

Feb. 19, 1929.

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L. F. MOODY

HYDRAULIC TURBINE

Filed June 25, 1924

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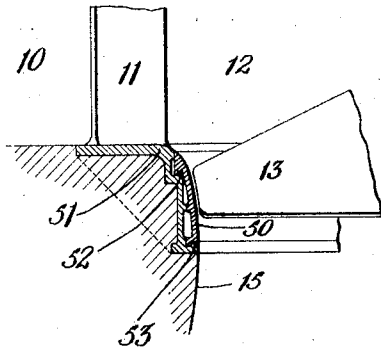


Fig. 1a.

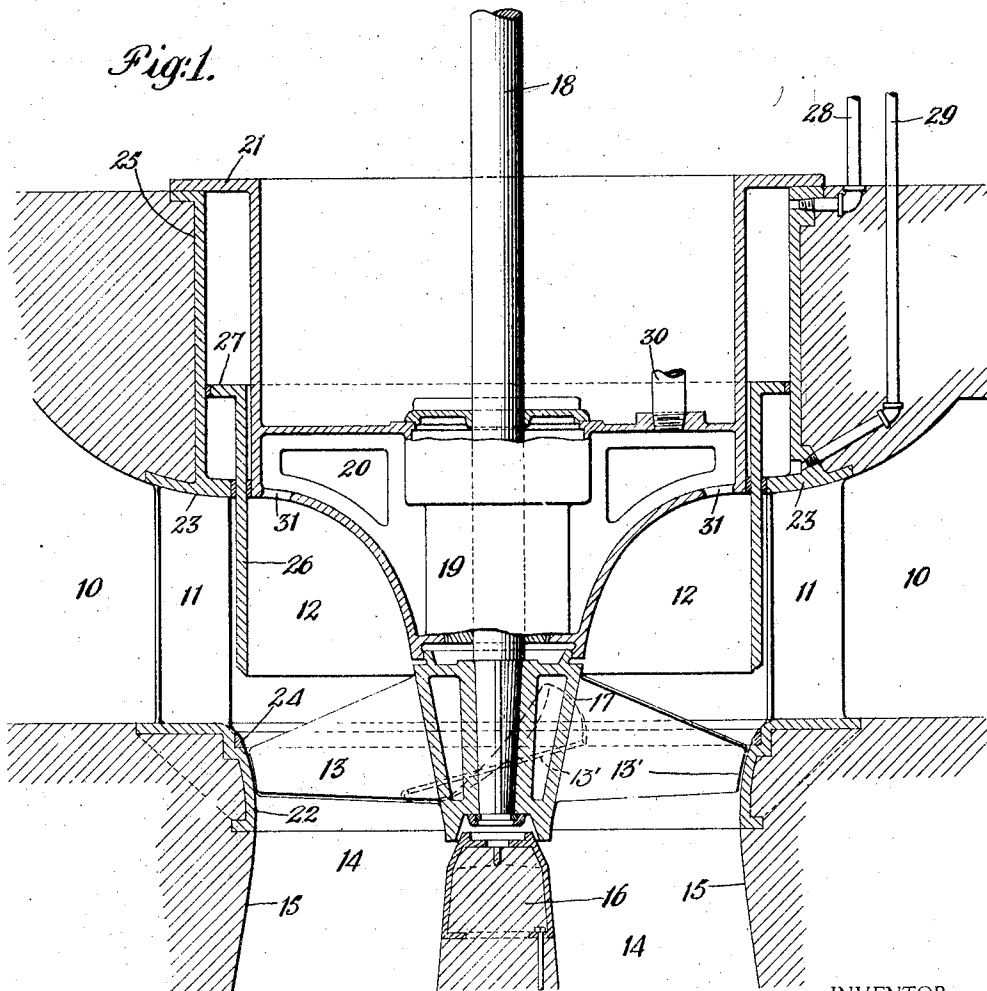


Fig. 1.

