Feb. 24, 1925.

1,527,760

H. B. TAYLOR

ANNULAR JET TURBINE

Filed June 16, 1921

2 Sheets-Sheet 1

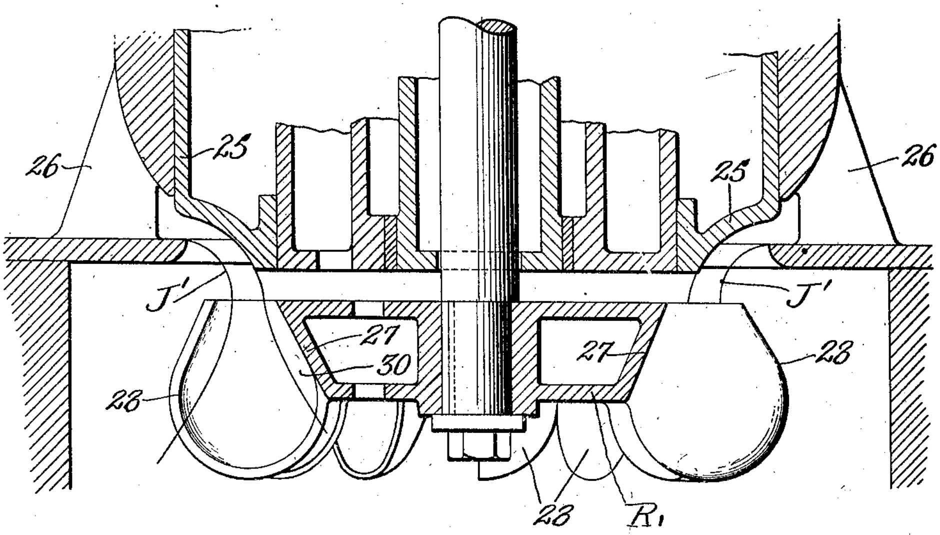



Fig:5.

Fig:1.

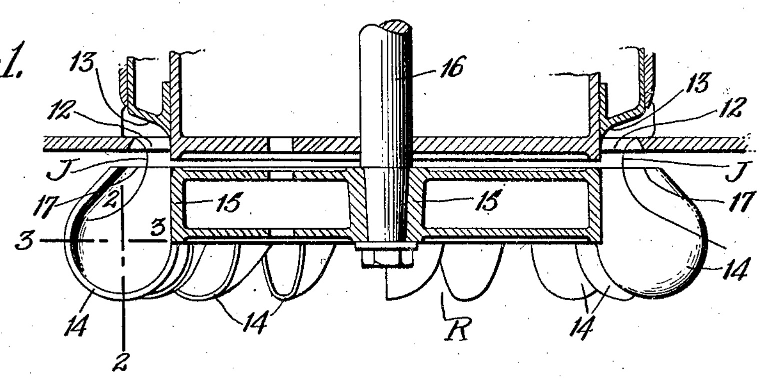
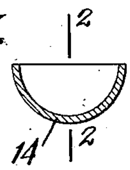



Fig:3.



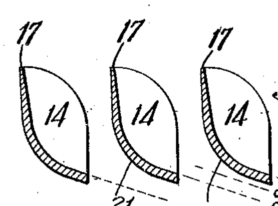




Fig:2.

