BEST AVAILABLE COPY

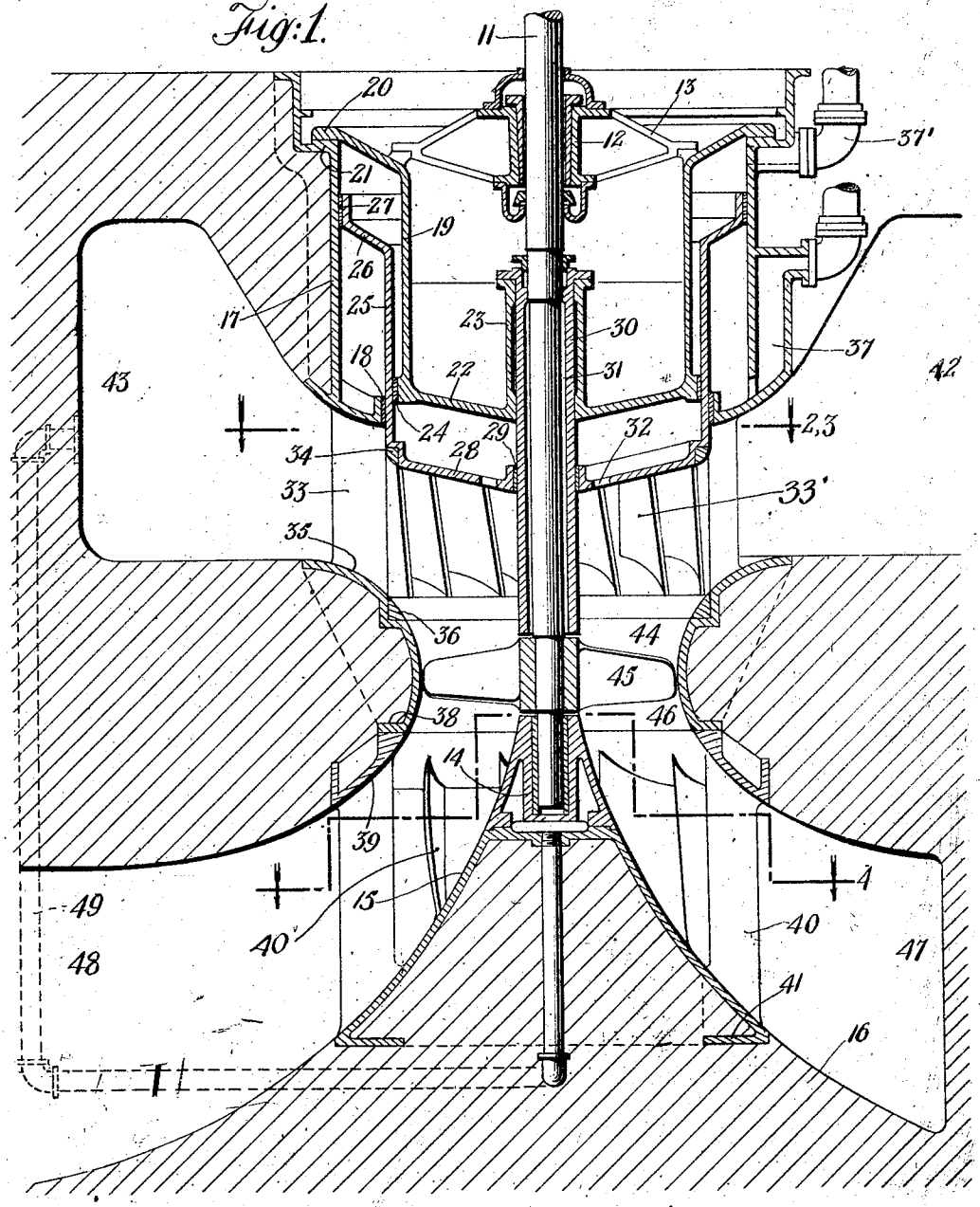
May 4, 1926. 1,583,415

L. F. MOODY

HYDRAULIC TURBINE

Filed June 28, 1918 4 Sheets-Sheet 1

Fig: 1.



Inventor
Lewis F. Moody
By his Attorneys
Edwards Angell & Richmond

May 4, 1926. 1,583,415

L. F. MOODY

HYDRAULIC TURBINE

Filed June 28, 1918 4 Sheets-Sheet 2

Fig: 2.

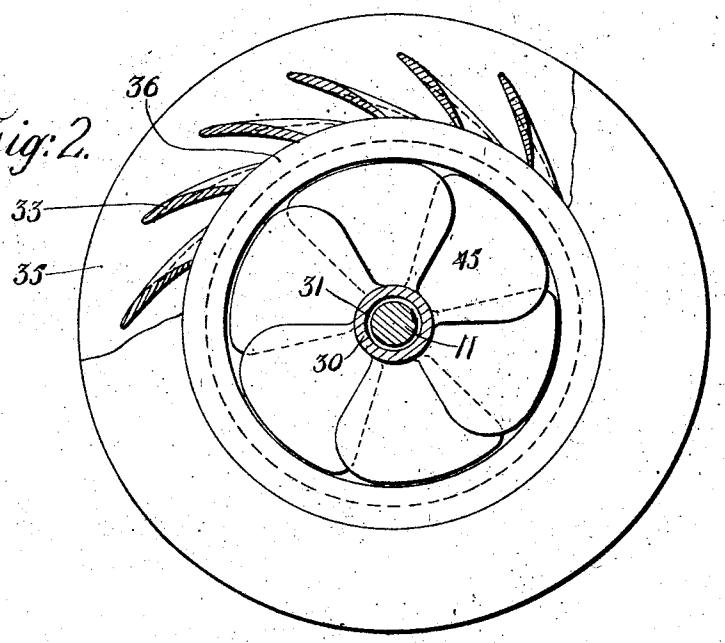
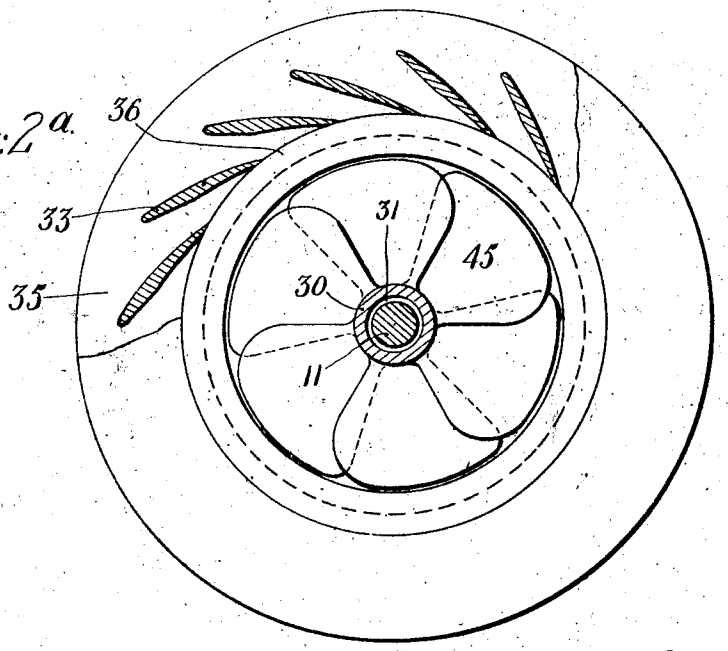


Fig: 2a.



Inventor
Lewis F. Moody.

By his Attorneys
Edwards Sager & Richmond

May 4, 1926. 1,583,415

L. F. MOODY

HYDRAULIC TURBINE

Filed June 28, 1918 4 Sheets-Sheet 3

Fig: 3.