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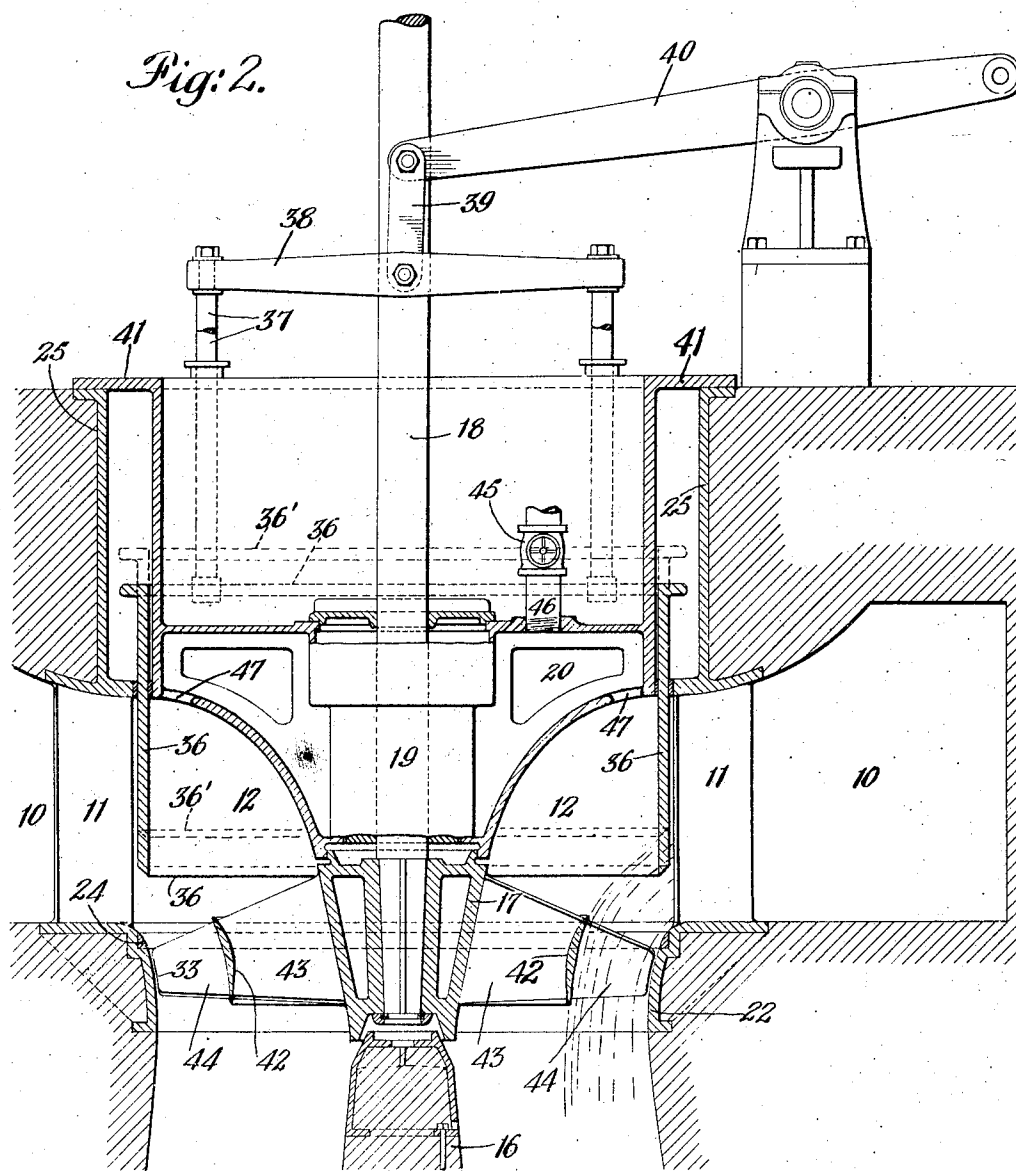
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5 Sheets-Sheet 2



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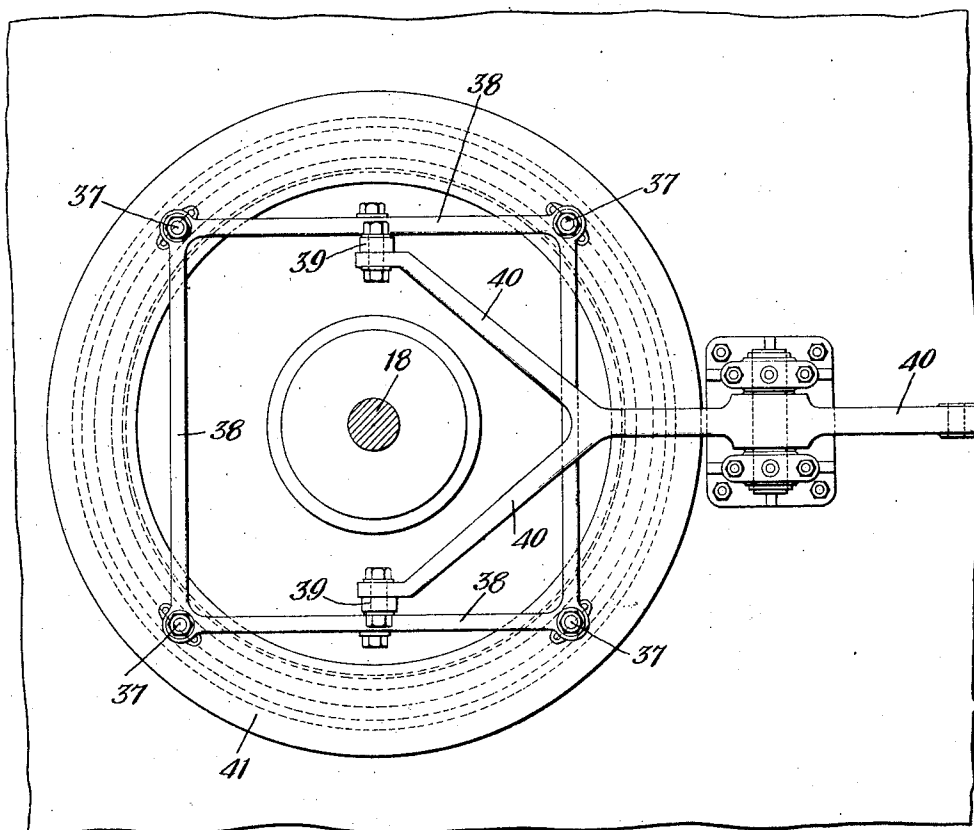


Fig. 3.