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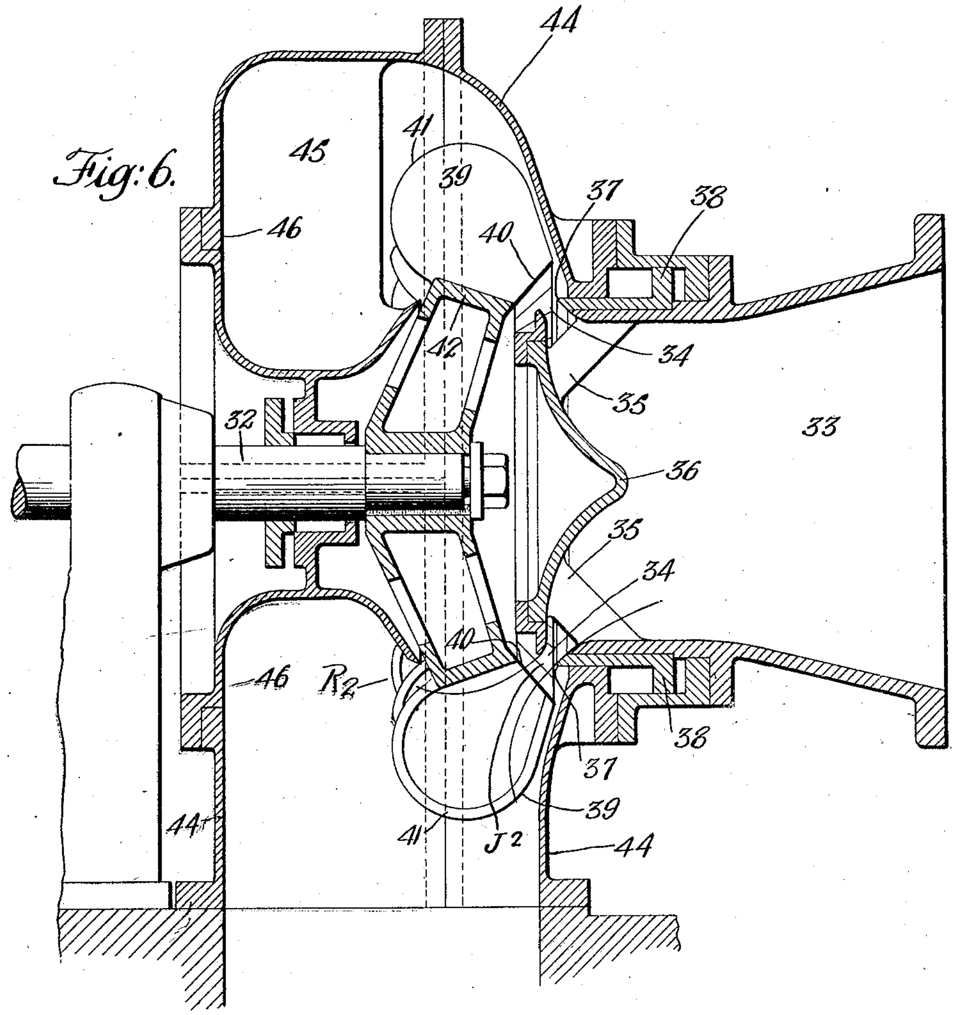
Fig: 6.



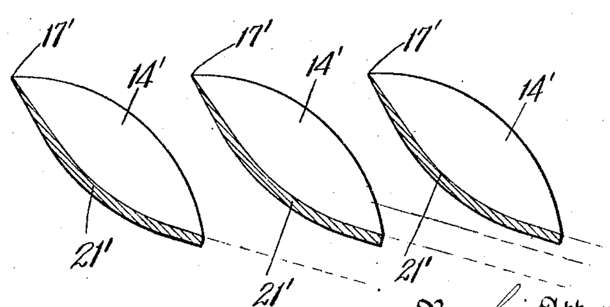




Fig: 4.

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# UNITED STATES PATENT OFFICE.

HARVEY BIRCHARD TAYLOR, OF PHILADELPHIA, PENNSYLVANIA.

## ANNULAR JET TURBINE.

Application filed June 16, 1921. Serial No. 477,891.

*To all whom it may concern:*

Be it known that I, HARVEY BIRCHARD TAYLOR, 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 Annular Jet Turbines, of which the following is a specification.

This invention relates to hydraulic turbines and particularly to turbines of the impulse type. The object of the invention is to provide such a turbine in which the jet will be of generally annular form so as to continuously act on all the runner buckets and to provide buckets for receiving the jet and efficiently guiding the stream lines so as to reduce frictional resistance.

Further objects of the invention particularly in the simple symmetrical formation of the buckets will appear from the following description taken in connection with the accompanying drawings, in which—

Fig. 1 is a vertical sectional view of a turbine illustrating the invention,

Fig. 2 is a sectional detail view on line 2—2 of Figs. 1 and 3,

Fig. 3 is a sectional detail view on line 3—3 of Fig. 1,

Fig. 4 is a section similar to Fig. 2 but illustrating a modification, and

Figs. 5 and 6 are views similar to Fig. 1 but illustrating modified forms of turbines.