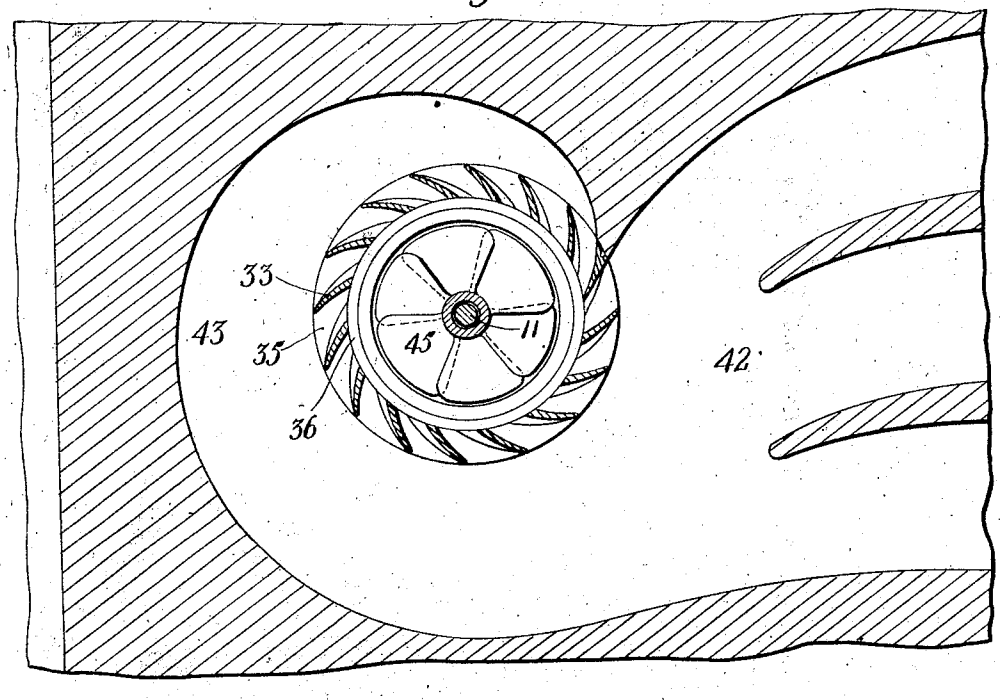
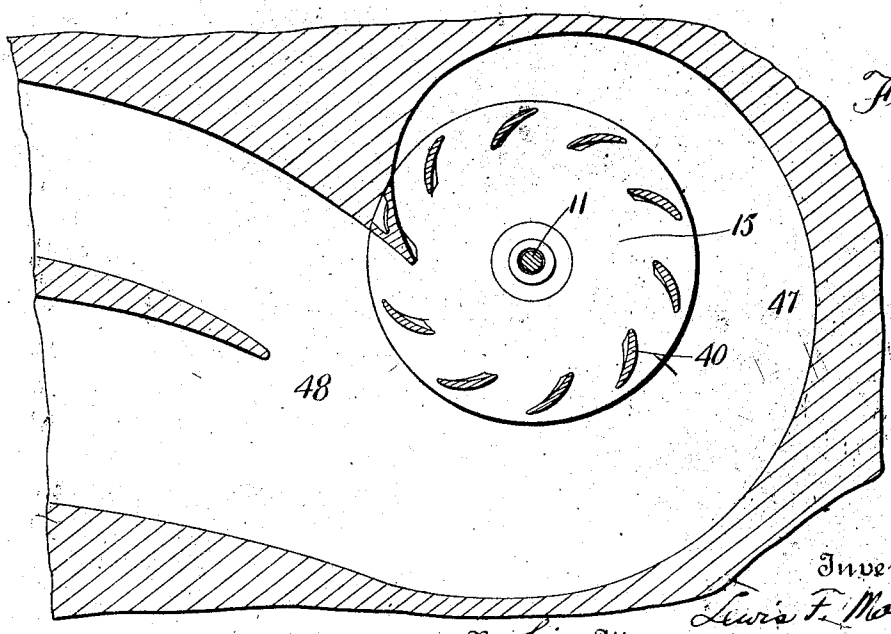


Fig: 4.



Inventor
Lewis F. Moody
By his Attorneys
Edwards Sager & Richmond

May 4 . 1926. 1,583,415

L. F. MOODY

HYDRAULIC TURBINE

Filed June 28, 1918 4 Sheets-Sheet 4

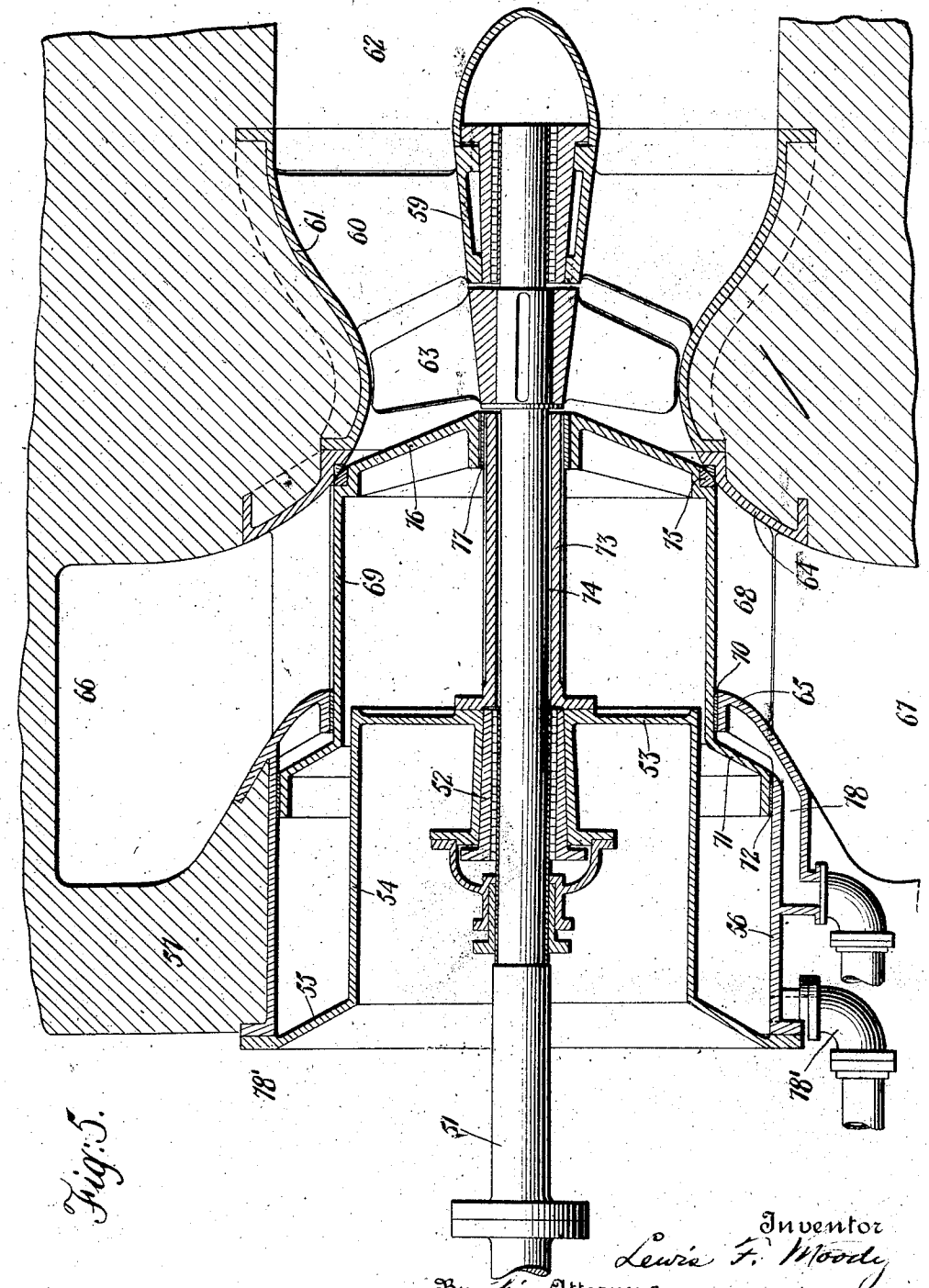


Fig. 5.

