pressure or otherwise. Said annular channel means may consist of two rings 56 with interposed blocks or spacers 57 arranged at intervals, screws or bolts 58 securing said rings and blocks together as a rigid whole. In order to relieve the friction and prevent binding or distortion of the parts, rollers 59 may be arranged around the ring at suitable points, these rollers being journaled in certain of the blocks 57 and rolling on the ring or wall 8. These rollers are especially desirable in case of a valve ring of extremely large diameter, and the number thereof will depend on the size of the ring.

Valves 55 engage with the operating ring means by an engagement permitting free radial movement of the valves,—for example by studs 60 in the valve slidably engaging in sockets 61 in the blocks 57. Valves 55 on the upper half of the machine may be held to their seats by action of gravity and steam pressure, but in the case of the valves on the lower side of the machine it may be desirable to provide supplemental means, consisting for example of springs 62, seated in the blocks 57 and valves 55 and holding the valves towards their seats.

The valve operating means above described may be actuated in any suitable manner, as for example by a gear 63 journaled in the casing ring 20 and engaging with a rack 64 on one of the blocks 57, said gear 63 being driven by a gear 65 on the shaft 66, journaled in suitable bearings in the steam trunk 5 and provided with operating means indicated at 67, a stuffing box 68 being provided where the shaft passes through the wall of the steam trunk. This operating means may be duplicated on opposite sides of the machine to balance the pressures on the annular valve-operating means and prevent binding.

The operation of the machine is as follows,—Steam is admitted to the inlet 30 of the outer steam chest 5 from any suitable steam supply and passes through the opening 6 into another steam or valve chest 7. In starting, the valve 55 will be wide open and the steam will flow through the tapering ports 9 and will issue therefrom at a high velocity, nearly equal to the maximum velocity due to the initial pressure of the steam. The steam, striking the buckets 10 will be deflected rearwardly and outwardly through the outlets 11, and then will be successively deflected by the fixed blades 13 and the movable vanes 12 and by the fixed blades 15 and movable vanes 14. The steam passing first in a general direction longitudinally of the turbine wheels and then in a general direction radially of said wheels finally passing to the space within the outer casing and passing from said casing through to the outer air or other exhaust opening 26 to the condenser or elsewhere as may be preferred. It will be understood that at each impact of the steam against the movable vanes of the turbine wheel, it will impart energy or rotative force to said wheel and in doing so the velocity of the steam itself will be decreased. While there will be a continual drop of pressure throughout the machine and a corresponding continuous increment, the velocity at each expansive step will be to some extent compensated for such loss in velocity by impact, it is my intention to so construct the machine that the actual velocity at each successive impact will be diminished, thereby concentrating as much as possible all the rotative power on the first impacts and avoiding to a large extent, loss in fluid friction. At each successive impact the steam reaches the vanes of the turbine with diminished velocity, and said vanes are correspondingly inclined at a more acute angle to the direction of movement than the preceding vanes so as to take more advantage of what velocity there is,—in other words, to prevent the steam from passing through in such a direct path between the vanes. The operation of the valve for controlling the admission of the steam will be obvious,—the valves 25 serving to cut off the ports one at a time in each group under the control of suitable regulating mechanism not shown.

The last few series of fixed and moving vanes 14, 15, may be so long as to be unable to resist the strains, they may in that case be provided with stiffening or bracing rings 70 to inset into the outer ends thereof.

The series of movable vanes 15 may be attached to the rings 36 by forming diagonal slots 71 in said rings as shown in Fig. 7, and placing the flat vanes in said slots and brazing them in place.

What I claim is:—

1. An expansive fluid turbine comprising a plurality of series of fixed blades to direct the fluid and a plurality of series of movable blades to receive the fluid from the fixed blades, the angle of the movable blades relative to their direction of movement being progressively varied.

2. An expansive fluid turbine comprising a plurality of series of fixed blades to direct the fluid and a plurality of series of movable blades to receive the fluid from the fixed blades, the angle of the movable blades relative to their direction of movement being progressively decreased.

3. An expansive fluid turbine comprising a plurality of series of fixed blades to direct the fluid and a plurality of series of movable blades to receive the fluid from the fixed blades, the angle of the movable blades relative to their direction of movement being progressively decreased, and the fixed blades being arranged substantially perpendicular to the movable blades which receive the fluid therefrom.

4. In an expansive fluid turbine the combination of expansive-fluid supply means, ports communicating therewith, a turbine wheel having a peripheral series of buckets to receive the fluid from said ports and having a plurality of series of vanes on each side of said series of buckets, the angle of said vanes to their direction of movement being progressively decreased and a plurality of series of fixed blades on each side of said series of buckets and between the successive series of moving vanes to receive the fluid from each series of vanes and direct it to the next series of vanes.

5. In an expansive-fluid turbine, ports communicating with said supply means to deliver the fluid at high velocity, the turbine wheel having a peripheral series of buckets to receive the fluid from said ports, said buckets having inlets extending inwardly and forwardly and outlets extending rearwardly and outwardly to each side of said buckets, said turbine wheel having a plurality of series of vanes at each side of the series of buckets, the angle of said vanes to their direction of movement progressively decreasing, and a plurality of series of fixed blades at each side of the series of buckets and interposed between the successive series of vanes on the turbine wheel.

6. A turbine wheel provided with a plurality of series of concentric vanes arranged in rings of progressively decreasing diameter and the angle of said vanes with their direction of movement decreasing progressively.

7. A turbine wheel provided with a plurality of series of concentric vanes arranged in rings of progressively decreasing diameter and the angle of said vanes with their direction of movement decreasing progressively, in combination with a plurality of series of fixed blades arranged in rings of progressively decreasing diameter and interposed between the successive series of vanes on the turbine wheel.

8. A casing comprising a frame-ring, annular side members secured at each side to said frame-ring and spiders connected to the annular side members in combination with a shaft mounted to rotate axially within said spiders, and a turbine wheel within the casing carried by said shaft.

9. A casing comprising a frame-ring, annular side members detachably fastened on each side of said frame-ring,

plates detachably fastened to said side members and having exhaust ports, a shaft mounted to rotate within said plates, and a turbine wheel within the casing, mounted on the shaft.

10. In a turbine, an annular valve chamber having ports in its inner wall, valves sliding on said wall to close said ports, and an annular operating device connected to said valves to cause such sliding movement thereof, the valves being freely movable in a radial direction in said annular operating means.

11. In a turbine, an annular vertically disposed valve chamber having ports in its inner wall, valves sliding in said wall to close said ports, and an annular operating device connected to said valves to cause such sliding movement thereof, the valves being freely movable in a radial direction in said annular operating means, and springs on the lower valves holding them toward the valve chest wall.

12. In a turbine, an annular valve chamber having ports in its inner wall, valves sliding on said wall to close said ports, and an annular operating device connected to said valves to cause such sliding movement thereof, the valves being freely movable in a radial direction in said annular operating means, said annular operating means having anti-friction rolls engaging the valve chest wall.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 1st day of September, 1904.

SOLOMON TOWNSEND HOLLY.

In presence of—
A. P. KNIGHT,
ANNA M. HOLLY.