In the embodiment of the invention shown in Figs. 1 to 3 the jet J passes downward out of annular orifice 12 the amount of the flow being controlled by varying the thickness of the jet by adjusting the position of the annular wedge 13 in orifice 12. The runner R comprises buckets 14 mounted on a central hub 15 on shaft 16. The hub 15 is cylindrical and the surfaces of the buckets curve into and merge with the cylindrical outer surface of this hub which is continuous between the buckets. The buckets 14 are cup shaped curving backward from the entrance edge 17, as shown in Fig. 2, which is a cross section as cut by a central cylindrical surface, and also curving backward from the vertical center on each side as indicated in Fig. 3 which shows a cross-section cut by a plane surface perpendicular to the axis of the turbine. A continuous shroud ring or band could be used to connect the buckets, but this would only be employed for mechanical reasons and to reduce windage, and would not have any hydraulic function, as it would not be in contact with the water. It will, in many cases, be preferable to omit a continuous band and to form each bucket 14 separately as shown, and when desired the buckets can be cast separately and bolted or otherwise attached to the hub. By the use of such cup shaped buckets, the water stream entering each bucket can be kept together so as to occupy a minimum volume, and have both its bucket surface and air surface reduced in order to keep the surface friction to the least possible value. The curved form of the bucket in a section normal to the flow, such as Fig. 3, prevents undue spreading of the water stream. If the stream is permitted to spread out it becomes an excessively thin sheet with consequent tendency toward roughening of the surfaces and spraying. The curvature of the bucket's transverse to the flow prevents this and tends to keep the water in a compact mass. At the same time, the bucket 14 has small dimensions and therefore does not create excessive windage. The discharge edges of the buckets are so proportioned that the discharged jet will just escape contact with the back 21 of the next succeeding bucket. The inflow edge 17 of the bucket as shown in Fig. 2 will be given an angle suitable to the relative direction of entrance of the jet with respect to the wheel.

The bucket shown in Figs. 1 to 3 is suitable for a moderate specific speed, the speed however being much higher than that of impulse turbines of the usual tangential type. If still higher specific speeds are desired, the inflow edge of the bucket would be inclined forward in the direction of rotation to suit a relative direction of entrance having a backward direction with respect to the wheel. This would be suitable for a high peripheral velocity of the runner and as shown in Fig. 4 the buckets 14′ have their entrance edges 17′ inclined forward, the discharge from the buckets being diagonally backward so as to clear the rear surfaces 21′ of the following buckets.

In Fig. 5 the jet J′ curves from radial to axial at its base and the thickness of the jet is controlled by the axially movable plunger 25 while an inclined direction or whirl may be imparted to it by the stay and guide vanes 26. The runner R′ has its hub conical at its peripheral surface 27 and the buckets 28 are cup shaped somewhat as in Figs. 1 to 3 but having their inner surfaces curving into and merging with this conical surface 27. The buckets 28 have a diagonal inward direction of discharge at the inner edges and a diagonal outward discharge at the outer edges thus differing from the corresponding axial and radial discharge from the buckets 14 of Figs. 1 to 3. In the Fig. 1 form the inner surface of the jet J is projected parallel to and in contact with the outer cylindrical surface of the hub 15 but in Fig. 5 the inner surface of the jet J′ does not contact with the conical surface 27 of the hub but leaves an intervening air space 30. Although in the embodiments shown the buckets are carried by a conical or cylindrical surface having straight line elements, these elements could be curved so that the buckets would merge with surfaces of revolution generated by a curved line.

In the embodiment of the invention shown in Fig. 6 the runner $R_2$ has its shaft 32 horizontal. The flow enters axially through casing 33 and passes out as jet $J_2$ through the diagonally directed annular orifice 34. The stay vanes 35 are inclined to give a whirl to the jet and carry the cap piece 36 at their inner ends. The outer edge 37 of orifice 34 is axially movable on annular piston member 38. As drawn the edge 37 in contact with the flow is narrow but if desired this can be widened to form a lip extending toward the buckets to reduce the distance traversed by the jet after leaving the orifice and before entering the runner.