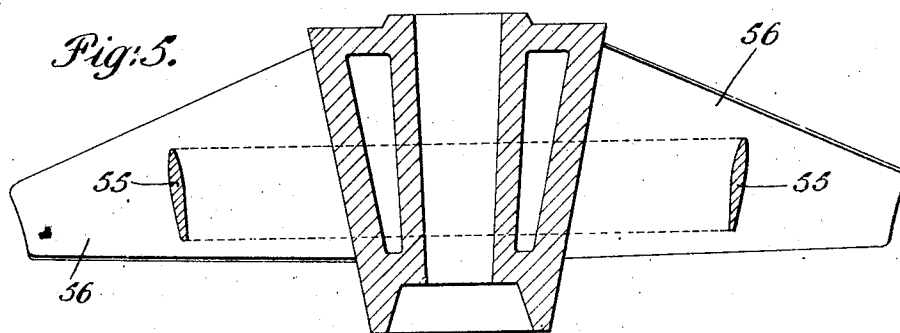
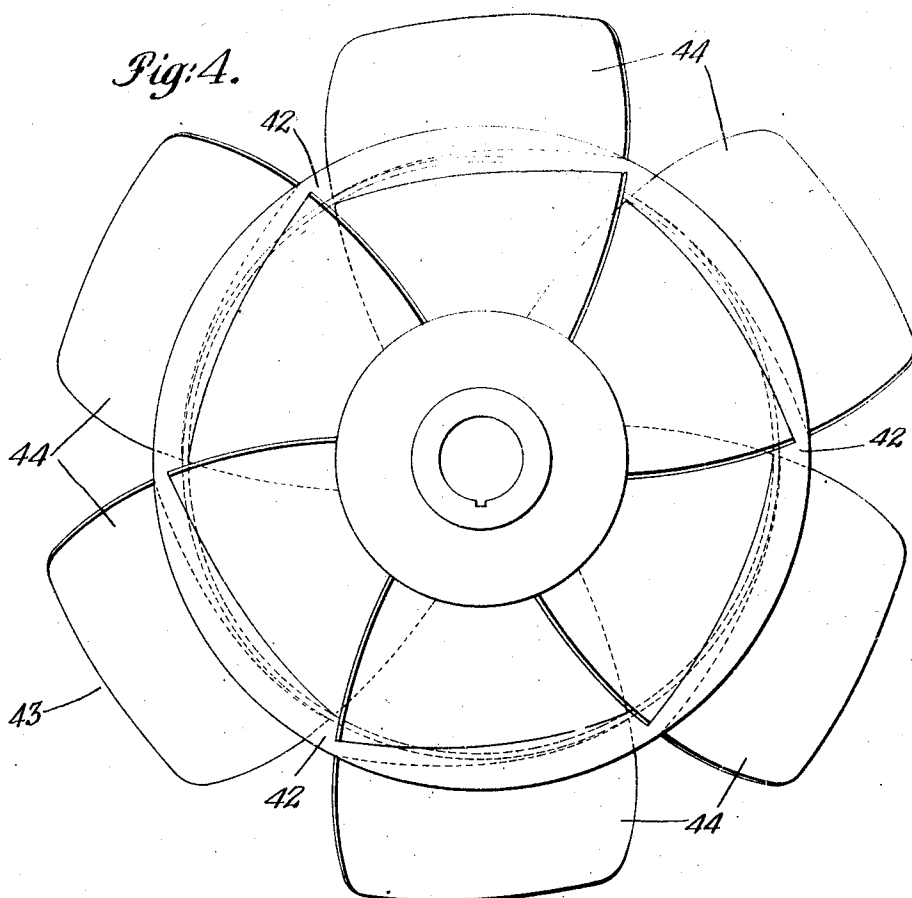
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5 Sheets-Sheet 4



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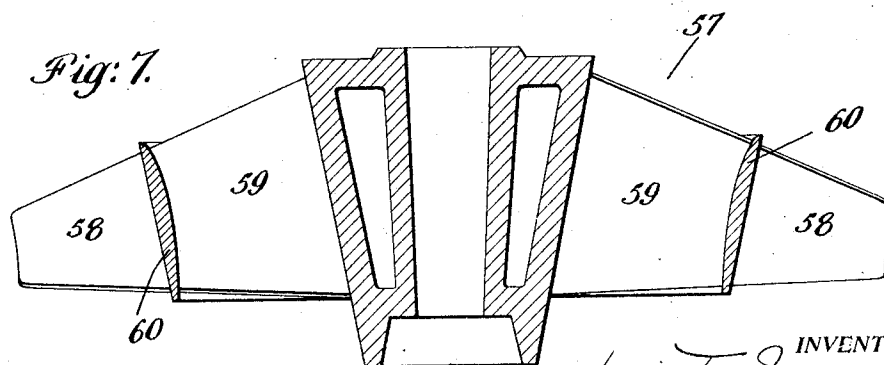
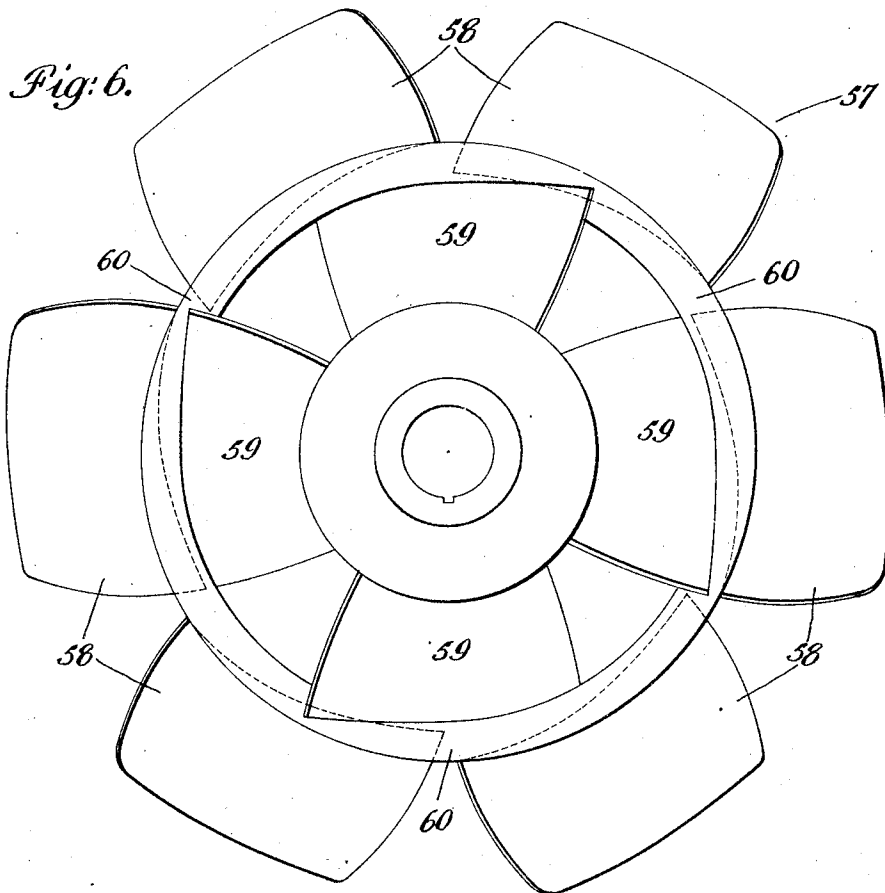
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HYDRAULIC TURBINE.