Inventor
Lewis F. Moody
By his Attorneys
Edwards Sayer & Richmond

Patented May 4, 1926. 1,583,415

UNITED STATES PATENT OFFICE.

LEWIS FERRY MOODY, OF PHILADELPHIA, PENNSYLVANIA.

HYDRAULIC TURBINE.

Application filed June 28, 1918. Serial No. 242,391.

To all whom it may concern:

Be it known that I, LEWIS FERRY MOODY, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Hydraulic Turbines, of which the following is a specification.

The principal object of my invention is to provide a new and improved hydraulic turbine. Another object of my invention is to provide an improved hydraulic turbine that shall be well adapted for operation at high specific speed under comparatively low head. Still another object has to do with regulating the flow of water through such a turbine. These and various other objects of my invention will become apparent on consideration of a disclosure of a limited number of specific forms in which the invention may be embodied as set forth in the following specification taken with the accompanying drawings. It will be understood that further modifications than those shown in the drawings can be made that will fall within the scope of my invention.

Referring to the drawings,

Fig. 1 is an axial section of a vertical shaft turbine embodying my invention;

Fig. 2 is a horizontal section on the line 2, 3 of Fig. 1, the plunger gate being removed;

Fig. 2ª is a section corresponding to Fig. 2 but showing a modification.

Fig. 3 is a more extended section than in Fig. 2 taken on the same line but on a reduced scale;

Fig. 4 is a reduced scale section taken on the line 4 of Fig. 1;

Fig. 5 is an axial section of a horizontal shaft turbine embodying my invention.

Referring to the modification shown in Figs. 1 to 4, the vertical shaft 11 is carried in the upper bearing 12 and the lower bearing 14. The upper bearing 12 is in a frame 13 extending across the pit, and the lower bearing 14, which is of lignum vitae, is set in the apex of the conical member 15 which rests on the concrete base 16.

The cylindrical frame 17 lines the pit and carries a circular bronze bushing 18 at its lower end. The smaller co-axial cylinder 19 hangs from a flange 20 which rests on the ledge 21. At its lower end the cylinder 19 is closed across by the conical wall 22, at the edge of which is an external circular bronze bushing 24. Between the bushing members 18 and 24 is the movable cylinder 25 having the flange 26 at its upper end carrying a bronze bushing 27 in engagement with the inside face of the cylindrical wall 17. The cylinder 25 is closed across at the bottom by the flatly conical wall 28 which has a hole at the center with a bushing 29 on the inside face thereof. The wall 22 carries a sleeve 23 with packing around the shaft 11 and from this sleeve 23 extends a tube 30 with a clearance 31 around the shaft 11. The bushing 29 engages the outer surface of the tube 30. Holes 32 in the conical wall 28 provide for an approximate equilibrium of fluid pressure on both sides of said wall 28.

The cylindrical liner 17 is supported by the circumferential row of guide vanes 33 which stand on the ring 35. This ring 35 carries a bronze seat 36 adapted to be engaged by the bushing 34 around the outside lower edge of the plunger 28—25. Standing up from the base 41 of the cone 15 are stay vanes 40 which carry a crown ring 39 on which rests the base flange 38 of the ring 35, and the exposed surfaces of the ring 35 and crown ring 39 form a surface of revolution gradually curving and flaring downward and outward from a point of minimum diameter adjacent the runner 45.

Ports 37 and 37′ in wall 17 may admit pressure fluid to act against annular piston 26, or may exhaust such pressure fluid as the case may be.

The water flows to the turbine through the conduit 42 and enters the contracting volute inflow passage 43 so that it is delivered with a whirling motion and with increasing velocity to the vanes 33. These vanes 33 function both as guide vanes and stay vanes. They are inclined to corresponding radii as shown in Figs. 2 and 3 and in the particular form shown in this drawing are more nearly perpendicular to said radii at their lower ends than at their upper ends and change their inclination gradually between the two extremes. See also Fig. 1, where the reference character 33′ indicates a single vane as seen in elevation. In the modification shown in Fig. 2ª the vanes have their parts at various heights inclined alike to the coresponding radii. The inner edges of the vanes 33 are close to the outside surface of the cylindrical plunger 25 when the latter is lowered to make the bushing 34 engage the seat 36.

The space to which the guide vanes 33 deliver the water is designated 44 and below this are the runner vanes 45 carried by the shaft 11. As the water leaves the runner vanes 45 it enters the space 46 around the apex of the cone 15 and passes between the stay vanes 40 to the volute discharge chamber 47. The vanes 40 are primarily stay vanes, but are placed at a suitable angle to corresponding radii so as to offer a minimum resistance to the water, which traverses the chamber 46 with a whirling movement. These vanes 40 are preferably twisted somewhat like the intake guide vanes 33 but more nearly perpendicular to the radii at their upper end than at their lower ends. See Fig. 4 and also reference character 40′ in Fig. 1 where a single vane appears in elevation. The volute conduit 47 receives this water in this natural whirling direction and conducts it in paths of expanding cross-section so as everywhere to reduce its velocity and deliver the integral stream to the outflow conduit 48.

The pipe 49 conducts water from the inflow conduit 43 and causes it to flow into the lower end of the bearing 14 and upward through the bearing, thus furnishing a circulation of cooling water through the bearing and out, preventing any accumulation of sand or other foreign matter in that bearing.

The water flowing to the turbine through the conduit 42 enters the volute inflow chamber 43 where it is accelerated, its potential energy being converted into kinetic energy of whirl as it is delivered through the guide vanes 33 to the space 44 beneath the conical wall 28 of the plunger gate 28—25. This whirling water engages the vanes 45 thereby impressing a torque on the shaft 11 and causing it to rotate and to develop power.

As the water leaves the runner vanes 45 and enters the space 46 it may retain some degree of whirling velocity. In the expanding volute chamber 47 this whirling velocity will be transformed into pressure head by the reduction of velocity due to increasing cross section, and to this extent back pressure will be taken off from the chamber 46, increasing the portion of the total head which is effective upon the runner 45.

As the water passes the vanes 33, its direction of flow is made up of two components, one radially inward, the other whirling, hence according to the commonly used form of expression, there is a radial inward flow at this place. Where the water engages and passes the runner vanes 45, the components of direction of flow are parallel to the axis and whirling, hence here the flow is said to be axial. Where the water departs past the vanes 40 the direction components are radially outward and whirling, hence here the flow is said to be a radial outward flow.

The turbine is regulated by varying the magnitude of the stream of water flowing therethrough. For a normal load the plunger gate 28—25 will have about the position shown in Fig. 1 and will be raised for an overload or lowered for a partial load. When it is lowered it decreases the annular inflow opening to the space 44 defined by the inner edges of the vanes 33. As described heretofore, the guide vanes 33 may be formed so that the passages between them are of a section varying from top to bottom. As shown in the drawings, particularly Fig. 2, the inflow openings between consecutive vanes decrease in width from the top to the bottom and the angle of admission of the water in relation to corresponding radii increases from the top to the bottom. The purpose in admitting the water more nearly in a radial direction at the top is because this water composes the upper stream elements entering the center portion of the runner at normal gate operation (see Fig. 1). The water is admitted more nearly in a tangential direction at the bottom of the vanes 33 and thus is given a large amount of whirl about the axis of the runner and enters the outer or peripheral portion of the runner (Fig. 1) which, moving at a higher velocity, requires a correspondingly increased velocity of whirl. In closing the gate, the average effective width of the passages between the guide vanes diminishes as the gate approaches its seat so that the change in shape of the guide vanes produces a condition approximating to that due to pivoted movable guide vanes as commonly employed, and in addition there is given a reduction in the axial width of the entrance space as the gate is closed.