The water enters the runner in a jet $J_2$ continuous around the periphery of the runner the flow being in a diagonally outward direction that is, away from the turbine axis. The buckets 39 are of the doubly curved or cup shaped type having inflow edges 40 inclined forward in the direction of rotation to suit a high peripheral velocity of the runner, and the outflow portion 41 of the bucket is deeply cupped so as to approach a semi-circular shape, in order to maintain a compact stream of water through the bucket. As shown, the jet will spread so as to discharge in greatly diverging directions from the bucket, it being possible with this cup-shaped type of bucket to have the discharge extend through an angle approaching almost 180°, and this can be done without requiring a large extent of surface in contact with the jet. In the arrangement shown, both the inner and outer surfaces of the jet are clear of contact with continuous bounding walls, but when desired the surface of the hub 42 could be made to conform with the inner surface of the jet.

The discharge from the runner is received in a discharge casing 44 which is generally cylindrical but contains a wedge-shaped dividing wall 45 in a vertical plane containing the axis, above the shaft 32. This dividing wedge 45 is for the purpose of separating the flow and leading it smoothly into the plane surface 46 which forms the end wall of the discharge casing.

Among the advantages of the turbine of Fig. 6 may be mentioned the simple form and small size of the nozzle casing 33, this portion of the turbine being of the smallest possible dimensions and therefore of minimum weight and cost for a given capacity of turbine. The discharge casing 44 which is of larger size, is not subject to the high pressure to which the intake casing is subjected, so that the discharge casing can be of reduced thickness and weight. It is thus seen that up to the point where the hydraulic pressure is reduced the water is contained within a casing of simple form and minimum dimensions. The outward diagonal direction of discharge permits the flow through the runner to be conducted in the shortest possible path, with minimum deflection, and the axial thrust is less than would be produced in a turbine of the axial flow type. With this axial supply type of impulse turbine the turbine units may be advantageously positioned in the power house with the unit shafts perpendicular to the long dimension of the power house, the units being supplied by a series of parallel pipes. With this arrangement each unit would be equipped with a thrust bearing which could be placed on the outward end of the generator shaft, that is, the opposite end from the turbine, to carry the axial component of the thrust of the jet upon the wheel buckets. The runner would be overhung on the end of the generator shaft so that a single unit shaft could be used. Another possible arrangement comprises the use of two turbines to drive each generator, these being placed at opposite ends of the generator with both runners mounted on the overhung ends of the generator shaft. In this case, the end thrust on the shaft would be balanced, and it would be sufficient to equip the bearings with thrust collars to preserve alignment and to carry any small unbalanced thrust which might occur. The water would in most cases enter the two turbines in a direction normal to the turbine axis, and would have to be turned through a right angle into the nozzle casing of each turbine. The units in the power house could either be placed with their shafts in line or with the shafts perpendicular to the long dimension of the power house.

I claim:

1. In an impulse turbine the combination with means for forming a free jet having components of flow parallel to the axis of the turbine runner, of a runner having buckets

with jet receiving surfaces curved transversely to the stream lines of the jet.

2. In an impulse turbine the combination with means for forming a free jet having components of flow parallel to the axis of the turbine runner, of a runner having buckets with jet receiving surfaces curved transversely to the stream lines of the jet on each side of said jet.

3. In an impulse turbine the combination with means for forming a free jet directed diagonally outward away from the axis of the turbine runner, of a runner having buckets with jet receiving surfaces curved transversely to the stream lines of the jet.

4. In an impulse turbine the combination with means for forming a free jet directed diagonally outward away from the axis of the turbine runner, of a runner having buckets with jet receiving surfaces curved transversely to the stream lines of the jet, said surfaces on their entrance edges being inclined forward toward the direction of motion of the runner.

5. In an impulse turbine the combination with means for forming an annular jet having axial components of flow, of a runner having buckets with jet receiving surfaces curved transversely to the stream lines of the jet.