Application filed June 25, 1924. Serial No. 722,228.

This invention relates to hydraulic turbines and particularly to turbines of relatively high specific speed.

One object of the invention is to provide such a turbine in which the construction and operation will be simplified and cheapened by dispensing with the usual wicket gates and replacing them by a simple, sliding cylinder gate to control the flow with a transition space intervening between the gate and the entrance edges of the runner blades in order to insure steady, smooth and efficient action of the runner.

Another object of the invention is to provide a special, compound form of runner particularly adapted to cooperate with such a means of control.

A further object of the invention is to provide means for admitting air to the region behind the gate when in intermediate position.

In the accompanying drawings illustrating the invention

Fig. 1 is a vertical sectional view of the turbine showing a means of actuating the gate by fluid pressure;

Fig. 1^a is a sectional view showing a modified detail in the turbine of Fig. 1;

Fig. 2 is a vertical sectional view of a modified form of the turbine having mechanical means of actuating the gate and showing a special form of runner;

Fig. 3 is a plan view of the turbine of Fig. 2;

Fig. 4 is a plan view of the runner of Figs. 2 and 3 shown separately;

Fig. 5 is a transverse sectional view showing a modification of the runner of Fig. 4, and

Figs. 6 and 7 show, in plan and section, respectively, another modification of the runner.

In the embodiment of the invention shown in Fig. 1, water enters from the casing 10 and passes through the guide vanes 11 which are inclined or angularly disposed so as to give it a combined radial and tangential motion with respect to the turbine axis. It then passes through the transition space 12 which turns the radial components into an approximately axial direction and directs the water against a high-speed, unshrouded, propeller-type runner 13. The runner blades, as indicated in Figures 1 and 4, are adapted for high specific speed by having surfaces everywhere inclined downwardly and

rearwardly with respect to the runner rotation, these surfaces in their outer portions near the blade tips 13' being relatively flat and only slightly curved and having a direction more nearly tangential than axial. The water is discharged from the runner in a direction chiefly axial and with tangential components of reduced amount and enters the draft tube 14, which is preferably of the annular form shown, comprising the outer wall 15 and inner core 16. The draft tube gradually enlarges in the direction of flow to decelerate the velocity of discharge from the runner. The runner 13 contains the hub 17 keyed to the vertical shaft 18 which is laterally supported by the guide bearing 19. The bearing 19 is carried within the head cover 20 which is connected by the flange 21 with the pit liner 25 extending upward from the speed ring having vanes 11.

A casing or curb ring 22 surrounds the tips of the runner blades and forms the base for the stay vane ring 11, 25. The casting 22 may contain a removable seat ring 24 for the cylinder gate 26 or when desired may contain a removable and renewable liner 50 adjacent to the runner blade tips as shown in Fig. 1^a. This liner can be either in a single casting or in two or more sections and is held in place by suitable bolting. The lower ring 51 of the speed ring has the liner fitted to it by machining, the ring 51 being provided with annular shoulders 52, 53 supporting the liner 50 and permitting it to be removed upward. As shown the liner integrally carries the seat ring for the cylinder gate 26, but this seat may be separate where desired. When turbines of the propeller type are applied to fairly high heads, such a liner is advantageous in case corrosion develops in the casing surrounding the runner due to eddies formed adjacent to the runner blades, and the liner will have a further advantage of being renewable in case foreign material becomes lodged in the clearance space outside the runner blades and scores the surface of the wall.

The cylinder gate 26 slides between the upper distributor ring 23 and the head cover 20 and is actuated by the piston flange 27 sliding within the pit liner 25 which, with the head cover 20, forms an annular cylinder. Fluid pressure may be admitted or exhausted under control of the turbine governor through pipes 28 and 29 to lower or raise

the cylinder gate 26 and thus to regulate the flow through the turbine and thereby to control its load and speed.

With the cylinder gate 26 in fully open position, the flow entering through the intake 10 and combined guide and stay vanes 11 passes with combined radial and tangential components into the transition space 12 where it is turned downward toward the axial direction and on to the runner 13. In this transition space the streams from the passages between the vanes 11 are gathered together into a continuous rotating mass before being directed against the runner. At intermediate positions of the cylinder gate 26, the upper, inner portion of the flow will be partially cut off so that at partgate the flow will be delivered mainly at the outer ends of the runner blades.