In the form of plunger shown in the drawing, the guiding surface 28 in contact with the water flowing to the runner is shaped as a comparatively flat cone, having but little curvature in the portion near the axis as viewed in cross-section. By avoiding an axial elongation of this wall such as would be required to guide the water into the axial direction along a surface of curved cross-section, it is possible to reduce the distance at which the runner must be placed below the guide vane orifices to permit the plunger to be closed. The water in the space 44 is permitted to follow its own free path. The form of the water passage thus provided between the guide vanes and the runner is consistent with non-turbulent stream line flow, and in agreement with hydrodynamic principles. The water from the inflow chamber 42, 43 is directed radially and axially with a proper component of whirl into the transition space 44 where it is transformed into a single rotating axially progressing stream. The upper elements more remote from the runner are carried more nearly central.

When twisted guide vanes are used, as in the arrangement shown in Figs. 1, 2 and 3, the upper elements are carried with a smaller velocity of whirl while the lower, nearer elements of the stream are carried at higher peripheral velocity and intermediate points merge between the two. There are no crossings in the stream lines and eddies and cross currents are avoided. The stream as a whole in this transition is formed into a solid whirling mass directed axially against the runner in a most efficient manner. In regulation the guiding end of the gate follows the inflow, varying the transition space to meet the changes in flow and maintaining always conditions approaching maximum efficiency.

The annular space 46 is contained between the flaring conical core or cone 15 and the outer surface of revolution formed by the exposed surfaces of ring 35 and crown ring 39. In this space 46 the flow passes from the runner 45 to the discharge passage 47. The outer wall formed by rings 35, 39 is therefore a draft tube flaring downward and outward to a maximum at its outlet end where it discharges into the discharge 47. The outwardly flaring form of this draft tube wall permits it to discharge into the space 47 within a short distance from the runner 45 so that the draft tube is of comparatively short length; into it the central core 15 extends from below, that is from the direction of its flared outlet end, and the core 15 is disposed centrally in the draft tube and terminates close to the center of the runner 45. In the annular space 46 between the outer draft tube surface and the inner core 15 the flow passing from the runner 45 to discharge space 47 is in the form of a hollow annular column around the central core 15 and expanding in cross sectional area in the direction of flow.

The raising of the gate 28—25 is accomplished by the admission of pressure fluid through port 37 below the annular piston 26 in the annular cylindrical space between the stationary wall 17 and the movable wall 25. Reciprocally the lowering of this gate is effected by admitting the pressure fluid through the port 37′ above the annular piston 26. When pressure fluid is admitted at one port 37 or 37′ it is exhausted at the other port 37′ or 37. The pressure on the head 28 is balanced by virtue of the holes 32.

The gate mechanism here disclosed is much more rugged in structure than can be obtained when the wicket gates are used; the risk of breakage from trash, ice, or other obstructions is greatly reduced; and it is reasonably assured that the gates can easily be closed at any time without obstruction from accumulated trash. This form of gate provides for much tighter closure than is possible with wicket gates, the bushing 34 engaging the seat 36 to effect a tight closure, so that it will not ordinarily be necessary to close the head gates across the conduit 42 or to employ brakes to stop the turbine after the turbine gate is closed.

Among the advantages of my improved construction, in addition to the simplification and certainty of operation of the regulating gate are the following. A simpler form of runner vane surface can be used than in other types of high speed turbines and this gives an advantage in design and manufacture. The runner can be made of lighter weight than in other types of turbines, thus reducing the weight of the rotating parts and reducing the load on the thrust bearing. Only a comparatively small number of vanes are necessary in the runner. The spaces between the runner vanes may be large so as to reduce the risk of clogging by trash. The blades of the runner have relatively small inclination with relation to a radial plane, that is a plane perpendicular to the axis, and they have a relatively large inclination to a meridian plane, that is, a plane containing the axis. The edge of the runner blade is an inclined line, the vertical component of which is shown in Fig. 1, while its horizontal extent is shown in the remaining figures, so that its vertical extent is much less than its horizontal extent, and the general plane of the blade has an inclination to a radial plane, which is less than that to a meridian plane.

I desire to direct attention to the manner in which the construction shown in Fig. 1 supports the various elements. The pit liner or cylinder 17 stands on the circularly arranged vanes 33, which from this point of view serve as stay vanes. These stay vanes 33 stand on the ring 35 which in turn rests on the crown ring 39, and this is supported by the stay vanes 40 which stand on the base 41 of the cone 15 upon the concrete base 16.

In the modification shown in Fig. 5, the shaft is horizontal and the gate is on the discharge side of the runner. The horizontal shaft 51 is in the bearing 52 supported in the fixed cylinder 54 which has its flange 55 bolted to the liner 56 supported in the concrete structure 57. Another bearing is provided in the head 59 supported by the vanes 60 in the casing 61. The shaft 51 carries the runner vanes 63. Water enters through the conduit 62 from the right and is given a whirling motion by the vanes 60 which are curved for this purpose. The velocity is also increased by the convergence of the passage within the casing 61. The runner vanes 63 are of the same general design as the runner vanes 45 in Fig. 1.

At its end the cylinder 56 carries a ring 65 extending from which are the stay vanes 68 with their opposite ends connected with

the ring 64 which is bolted to the casing 61. Around the stay vanes 68 is the volute discharge chamber 66 of increasing cross-section across the lines of flow so as to decrease the velocity of the water discharged from the runner 63 and deliver it with reduced velocity into the draft tube 67.

The plunger gate 69—76 has the cylindrical wall 69 with the flatly conical wall 76 across its end. The inside edge of the ring 65 carries a bronze bushing 70 engaging the cylindrical surface 69 and the end of the cylinder 69 has a piston-flange 71 with a bronze bushing 72 engaging the inner face of the cylindrical liner 56. The tube 73 is supported from the wall 53 with a slight clearance 74 around the shaft 51 and the end wall 76 has a bronze bushing 77 engaging the outer surface of the tube 73. A bronze seat and bushing are also shown at 75 to facilitate a tight closure of the gate.

In the modification of Figure 5, there is no perforation in the head 76 (such as at 32 in the head 28 in Fig. 1), so that head 76 is subject at all times to the pressure at the left of runner 63, whatever that pressure may be. Pressure fluid admitted through port 78 acts on the annular piston 71 and is supplemented by the pressure on head 76 to move the gate to the left. On the contrary, to close the gate, pressure fluid is admitted through port 78′ and acts to the right on the whole annular piston 71—76 between cylinder wall 56 and sleeve 73. When pressure fluid is admitted at one port 78 or 78′, it is exhausted at the other port 78′ c. 78. The pressure of the water in the penstock may under suitable conditions be utilized to operate the gate.

In both types of turbine here shown, the plunger gate is arranged so that it may readily be withdrawn in an axial direction for purposes of replacement or repair without disturbing the parts set in the concrete. Referring to Fig. 1, such removal of the plunger gate 25—28 may readily be effected by removing the cover casting 19, together with the parts attached to it, namely, the bearing frame 13 and the sleeve 30. These parts might be arranged to be removed over the upper end of the shaft 11, leaving the shaft and runner in place, or the shaft and runner themselves could be withdrawn. In any case the pit liner 17 with the speed vanes 33, the liner 35 and the bushing 36 would not be disturbed, nor would the draft tube stay vane structure comprising the vanes 40 need to be disturbed, nor the lower guide bearing 14.

I claim:—

1. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, and a co-axial cylindrical gate across said conduit.

2. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, and a co-axial cylindrical gate across said conduit, said gate having a wall across its end.

3. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, a co-axial cylindrical gate across said conduit, and vanes across said radial flow conduit outside said gate and adjacent thereto when the gate is in its closed position.

4. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, a co-axial cylindrical gate across said conduit, and vanes across said radial flow conduit outside said gate and adjacent thereto when the gate is in its closed position, said gate having a wall across its end.

5. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, and a co-axial cylindrical gate across said conduit having a closing wall formed as a surface of revolution across its end.

6. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, a co-axial cylindrical gate across said conduit having a wall across its end, and guiding means at the entrance to said conduit, outside of said cylindrical gate in its closed position.

7. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, a co-axial cylindrical gate across said conduit, an annular piston extending from said cylindrical gate and a fixed hydraulic cylinder in which said piston can operate.

8. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith and a co-axial cylindrical gate across said conduit, said conduit being of expanding cross section across the stream elements for sections more and more remote from the runner.

9. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and co-axial therewith, and a co-axial cylindrical gate across said conduit, said conduit being in the form of a volute of expanding cross section for sections more and more remote from the runner.

10. In a hydraulic turbine, a runner of axial flow type comprising unshrouded runner vanes fixed on said shaft and a plunger gate coaxial with said runner, said plunger gate being substantially cylindrical and having a transverse end wall and being movable along the axis to control the water supply thereto.

11. In a hydraulic turbine, a runner of axial flow type comprising unshrouded runner vanes fixed on said shaft, a co-axial radial flow conduit at one end of said runner and a co-axial cylindrical gate across said conduit.

12. In a hydraulic turbine, a runner, a single cylindrical plunger gate with transverse end wall coaxial therewith and movable longitudinally with respect to the axis to regulate the flow through the runner, a co-axial hydraulic cylinder and a piston in said cylinder directly connected with said gate.

13. In a hydraulic turbine, a runner, a single gate co-axial therewith and movable longitudinally with respect to the axis to regulate the flow through the runner, a co-axial hydraulic cylinder and an annular flange on said gate within said cylinder serving as a piston.

14. In a hydraulic turbine, a runner, a cylindrical gate co-axial therewith and movable longitudinally to open or closed position, an annular flange on said gate to serve as a piston, a fixed cylinder and corresponding cylinder heads around said piston, and ports at the ends of said cylinder for the admission or exhaust of pressure fluid.

15. In a hydraulic turbine, a runner of axial flow type, a conduit leading to the runner, means in said conduit to give the water a whirling approach to the runner with increasing velocity, a conduit leading away from the runner, means to guide the water in a whirling direction in said last named conduit and with decreasing velocity, one of said conduits being of radial flow type, and a co-axial cylindrical gate across said radial flow conduit.

16. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, and fixed twisted vanes around the axis parallel therewith and across the conduit.

17. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, fixed twisted vanes around the axis parallel therewith and across the conduit, and a co-axial cylindrical gate within said vanes.

18. In a hydraulic turbine, a runner of axial flow type, a radial flow conduit at one end of said runner and coaxial therewith, and fixed twisted radial flow vanes around the axis parallel therewith and across the conduit, said vanes being more nearly radial at points more remote from the runner.

19. In a hydraulic turbine, a conduit enclosed by a casing and comprising a radial flow portion, an axial flow portion, and a transition space surrounding the common axis in which the flow changes from radial to axial; inward flow guide vanes in said radial flow portion, an axial flow runner in said axial flow portion, and a coaxial plunger gate forming a boundary wall for said transition space.

20. In a hydraulic turbine, a runner, a cylindrical plunger gate around the runner axis with a transverse end wall toward the runner and spaced therefrom, a fixed casing member within which said gate is fitted, and a head cover detachaby connected across the casing beyond the gate from the runner, whereby upon removal of said head cover the gate can be removed from within said casing member.

21. In a hydraulic turbine, an axial flow runner, radial flow guide vanes, and a flatly conical deflector to engage and deflect water flowing through and between said runner and vanes.

22. In a hydraulic turbine, an axial flow runner, radial flow guide vanes, and a flatly conical deflector adjustable longitudinally with respect to the runner axis and adapted to engage and deflect water flowing through and between said runner and vanes.

23. In a hydraulic turbine, an axial flow portion, a co-axial radial flow portion, a transition space interposed between them and a co-axial cylindrical plunger gate having a head which forms a boundary wall for said transition space.

24. A hydraulic turbine having a gate in the form of a cylinder with an end wall rigidly united thereto and formed as a surface of revolution, said gate being capable of regulating the flow through the turbine by opening or closing with axial movement, and inward flow guide vanes surrounding said gate and closely adjacent thereto.

25. A hydraulic turbine having a gate in the form of a cylinder with an end wall rigidly united thereto and formed as a surface of revolution, said gate being capable of regulating the flow through the turbine by opening or closing with axial movement.

26. A hydraulic turbine having inward flow guide vanes and a regulating gate in the form of a cylinder and an end wall rigidly united thereto and formed as a surface of revolution said gate being axially movable within said guide vanes.

27. A hydraulic turbine having inward flow guide vanes and a regulating gate in the form of a cylinder and an end wall formed as a surface of revolution, said gate being axially movable within said guide vanes, and fluid pressure means to move said gate.

28. In a hydraulic turbine, a runner of axial flow type comprising unshrouded runner vanes fixed on said shaft, a plunger gate coaxial with said runner and movable along the axis to control the water supply thereto, and means around said gate to turn the water into a direction having a tangential component on its way to the runner.

29. The method of utilizing the energy of

water under head which consists in directing its flow inwardly and axially and with a whirling component varying at different parts of the stream, forming it into a single rotating axially advancing stream, directing this stream against a suitable runner, absorbing a part only of the whirl energy by the runner, and absorbing another substantial part of the whirl energy of the water after leaving the runner by reducing its velocity by expanding its cross section.

30. In a hydraulic turbine, the combination with an axial runner chamber, and a coaxial radial inflow chamber, of an intermediate transition space directly connecting said chambers, means for guiding the flow into said transition space so that it will form a whirling axially progressing stream in said axial runner chamber, and means for moving a wall of said transition space to control the flow therethrough.

31. In a hydraulic turbine the combination with a contracting volute inflow passage directing the flow inwardly at an angle to the radii of a central axis, a transition space receiving said flow and turning it from radial to axial, a substantially axial flow runner adapted to abstract only a portion of the whirl from the flow, a radially expanding annular outflow passage decelerating the flow so as to convert the velocity head of both meridian and whirling components into effective pressure head.

32. A hydraulic turbine structure comprising a fixed cylindrical liner tube, a movable plunger gate within said tube, a central rotatable runner shaft, a cover plate, and pressure means between said liner tube and said plate for moving said gate, said liner tube being greater in diameter than any of said movable parts and said cover being detachable to permit easy removal of all of said movable parts.

33. In a hydraulic turbine a runner, a cylindrical plunger gate around the runner axis and free from engagement with the runner, a fixed casing member within which such gate may be reciprocated in the direction of the axis and a head cover detachably connected across said casing member beyond the gate from the runner, whereby the gate may be removed from the casing upon removal of said head cover.

34. In a hydraulic turbine the combination with a runner, of an intake passage for the flow thereto comprising an entrance space in advance of said runner, and means for relatively moving the surfaces of said entrance space to expand or contract the latter and control the flow through said turbine, comprising an annular plunger and fluid pressure operated means for moving said plunger.

35. Apparatus for regulating the flow through a hydraulic turbine comprising means for guiding the flow inwardly toward an axis, means for turning the flow toward the axial in a transition space, and means for moving one of the surfaces of said transition space to vary the size of said transition space to control the flow therethrough.

36. In a hydraulic turbine the combination with an unshrouded propeller type runner receiving the flow in a nearly axial direction, of an intake passage guiding the flow inwardly and with a whirl around the axis, means forming a transition space guiding the flow from said inwardly directed intake to said runner, and an axially movable gate moving across said transition space to control the flow.

37. In a hydraulic machine the combination with a rotor, of a passage communicating with said motor comprising radial and axial flow portions connected by a transition space at least one side of which is bounded by a surface connecting said radial and axial flow portions, and means for relatively moving the bounding surfaces of said transition space to expand or contract the latter and to control the flow through said rotor.

38. In a hydraulic turbine the combination with a runner, of an intake passage for the flow thereto comprising an entrance space one side of which forms a surface curving from the radial to the axial direction, and means for relatively moving the surfaces of said entrance space to expand or contract the latter and control the flow through said turbine.

39. In a hydraulic turbine the combination with a runner and guide vanes in advance of the runner, of a contracting inflow passage so formed at its lower surface as to direct the flow to the guide vanes in directions contained in a plane normal to the turbine axis and in line with the lower edge of said guide vanes.