When desired, air may be admitted to the inner portion of the transition space 12 so that the annular stream entering the transition space at partgate positions of the cylinder gate 26 will have an inner free surface within which the space 12 is free from the flow by the admission of air. The space behind the cylinder gate which would otherwise be occupied by water in a more or less eddying and turbulent condition will be replaced by air, and the loss of energy in such eddies will be reduced or avoided. At the same time the internal circulation within the runner occurring at partgate involving an upward flow near the hub and a return flow through the outer portions of the blades will be reduced. The air admitted through the pipe 30 which may be fitted with suitable valve or control means passes through the ports 31 into the transition space.

The cylinder gate 26 has relatively small radial thickness, so that in closing it occupies little volume, the volume of the transition space 12 remaining substantially constant. The cylinder gate is advantageous in being subject to but little hydraulic load and requiring little power to operate it, the governor power being required chiefly to overcome the friction of the gate. The gate mechanism is, in the arrangement shown, reduced to a single moving part of rugged construction and simple arrangement. This form of turbine is therefore simple and durable and relatively inexpensive, and is particularly suited to installations of small or moderate size under low or moderate heads.

The transition space and runner are of such form and so arranged with relation to the cylinder gate that the runner blades do not pass immediately through the region of turbulence behind the gate when in partgate position. Sufficient space is provided for the water to form a smoothly flowing, continuous body of water by the time it encounters the runner blades with but little turbulence then remaining, thus avoiding unsteadiness of

operation of the runner or corrosive effects on the runner blades.

A turbine of this form is well adapted to installations operating under relatively steady loads and where very high partgate efficiency is not important. An enclosed intake passage or casing 10 may be used as shown, this casing being preferably of volute form, or when desired, the turbine can be arranged for an open flume setting.

Fig. 2 shows a modified form of the turbine in which the cylinder gate is actuated by a gate mechanism similar to that shown instead of by the direct application of fluid pressure. This figure also illustrates a modified form of runner especially adapted to cooperate with the cylinder gate method of control. The form of runner shown in this figure is particularly adapted for more moderate values of specific speed and for a higher range of heads than the runner of Fig. 1.

In the turbine of Fig. 2, the cylinder gate 36 is shown in two positions—36 and 36'—the latter being indicated by dotted lines. The gate is actuated by draw rods 37 passing through stuffing boxes in the head cover flange 41. Fig. 3 indicates in plan view the arrangement of these draw rods which are connected by a frame or yoke 38. The yoke 38 is in turn raised and lowered by the lever 40 connected to the yoke by links 39 and actuated by any suitable operating means such as a fluid pressure piston and cylinder controlled by a governor.

The runner 43 is of a special compound type comprising two concentric series of vanes or blades one within the other, the two series being separated by an intermediate ring or partition 42 conforming to the flow lines through the runner. This ring connects the vanes together at an intermediate point between the hub and the tips. This ring thus carries on its exterior a series of unshrouded blades 44 having no further connection at their tips. This partition increases the mechanical strength of the runner by interconnecting all of the blades and is placed at such a radial position between the tips and hub that it provides both maximum mechanical strength and at the same time has a lower linear velocity through the water than it would have if placed at the outer tips of the blades. This reduced linear velocity correspondingly reduces the hydraulic surface losses due to the dragging of the ring through the water, since the water in contact with this ring has a lower relative velocity against the ring than would occur if the ring were located at the blade tips. The ring is also advantageous under partgate conditions of operation such as would occur with the cylinder gate in the position 36'. When the gate is in such position, the ring or partition will serve to guide the flow and to reduce the wasteful internal circulation of water within

the runner. In the partgate position 36', the flow will be approximately as indicated in broken lines.

In the turbine of Fig. 2, air admission to the transition space may be provided through the control valve 45, pipe 46 and ports 47.

Fig. 4 shows the runner drawn to a larger scale and indicates the subdivision of the blades by the partition ring.

Fig. 5 shows a modification comprising a partition ring 55 of reduced area having a smaller height than the runner blades 56. In this modification, the ring does not completely subdivide the runner and is less effective in guiding the flow. On account of its reduced area, this form of partition ring is better suited to higher specific speeds than the construction used in Figs. 2 and 4, merely sufficient area of partition being provided to act as a strut or stay between blades and thus to increase the mechanical strength of the runner.

In Figs. 6 and 7 a further modified form of runner is shown. This runner 57 is similar to that of Figs. 2 and 4 with the exception that the outer series of blades 58 contains a different number of blades from the inner series 59 within the partition 60. In this case four blades or vanes 59 are used in the inner series, this number being sufficient to provide proper guidance for the flow through the central portion of the runner, and six unshrouded blades 58 are used in the outer series where the circumferential distance around the runner is greater.

The compound forms of runners shown furnish a useful construction for the intermediate range of specific speeds between the high speed Francis or mixed-flow form of runner having an outer band or shroud ring and the unshrouded propeller type runners of still higher specific speed. On account of the added strength furnished by the partition ring, the inner series of blades can be made thinner or shorter or fewer in number than would be necessary in a simple unshrouded runner, and this can be accomplished without incurring the hydraulic losses due to an outer band or shroud. This compound form of runner is capable of securing increased partgate efficiencies as well as high maximum efficiencies in runners of moderately high specific speeds.

It will be noted in Fig. 4 that the inner series of blades if projected on to a plane normal to the runner axis would have a projected area at least as great as the annular passage formed between the runner hub and the circular partition 42, whereas the similarly projected area of the blade portions disposed outside of the partition 42 will be less than an annular passage formed between the partition 42 and a circle or casing surrounding the blade tips.

I claim:—

1. In a high specific speed turbine the combination with a runner having blades with surfaces which are everywhere inclined downwardly and rearwardly with respect to their rotation, of an intake for the flow to said runner, a substantially constant volume transition space between said runner and said intake turning the flow from radial toward axial, and an adjustable cylindrical gate surrounding said transition space and having relatively small radial thickness.

2. In a high specific speed turbine the combination with a runner having blades which are everywhere inclined downwardly and rearwardly with respect to their rotation, of an intake for the flow to said runner, a substantially constant volume transition space between said runner and said intake turning the flow from radial toward axial, and an adjustable cylindrical gate surrounding said transition space and having relatively small radial thickness.

3. In a high specific speed turbine the combination with a runner having a partition ring between the hub and the tips of the runner blades, of an intake for the flow to said runner, a transition space between said runner and said intake turning the flow from radial toward axial, and an adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner.

4. In a high specific speed turbine the combination with a runner having a partition ring between the hub and the tips of the runner blades, of an intake for the flow to said runner, a transition space between said runner and said intake having an inner surface turning the flow from radial toward axial, and an adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner, said partition ring curving toward an axial direction.

5. In a hydraulic turbine the combination with an unshrouded axial flow runner, means for directing to said runner actuating fluid having flow lines lying in a substantially axially extending surface, and a shaft for said runner, of a cover member for supporting a bearing for said shaft, a stay vane ring in the flow to said runner and supporting said cover member, and a cylindrical control gate sliding between said stay vane ring and said cover.

6. In a hydraulic turbine the combination with a runner of approximately axial flow type, of an intake for the flow thereto, means forming a transition space between said runner and intake, a cylinder gate surrounding said transition space, and air supply means to said transition space within said gate.

7. In a hydraulic turbine the combination with a runner, of an intake for the flow thereto, means forming a constant volume transi-

tion space between said runner and intake, air supply means for said transition space, and adjustable cylindrical gate mechanism surrounding said space operable to vary the flow while the volume of said space remains constant.

8. In a high specific speed turbine the combination with a runner, of an intake for the flow to said runner, a transition space between said runner and said intake turning the flow from radial toward axial, an adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner, and an air supply means to said transition space.

9. In a high specific speed turbine the combination with a runner having a partition ring between the hub and the tips of the runner blades, of an intake for the flow to said runner, a transition space between said runner and said intake having an inner surface turning the flow from radial toward axial, an adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner, and an air supply means to said transition space.

10. In a high specific speed turbine the combination with a runner of substantially axial flow type, said runner having blades with surfaces which are everywhere inclined downwardly and rearwardly with respect to their rotation, of an intake for the flow to said runner, a transition space between said runner and said intake having an inner surface turning the flow from radial toward axial, and an adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner.

11. In combination with a turbine having means forming an intake and discharge, of a runner receiving flow from said intake, and comprising a plurality of blades unshrouded at their tips and having an intermediate partition extending around the runner and connecting the blades between the hub and the blade tips, said partition being so positioned that a substantially axial flow initially engages the edge thereof.

12. In combination with a turbine having means forming an intake and discharge, of a runner receiving flow from said intake, and comprising a plurality of blades unshrouded at their tips and having an intermediate partition extending around the runner and connecting the blades between the hub and the blade tips, said partition being nearer to the tips than to the hub and so positioned that the entrance edge thereof is initially engaged by a substantially axial flow.

13. In combination with a turbine having means forming an intake and discharge, of a runner receiving flow from said intake, and comprising a plurality of blades unshrouded at their tips and having an intermediate par-

tion extending around the runner and connecting the blades between the hub and the blade tips, said partition curving between its entrance and discharge edges, the entrance edge being so positioned that a substantially axial flow will initially engage the same.

14. In a hydraulic turbine the combination of intake guide vanes directing the flow with radial components, guiding means forming a transition space turning the flow from radial toward axial, a runner receiving the flow from said transition space, a cylindrical control gate having a circular edge moving axially in said transition space and fluid pressure operated means for moving said gate to control the flow to the runner.

15. In combination, a hydraulic turbine runner comprising an inner series of vanes, a partition ring connecting the ends of said vanes, an outer series of unshrouded vanes extending outward from said partition ring and means forming an entrance and discharge for said runner.

16. A turbine having stationary guide vanes, a transition space of substantially constant volume and a runner, a cylinder gate sliding within said guide vanes, and a stationary inner wall forming the inner surface of said transition space within said gate and extending from said gate to said runner.

17. A turbine having a runner of approximately axial flow type, stationary guide vanes for directing the flow thereto, means forming a transition space between said guide vanes and runner, said transition space being bounded by a stationary wall which curves from radial towards axial, and a cylinder gate sliding within said guide vanes whereby said transition space maintains a substantially constant volume during variable gate control.

18. A turbine having stationary guide vanes, a transition space and a runner, the inner wall of the transition space being stationary and continuous in contour with the runner hub and a cylinder gate sliding within the guide vanes and located outside of the stationary wall of the transition space whereby said transition space maintains a substantially constant volume during variable gate control.

19. The combination with a runner having outwardly extending blades and an intermediate partition ring, of a draft tube having an outer wall and an inner central core forming between them an annular passage expanding in the direction of flow.

20. The combination with a runner having outwardly extending unshrouded blades and an intermediate partition ring, of a draft tube having an outer wall and an inner central core forming between them an annular passage expanding in the direction of flow.

21. The combination with a runner having outwardly extending unshrouded blades and

an intermediate partition ring, of a draft tube having an outer wall and an inner central core forming between them an annular passage expanding in the direction of flow, the discharge from said runner being substantially axial in direction.