40. In a hydraulic turbine the combination with a runner and guide vanes in advance of the runner, of a contracting inflow passage so formed at its lower surface as to direct the flow to the guide vanes radially inward in directions contained in a plane normal to the turbine axis and in line with the lower edge of said guide vanes, said inflow passage being adapted to impart to the entering flow a whirl around the axis of the runner.

41. The combination with a hydraulic turbine having a radial entrance flow passage and means for turning the flow toward an axial direction, of an axial flow unshrouded runner with blades overlapping to a small extent so as to have a blade area equal to the disk area of the runner viewed in a direction along the axis.

42. The combination with a hydraulic tur-

bine having a radial entrance flow passage and means for turning the flow toward an axial direction, of an axial flow unshrouded runner with blades overlapping to a small extent so as to have a blade area equal to the disk area of the runner viewed in a direction along the axis the runner blades having an inclination to a radial plane less than the inclination of said blades to a meridian plane.

43. The combination with a hydraulic turbine having a radial entrance flow passage and means for turning the flow toward an axial direction, of an axial flow unshrouded runner with blades overlapping to a small extent so as to have a blade area equal to the disk area of the runner viewed in a direction along the axis, the runner blades having an inclination to a radial plane less than 30°.

44. In a hydraulic turbine an entrance conduit comprising a radial flow inlet portion having guide vanes therein, a vane-free transition space extending inward from said vanes and turning the flow toward an axial direction, and an axial flow runner receiving the flow from said transition space and comprising unshrouded blades overlapping to a small extent viewed in a direction along the axis of the runner.

45. In a hydraulic turbine, a conduit enclosed by a casing and comprising a radial flow inlet portion having guide vanes therein, and an axial flow portion, a vane-free transition space extending from said radial flow portion to a point in said axial flow portion beyond the inlet thereof and in which the flow changes from radial to axial and axially advances, and an unshrouded axial flow runner with blades overlapping to a small extent so as to have a blade area equal to the disk area of the runner viewed in a direction along the axis.

46. In a hydraulic turbine, a conduit enclosed by a casing and comprising a radial flow inlet portion having guide vanes therein, and an axial flow portion, a vane-free transition space extending from said radial flow portion to a point in said axial flow portion beyond the inlet thereof and in which the flow changes from radial to axial and axially advances, an axial flow runner axially beyond said point in said axial flow portion, and adapted to discharge the flow with a whirl, and a draft tube receiving the flow from said runner and adapted to convert both axial and whirling velocity components of the discharge into pressure head.

47. The method of utilizing the energy of water under head which consists in directing its flow inwardly from all sides so that the water in a plane normal to a common axis and at all points equidistant from that axis has a radial component and a whirling component of substantially constant value, changing the radial components to axial direction but preserving the whirling components so as to produce a solid stream whirling about and advancing along said axis, passing this stream axially through a suitable runner adapted to discharge the flow with a whirl and converting both the axial and whirling velocity components of the discharge from the runner into pressure head in a suitable draft tube.

48. The method of utilizing the energy of water under head which consists in directing its flow inwardly from all sides so that the water in a plane normal to a common axis and at all points equidistant from that axis has a radial component and a whirling component of substantially constant value, changing the radial components to axial direction but preserving the whirling component so as to produce a solid stream whirling about said axis, then advancing said solid stream along said axis, passing this stream axially through a suitable runner so that said stream will whirl as it leaves the runner and converting both the axial and whirling velocity components of the discharge from the runner into pressure head in a suitable draft tube.

49. The method of utilizing the energy of water under head which consists in directing its flow inwardly from all sides with radial and whirling components with respect to a common axis, changing the radial components to axial direction but preserving the whirling component so as to produce a solid stream whirling about and advancing along the axis, passing this stream axially through a suitable runner so that said stream will whirl as it leaves the runner and converting both the axial and whirling velocity components of the discharge from the runner into pressure head in a suitable draft tube.

50. The method of utilizing the energy of water under head which consists in directing its flow inwardly from all sides with radial and whirling components with respect to a common axis, changing the radial components to axial direction but preserving the whirling component so as to produce a solid stream whirling about the axis, then advancing said solid stream along the axis, passing this stream axially through a suitable runner so that said stream will whirl as it leaves the runner and converting both the axial and whirling velocity components of the discharge from the runner into pressure head in a suitable draft tube.

51. The method of utilizing the energy of water under head which comprises, directing a stream of water inwardly from all sides with radial and whirling components with respect to a common axis, changing the radial components to axial direction but preserving the whirling component so as to produce a solid whirling stream, then ad-

vancing said solid stream along said axis, passing this stream axially through a suitable runner so that said stream will whirl as it leaves the runner and converting both the axial and the whirling velocity components of the discharge from the runner into pressure head in a suitable draft tube.

52. The method of utilizing the energy of water under head which comprises, directing a stream of water inwardly from all sides towards a common axis so that the water in a plane normal to said common axis and at all points equidistant from said axis has a definite angular direction of flow with radial and whirling components changing the radial components to axial direction but preserving the whirling component so as to produce a solid stream whirling about and advancing along said axis, passing this stream axially through a suitable runner so that said stream will whirl as it leaves the runner and converting both the axial and whirling velocity components of the discharge from the runner into pressure head in a suitable draft tube.

53. The method of utilizing the energy of water under head which comprises, directing a stream of water inwardly from all sides towards a common axis so that the water in a plane normal to said common axis and at all points equidistant from said axis has a definite angular direction of flow with radial and whirling components, changing the radial components to axial direction but preserving the whirling component so as to produce a solid stream whirling about said axis, then advancing said solid stream along said axis, passing this stream axially through a suitable runner so that said stream will whirl as it leaves the runner and converting both the axial and whirling velocity components of the discharge from the runner into pressure head in a suitable draft tube.

54. In a hydraulic turbine of high specific speed, in combination with an intake adapted to impart a whirl to the flow and deliver it axially to the runner, of an axial flow runner having not more than six blades overlapping when viewed in the direction of the axis, a substantial portion of the entrance and discharge edges of said blades being shaped as straight lines.

55. In a hydraulic turbine of high specific speed, in combination with an intake adapted to impart a whirl to the flow and deliver it axially to the runner, of an axial flow runner having a hub less than half the largest diameter of the runner and blades overlapping when viewed in the direction of the axis, the entrance and discharge edges of each blade being joined to the blade tips by continuous curves.

56. In a hydraulic turbine of high specific speed, in combination with an intake adapted to impart a whirl to the flow and deliver it axially to the runner, of an axial flow runner having a hub less than half the largest diameter of the runner and blades overlapping when viewed in the direction of the axis, a substantial portion of the entrance and discharge edges of said blades being shaped as straight lines, and a substantial portion of the tip of each blade being curved in axial projection.

57. In a hydraulic turbine of high specific speed the combination with an intake adapted to impart a whirl to the flow and deliver it in generally axial direction to the runner, of an unshrouded axial flow runner, having a small number of blades of a relatively large amount of area, so that the blades overlap through at least a part of their length, the blades being inclined forward so that in the portions near their tips they make a relatively small angle with a plane normal to the axis, so that the outer half of the blade occupies a width in meridian projection less than half the width in axial projection.

58. In a hydraulic turbine of high specific speed the combination with an intake adapted to impart a whirl to the flow and deliver it in generally axial direction to the runner, of an unshrouded axial flow runner, having not more than six blades of a relatively large amount of area, so that the blades overlap through at least a part of their length, the blades being inclined forward so that in the portions near their tips they make a relatively small angle with a plane normal to the axis, so that the outer half of the blade occupies a width in meridian projection less than half the width in axial projection.

59. In a hydraulic turbine of high specific speed the combination with an intake adapted to impart a whirl to the flow and deliver it in generally axial direction to the runner, of an unshrouded axial flow runner, having a hub with a diameter less than half the largest diameter of the runner and a small number of blades of a relatively large amount of area, so that the blades overlap through at least a part of their length, the blades being inclined forward so that in the portions near their tips they make a relatively small angle with a plane normal to the axis, so that the outer half of the blade occupies a width in meridian projection less than half the width in axial projection.