22. In a hydraulic turbine the combination with a runner having unshrouded blades with an intermediate partition ring connecting said blades, of means for directing the flow to said runner comprising a transition space turning the flow toward the runner and an adjustable cylinder gate in said transition space.

23. In a hydraulic turbine the combination with a runner having unshrouded blades with an intermediate partition ring connecting said blades, of means for directing the flow to said runner comprising a transition space turning the flow toward the runner and a cylinder gate having a circular edge adjustable in the entrance portion of said transition space.

24. In a hydraulic turbine the combination of intake guide vanes directing the flow with radial and whirling components, guiding means forming a space turning the flow from radial toward axial between outer and inner concentric walls, a hydraulic turbine runner in said space having a plurality of blades, and a separate removable liner ring forming a part of the outer wall of said space adjacent to the outer end of said runner blades.

25. In a hydraulic turbine the combination of intake guide vanes directing the flow with radial and whirling components, guiding means forming a space turning the flow from radial toward axial between outer and inner concentric walls, a hydraulic turbine runner in said space having a plurality of blades unshrouded at their tips, and a separate removable liner ring forming a part of the outer wall of said space adjacent to said runner blade tips.

26. In a hydraulic reaction turbine the combination of intake guide vanes directing the flow with inward radial and whirling components, a runner, a cylinder gate between said guide vanes and runner, and air supply means admitting air to the flow between said gate and the runner.

27. In a hydraulic turbine, the combination with a runner having a hub and unshrouded blades extending therefrom, said blades within a certain annular area having a projected area in a plane normal to the runner axis not materially greater than the area of said annular area projected in the same plane, of an intake for the flow to said runner, a transition space between said runner and said intake turning the flow from radial toward axial, and an axially adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner.

28. In a hydraulic turbine the combination with a runner having blades the adjacent ones of which when viewed in an axial direction overlap one another in the portion near the axis and have open spaces therebetween in the portion near the periphery, of an intake for the flow to said runner, a transition space between the said runner and said intake turning the flow from radial toward axial, and an axially adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner.

29. In a hydraulic turbine the combination with a runner having blades which when viewed in an axial direction overlap one another in the portion near the axis and have open spaces between adjacent blades in the portion near the periphery, of an intake for the flow to said runner containing inclined guide vanes, a transition space between the said runner and said intake turning the flow from radial toward axial, and an axially adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner.

30. In a hydraulic turbine the combination with a runner having blades which when viewed in an axial direction overlap one another in the portion near the axis and have open spaces between adjacent blades in the portion near the periphery, of an intake for the flow to said runner containing inclined guide vanes, means forming a transition space between said runner and said intake for turning the flow from radial toward axial, an axially adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner, whereby said transition space forming means and said gate permit the volume of said space to remain constant during variable control of the gate mechanism.

31. In a hydraulic turbine the combination with a runner having blades which when viewed in an axial direction overlap one another in the portion near the axis and have open spaces between adjacent blades in the portion near the periphery, of an intake for the flow to said runner containing inclined guide vanes, means forming a transition space between the said runner and said intake for turning the flow from radial toward axial, an axially adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner, and means for supporting said runner below said transition space thereby to allow axial flow to said runner whereby said space forming means and gate mechanism permit the volume of said space to remain constant during variable control of the gate mechanism.

32. In a hydraulic turbine the combination with a runner having blades which in a radial plane overlie one another near the runner

axis, and blades adjacent their periphery being spaced to provide an axial open space therebetween, of an intake for the flow to said runner, a transition space between the runner and intake turning the flow from radial toward axial, and an adjustable cylindrical gate surrounding said space and having a circular edge controlling the flow to the runner.

33. In combination with a turbine having a runner provided with unshrouded blades and partitions intermediate the ends thereof, means for directing fluid flow simultaneously to each side of the partitions, and means for directing fluid flow to the blades on only one side of the partitions.

34. In a hydraulic turbine the combination with a runner provided with blades having partitions intermediate their ends, means for directing flow simultaneously to opposite sides of said partitions, means for directing fluid flow to said blades on only one side of said partitions, and means for supplying air to said blades on the other side of said partitions.

35. A hydraulic turbine runner having blades which when projected on a plane perpendicular to the runner axis overlies one another adjacent the runner hub, the blades adjacent their periphery being spaced so as to provide an axial open space, and a cylindrical gate for controlling flow to said runner and movable in a direction whereby fluid during all gate openings flows to the runner periphery.

36. A hydraulic turbine runner having two concentric annular water passages each passage containing a separate series of vanes the inner series having a projected area in a plane normal to the axis at least equal to the area of the respective annular passage projected in the same plane, while the outer series has a projected area less than that of its annular passage.

37. In combination with a turbine having means forming a substantially radial flow inlet, of a runner provided with blades and a partition intermediate the ends thereof, means for directing a substantially axial fluid flow from said radial inlet simultaneously to each side of the partition, and means for directing fluid flow on only one side of the partition.

38. In combination with a turbine having a runner provided with blades and a partition intermediate the ends thereof, means forming a vane free transition space, and adapted to direct an axial flow of fluid simultaneously to each side of said partition, guide vanes for whirling fluid flow through said transition space, means for directing fluid flow to the blades on only one side of said partition, and a draft tube for receiving fluid discharge from said runner and gradually

enlarging in the direction of flow to decelerate the velocity of the discharge fluid.

39. In a high specific speed turbine the combination with a runner having blades with surfaces upon which the water impinges and which are everywhere inclined downwardly and rearwardly with respect to the runner rotation, of an intake for the flow to said runner, a transition space between said runner and said intake turning the flow from radial toward axial, an adjustable cylindrical gate of relatively small thickness surrounding said transition space, and a draft tube gradually enlarging in the direction of flow for decelerating fluid discharge from the runner.