60. In a hydraulic turbine the combinataion with an entrance passage adapted to impart a whirl to the flow and guide it in an axial direction with radially inward components, of a runner having not more than six blades with an area not less than the disk area of the runner and receiving said entrance flow axially.

61. In a hydraulic turbine the combination with an entrance passage adapted to impart a whirl to the flow and guide it in an axial direction with radially inward components, of a runner having not more than six blades with an area not less than the disk area of the runner and receiving said entrance flow axially and discharging said flow substantially axially.

62. In a hydraulic turbine the combination with an entrance passage adapted to impart a whirl to the flow and guide it in an axial direction with radially inward components, of an unshrouded runner having not more than six blades with an area not less than the disk area of the runner and receiving said entrance flow axially.

63. In a hydraulic turbine the combination with an entrance passage adapted to impart a whirl to the flow and guide it in an axial direction with radially inward components, of an unshrouded runner having not more than six blades with an area not less than the disk area of the runner and receiving said entrance flow axially and discharging said flow substantially axially.

64. In a hydraulic turbine the combination with an entrance passage adapted to impart a whirl to the flow and guide it in an axial direction with radially inward components, of a runner having not more than six blades with an area not less than the disk area of the runner and receiving said entrance flow axially and a discharge passage receiving the discharge from said runner and decelerating it between coaxial surfaces of revolution.

65. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising unshrouded blades with an area not less than the disk area of the runner and receiving the flow axially and discharging it axially.

66. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising unshrouded blades with an area not less than the disk area of the runner and receiving the flow axially and with relatively small radially inward components and discharging it more nearly axially.

67. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising not more than six unshrouded blades with an area not less than the disk area of the runner and receiving the flow axially and discharging it axially.

68. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising unshrouded blades receiving the flow axially and discharging it axially, the axially projected area of said blades being not less than the disk area of a circle passing through the tips of said blades.

69. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising unshrouded blades receiving the flow axially and with relatively small radially inward components and discharging it axially, the axially projected area of said blades being not less than the disk area of a circle passing through the tips of said blades.

70. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising not more than six unshrouded blades receiving the flow axially and discharging it axially, the axially projected area of said blades being not less than the disk area of a circle passing through the tips of said blades.

71. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising not more than six unshrouded blades with an area not less than the disk area of the runner and receiving the flow axially and discharging it axially, said blades overlapping in axial projection throughout at least a portion of their length.

72. In a hydraulic turbine of high specific speed the combination with a radial inflow passage adapted to impart a whirl to the flow, of means for turning the flow toward an axial direction, and an unshrouded axial flow runner having a small number of blades of a relatively large amount of area, the blades being so formed that when viewed in axial projection no open space is left between successive blades for the greater portion of the blade length and said blades being inclined forward so that in the portions near their tips they make a relatively small angle with a plane normal to the axis.

73. In a hydraulic turbine of high specific speed the combination of a radial entrance flow passage adapted to impart a whirl to the flow and means for turning the flow toward an axial direction, of an axial flow runner having a small number of unshrouded

blades, said blades being so formed that when viewed in axial projection no open space is left between successive blades for the greater portion of the blade length so as to have a blade area equal to the disk area of the runner viewed in a direction along the axis, the runner blades having an inclination to a plane normal to the axis less than the inclination of said blades to a meridian plane.

74. In a hydraulic turbine of high specific speed the combination with an entrance passage adapted to impart a whirl to the flow and vary said whirl with variations in the gate opening and guiding the flow from radial toward an axial direction, of an axial flow runner having a small number of unshrouded blades and a projected blade area not less than the disk area, the blades being formed so that when viewed in axial projection no open space is left between successive blades for the greater portion of the blade length, and a draft tube receiving the discharge from said runner axially and adapted to gradually decelerate the axial components of the velocity.

75. In a vertical shaft turbine of high specific speed the combination with an intake conduit leading the flow toward the turbine, of an inflow chamber formed to impart a whirl to the entering flow and comprising a transition space of circular formation receiving the whirling flow and turning said flow toward an axial direction, a substantially axial flow runner with a blade area substantially equal to the disk area of the runner and receiving the whirling flow from said transition space and adapted to abstract a portion of the whirl and to discharge the whirling outflow substantially axially, and an axialy extending draft tube adapted to lower the velocity of the axial components of the discharge and convert velocity head into pressure head.

76. In a hydraulic turbine of high specific speed the combination with an intake having means to impart a whirl to the flow and turning said flow from radial toward an axial direction, of a runner for said turbine comprising a small number of unshrouded blades discharging the flow axially, each blade in outline as projected on a plane perpendicular to the axis, having its entrance and discharge edges joined to the outer tips of the blade by smoothly rounded curves.

77. In a hydraulic turbine the combination with a radial inflow passage having guide vanes conforming to a whirling flow, of a transition space within said guide vanes adapted to turn the flow from radial to axial, an unshrouded runner receiving the flow from said transition space, said runner having its tips without substantial increase in diameter in the direction of flow so as not to flare outwardly and being removable upward without disturbing the surrounding wall of the passage.

78. In a vertical shaft turbine the combination with an intake conduit leading the flow toward the turbine and having one side wall extending adjacent to the turbine and the other side wall spaced therefrom, of a volute inflow chamber having its outer wall extending around the turbine to connect said side walls of said entrance passage and formed to impart a whirl to the entering flow, a transition space of circular formation receiving the whirling flow radially from said volute chamber and turning said flow toward an axial direction, a substantially axial flow runner receiving the whirling flow from said transition space and adapted to abstract a portion of the whirl and to discharge the whirling outflow substantially axially, and an axially extending draft tube adapted to spread the discharge outward away from the axis so as to lower the velocity of whirl and convert velocity head into pressure head.

79. In a vertical shaft turbine the combination with an intake conduit leading the flow toward the turbine and having one side wall extending adjacent to the turbine and the other side wall spaced therefrom, of a volute inflow chamber having its outer wall extending around the turbine to connect said side walls of said entrance passage and formed to impart a whirl to the entering flow, a transition space of circular formation receiving the whirling flow radially from said volute chamber and turning said flow toward an axial direction, a substantially axial flow runner receiving the whirling flow from said transition space, the blades of said runner overlapping when viewed along the axis and being inclined to abstract a portion of the whirl and to discharge the whirling outflow substantially axially, and an axially extending draft tube adapted to spread the discharge outward away from the axis so as to lower the velocity of whirl and convert velocity head into pressure head.

80. In a vertical shaft turbine the combination with an intake conduit leading the flow toward the turbine and having one side wall extending adjacent to the turbine and the other side wall spaced therefrom, of a volute inflow chamber having its side wall extending around the turbine to connect said side walls to said entrance passage and formed to impart a whirl to the entering flow, a transition space of circular formation receiving the whirling flow radially from said volute chamber and turning said flow toward an axial direction, a runner receiving the whirling flow from said transition space and having a small hub of a diameter less than the length of the runner blades from hub to tip, the blades of

said runner overlapping when viewed along the axis and being inclined to abstract a portion of the whirl and to discharge the whirling outflow substantially axially, and an axially extending draft tube adapted to spread the discharge outward away from the axis so as to lower the velocity of whirl and convert velocity head into pressure head.

81. In a vertical shaft turbine the combination with an intake conduit leading the flow toward the turbine, of a volute inflow chamber surrounding the turbine and receiving the flow from said conduit and imparting a whirl to the flow, a transition space of circular formation receiving the whirling flow radially from said volute chamber and turning said flow toward an axial direction, a runner receiving the whirling flow from said transition space and adapted to abstract a portion of the whirl and to discharge the whirling outflow substantially axially, an axially extending draft passage decelerating the flow and converting the whirling component of the velocity into effective pressure head, and a velocity decelerating conduit receiving the flow from said axially extending passage and turning said flow toward tailwater while continuing its deceleration.

82. In a hydraulic turbine the combination with an inflow chamber, of means for imparting a whirl to the inflow, a transition space radially receiving said whirling inflow and turning the flow toward an axial direction, a runner receiving the flow from said transition space and comprising overlapping blades formed to abstract a part of the whirl from the flow and to discharge the whirling outflow substantially axially, an axially extending draft tube receiving the flow from the runner and adapted to decelerate the flow while carrying it along the turbine axis and converting the whirling component of the velocity into effective pressure head, and a velocity decelerating outflow conduit receiving the flow from said draft passage and carrying it outward toward tailwater while continuing the velocity deceleration.

83. In a hydraulic turbine the combination with a substantially axial flow runner, of means for guiding the flow to said runner with a whirl comprising an inflow chamber adapted to impart a whirl to the entering flow, guide vanes, and a contracting transition space receiving the flow radially and turning it toward an axial direction with increasing whirl, the outer surface of said transition chamber continuously curving inward to a minimum diameter at the runner.

84. In a hydraulic turbine the combination with a substantially axial flow runner, of means for guiding the flow to said runner with a whirl comprising an inflow chamber adapted to impart a whirl to the entering flow, guide vanes, and a contracting transition space receiving the flow radially and turning it toward an axial direction with increasing whirl, the outer surface of said transition chamber continuously curving inward to a minimum diameter at the center of the runner.

85. In a hydraulic turbine the combination with a runner adapted to discharge the flow with a whirl, of means for decelerating the discharge from said runner comprising an axially extending draft passage decelerating the flow, and a radially extending outflow conduit radially receiving the flow from said draft tube passage and continuing the deceleration of the flow while turning it and carrying it toward tailwater.

86. In a hydraulic turbine the combination with a runner adapted to discharge the flow with a whirl, of means for decelerating the discharge from said runner comprising an axially extending draft passage spreading outwardly to decelerate the velocity of whirl and convert its velocity head into pressure head and an outflow conduit receiving the flow from said draft tube passage and continuing the deceleration of the flow while turning it and carrying it toward tailwater.

87. In a hydraulic turbine the combination with a runner adapted to discharge the flow with a whirl, of means for decelerating the discharge from said runner comprising an axially extending draft passage spreading outwardly around a central core member to decelerate the velocity of whirl and convert its velocity head into pressure head and an outflow conduit receiving the flow from said draft tube passage and continuing the deceleration of the flow while turning it and carrying it toward tailwater.

88. In a hydraulic turbine the combination with a runner adapted to discharge the flow with a whirl, of means for decelerating the discharge from said runner comprising an axially extending draft passage spreading outwardly around a central core member continuous with the contour of the runner hub to decelerate the velocity of whirl and convert its velocity head into pressure head and an outflow conduit receiving the flow from said draft tube passage and continuing the deceleration of the flow while turning it and carrying it toward tailwater.

89. In a hydraulic turbine the combination with a vertical shaft, of means for sustaining said shaft against axial thrust, and means for radially retaining said shaft comprising a radial bearing above the runner and a radial bearing below the runner.

90. In a hydraulic turbine the combination with a vertical shaft, of means for sustaining said shaft against axial thrust, and means for radially retaining said shaft comprising a radial bearing above the runner and

a radial bearing below the runner, said lower bearing being carried by a central core member in the discharge conduit from the runner.

91. In a hydraulic turbine a vertical shaft adapted to be rotatably sustained against axial thrust and having a radial bearing retaining said shaft radially, and means for vertically supporting the shaft and runner when they are slightly lowered comprising a central core member extending upwardly in the draft conduit from the runner so that the shaft and runner will be supported when the first named means is disconnected.

92. In a turbine the combination with a runner, of a draft tube therefor comprising an outer surface of revolution extending downward from the lowest discharge edge of the runner blades and flaring outward away from the axis to an annular outlet, and an inner surface of revolution beginning at the runner and extending downward therefrom and flaring outward to said outlet at its lower end, said inner and outer surfaces being formed and spaced to provide an annular draft tube passage from said runner to said outlet continuously increasing in cross sectional area in the direction of flow so as to decelerate the flow and convert velocity head into pressure head.

93. In a turbine the combination with an axial flow runner, of a draft tube therefor comprising an outer surface of revolution extending downward below the lowest discharge edge of the runner blades and flaring outward away from the axis to an annular outlet, and in inner surface of revolution beginning at the runner and extending downward therefrom and flaring outward to said outlet at its lower end, said inner and outer surfaces being formed and spaced to provide an annular draft tube passage from said runner to said outlet continuously increasing in cross sectional area in the direction of flow so as to decelerate the flow and convert velocity head into pressure head.

94. In a turbine the combination with a runner, of a draft tube therefor comprising an outer surface of revolution extending downward below the lowest discharge edge of the runner blades and flaring outward away from the axis to an annular outlet, and an inner surface of revolution beginning at the runner and extending downward therefrom and flaring outward to said outlet at its lower end, said inner and outer surfaces being formed and spaced to provide an annular draft tube passage from said runner to said outlet continuously increasing in cross sectional area in the direction of flow so as to decelerate the flow and convert velocity head into pressure head, and a velocity decelerating chamber receiving the flow from said annular passage.

95. In a turbine the combination with a runner, of a draft tube therefor comprising an outer surface of revolution extending downward below the lowest discharge edge of the runner blades and flaring outward away from the axis to an annular outlet, and an inner surface of revolution beginning at the runner and extending downward therefrom and flaring outward to said outlet at its lower end, said inner and outer surfaces being formed and spaced to provide an annular draft tube passage from said runner to said outlet continuously increasing in cross sectional area in the direction of flow so as to decelerate the flow and convert velocity head into pressure head and a collection chamber receiving the flow from said annular passage and collecting it and turning it toward final tailwater.

96. In a turbine the combination with a runner, of a draft tube therefor comprising an outer surface of revolution extending downward below the lowest discharge edge of the runner blades and flaring outward away from the axis to an annular outlet, and an inner surface of revolution beginning at the runner and extending downward therefrom and flaring outward to said outlet at its lower end, said inner and outer surfaces being formed and spaced to provide an annular draft tube passage from said runner to said outlet continuously increasing in cross sectional area in the direction of flow so as to decelerate the flow and convert velocity head into pressure head, and a velocity decelerating chamber receiving the flow from said annular passage and collecting it and turning it toward final tailwater.

97. In a turbine the combination with a runner, of a draft tube therefor comprising an outer surface of revolution extending downward below the lowest discharge edge of the runner blades and flaring outward away from the axis to an annular outlet, and an inner surface of revolution beginning at the runner and extending downward therefrom and flaring outward to said outlet at its lower end, said inner and outer surfaces being formed and spaced to provide an annular draft tube passage from said runner to said outlet continuously increasing in cross sectional area in the direction of flow so as to decelerate the flow and convert velocity head into pressure head, and a laterally enclosed conduit receiving the flow from said annular passage and conducting it to tailwater without exposing the flow to a free surface until it reaches tailwater.

98. In a hydraulic turbine the combination with a runner, guide vanes in advance of the runner and a ring connecting the ends of said guide vanes, of a contracting inflow passage having an outer wall of spiral or volute formation, and a transverse wall formed as a plane surface in line with the ring at the end of said guide vanes.

LEWIS FERRY MOODY.

CERTIFICATE OF CORRECTION.

Patent No. 1,583,415. Granted May 4, 1926, to

LEWIS FERRY MOODY.

It is hereby certified that the above numbered patent was erroneously issued to the inventor said Moody, whereas said Letters Patent should have been issued to William Cramp & Sons Ship & Engine Building Company, a corporation of Pennsylvania, said corporation being assignee of the entire interest in said invention, as shown by the records of assignments in this office; 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 22nd day of March, A. D. 1927.

M. J. Moore,
Acting Commissioner of Patents.

Seal.