40. In a high specific speed turbine the combination with a runner having a hub and blades extending outwardly therefrom provided with an intermediate partition ring, of means forming an intake for said runner, guide vanes for whirling the flow to said runner and spaced therefrom to form a transition space therebetween, and a draft tube having an outer wall expanding in the direction of flow for decelerating fluid flow discharged from said runner on each side of said partition.

41. In a high specific speed turbine the combination with a runner having blades with surfaces which in their outer portions near the blade tips are inclined downwardly and rearwardly with respect to the runner rotation so as to have a direction more nearly tangential than axial, of an intake for the flow to said runner, means forming a substantially constant volume transition space between said runner and said intake, turning the flow from radial toward axial, and an adjustable cylindrical gate surrounding said transition space, said gate being of relatively small thickness whereby said transition space maintains its constant volume.

42. In a hydraulic turbine the combination with an unshrouded axial flow runner, means for directing a substantially axially progressing and whirling intake flow to said runner, and a shaft for said runner, of a cover member for supporting a bearing for said shaft, a stay vane ring in the flow to said runner and supporting said cover member, and an open-ended cylindrical control gate sliding between said stay vane ring and said cover.

43. The combination in a hydraulic turbine comprising means forming a flow passage, a runner disposed therein and having two concentric annular water passages separated by a partition, each passage containing a series of vanes, the outer series having a projected area in a plane normal to the runner axis which is less than the area of the annular passage containing said series when projected in the same plane.

44. The combination in a hydraulic turbine comprising a passage having a radial inward-flow entrance provided with fixed stay vanes disposed between opposed stationary walls of said passage, a runner in said passage, said stay vanes being angularly disposed whereby whirl is adapted to be imparted to the fluid flowing to said runner, and a cylinder gate movable across said entrance through a suitable opening in one of said stationary walls whereby said cylinder gate is spaced from said runner by a portion of said stationary wall being interposed therebetween.

45. The combination in a hydraulic turbine comprising a passage having a radial inward-flow entrance provided with fixed stay vanes disposed between opposed walls of said passage, a runner in said passage, said stay vanes being angularly disposed whereby whirl is adapted to be imparted to the fluid flowing to said runner, and a cylinder gate of single thickness movable across said entrance through a suitable opening in one of said walls, the inner and outer surfaces of said cylinder gate having sliding contact with the stationary wall portion of said passage.

46. The combination in a hydraulic turbine comprising means forming a passage having a radial inward-flow entrance provided with fixed stay vanes angularly arranged so as to impart whirl to the inflowing fluid and being disposed between, and in fixed relation at all times to opposed stationary walls of a stay vane ring, a runner in said passage, and a cylinder gate movable downwardly in a closing direction through an opening formed in the upper one of said stationary walls whereby the inner and outer peripheries of said cylinder gate are each adjacent to a stationary portion of said upper wall forming a part of the fluid passage.

47. The combination as set forth in claim 46 further characterized by having said cylinder gate disposed and movable relatively close to the edges of the stay vanes.

48. The combination as set forth in claim 46 further characterized by having said cylinder gate disposed on the inner side of the outermost portion of said stay vanes in relatively close juxtaposition thereto.

49. The combination as set forth in claim 46 further characterized by having said cylinder gate disposed adjacent to the inner edges of said stay vanes and adapted to engage the lower wall of said entrance passage when in closed position.

50. The combination as set forth in claim 46 further characterized by moving said cylinder gate by fluid pressure means which exerts a fluid pressure operating force in the direction of gate movement.

51. The combination in a hydraulic turbine comprising means forming an intake and discharge passage, a runner of the propeller type, having an annular passage with a series

of vanes therein and an intermediate partition ring connecting said vanes, the upper and lower edges of said ring terminating adjacent the upper and lower edges of said vanes.

52. The combination in a hydraulic turbine comprising means forming an intake and discharge passage, a runner of the propeller type, having an annular passage and a series of vanes disposed therein, and an intermediate partition ring connecting said vanes, said ring being provided with an approximately straight outer surface in meridian section.

53. The combination in a hydraulic turbine comprising means forming an intake and discharge passage, a runner of the propeller type having an annular passage and a series of vanes disposed therein, and an intermediate partition ring connecting the end of said vanes, the upper and lower edges of said ring terminating adjacent the upper and lower edges of said vanes and said ring being inclined to the runner axis.

54. The combination in a hydraulic turbine comprising a passage having an intake turning from a radial to an axial direction into a discharge portion, a runner disposed in said passage and having a hub carrying blades extending outwardly therefrom, said blades being provided with an intermediate partition ring whereby the blades are divided into an inner and outer series of vanes, and guide vanes for whirling the flow to said runner and being common to both of said series while the discharge portion of said passage comprises a draft tube having an entrance common to both of said series.

55. In a high specific speed turbine the combination with a substantially axial flow runner having a relatively small number of unshrouded blades which for the major portion of their radial distance are in transverse section more nearly horizontal than vertical, of an intake for the flow to said runner, a transition space between said runner and said intake turning the flow from radial toward axial, an adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner, and an air supply means to said transition space.

56. In a high specific speed turbine the combination with a runner, of an intake for the flow to said runner, a transition space between said runner and said intake turning the flow from radial toward axial, an adjustable cylindrical gate surrounding said transition space and having a circular edge controlling the flow to the runner, and an air supply means adapted to admit air to said transition space at a point immediately behind said cylindrical gate during part gate operation thereby reducing the tendency toward eddy currents in said transition space.

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