6. In an impulse turbine the combination with means for forming an annular jet, of a runner having buckets with jet receiving surfaces curved transversely to and in the direction of the stream lines of the jet.

7. In an impulse turbine the combination with means for forming an annular jet, of a runner having buckets with jet receiving surfaces curved transversely and rearwardly with respect to the stream lines of the jet.

8. In an impulse turbine the combination with means for forming an annular jet, of a runner having buckets with jet receiving surfaces curved transversely and rearwardly with respect to the stream lines of the jet on each side of said jet.

9. In an impulse turbine the combination with means for forming an annular jet, of a runner having buckets with jet receiving surfaces curved transversely to the stream lines of the jet at first forwardly and then rearwardly with relation thereto.

10. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward from the axis, of a runner having buckets with jet receiving surfaces curved transversely to the stream lines of the jet.

11. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward from the axis, of a runner having buckets with jet receiving surfaces curved transversely to and in the direction of the stream lines of the jet.

12. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward from the axis, of a runner having buckets with jet receiving surfaces curved transversely and rearwardly with respect to the stream lines of the jet.

13. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward from the axis, of a runner having buckets with jet receiving surfaces curved transversely and rearwardly with respect to the stream lines of the jet on each side of said jet.

14. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward, of a runner having buckets arranged diagonally to receive said jet.

15. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward, of a runner having buckets arranged diagonally to receive said jet, and having jet receiving surfaces curved transversely with relation to the stream lines of said jet.

16. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward, of a runner having buckets arranged diagonally to receive said jet, and having jet receiving surfaces curved transversely and rearwardly with relation to the stream lines of said jet.

17. In an impulse turbine the combination with means for forming an annular jet directed diagonally outward, of a runner having buckets arranged diagonally to receive said jet, and having jet receiving surfaces curved transversely and rearwardly with relation to the stream lines of said jet on each side of the jet.

18. In an impulse turbine the combination with an axially directed inlet casing, of jet forming means supplied thereby adapted to direct an annular jet diagonally outward away from the axis, a runner having buckets receiving said jet and a discharge casing surrounding said buckets and receiving the discharge therefrom.

19. In an impulse turbine the combination with a horizontal axially directed inlet casing, of jet forming means supplied thereby adapted to direct an annular jet diagonally outward away from the axis, a runner having a horizontal shaft and buckets receiving said jet and a discharge casing surrounding said buckets and receiving the discharge therefrom.

20. In an impulse turbine the combination with means for forming a diagonally directed annular jet comprising plunger control means for regulating said jet, of buckets receiving said jet and extending diagonally outward around the axis.

21. In an impulse turbine the combination

with means for forming a diagonally directed annular jet comprising plunger control means for regulating said jet, of buckets receiving said jet and curved transversely.

22. In an impulse turbine the combination with means for forming a diagonally directed annular jet comprising plunger control means for regulating said jet, of buckets receiving said jet in cupped form.

23. In an impulse turbine the combination with means for forming a diagonally directed annular jet comprising plunger control means for regulating said jet, of buckets receiving said jet and extending diagonally outward around the axis, and a discharge casing collecting the flow from said buckets and comprising an upper portion having guiding surfaces leading the flow around the casing and discharging it downward.

24. In an impulse turbine the combination with means for forming a diagonally directed annular jet comprising plunger control means for regulating said jet, of buckets receiving said jet and extending diagonally outward around the axis, and a discharge casing collecting the flow from said buckets and comprising an upper portion having wedge formed guiding surfaces leading the flow around the casing and discharging it downward.

25. In an impulse turbine the combination with means for forming an annular jet, of a runner having buckets with jet receiving surfaces curved transversely with respect to the direction in which the stream lines enter the runner; and said surfaces at their entrance edges being inclined forward toward the direction of motion of the runner.

26. In an impulse turbine the combination with means for forming an annular jet, of a runner having buckets with jet receiving surfaces curved transversely with respect to the direction in which the stream lines enter the runner; and said surfaces at their entrance edges being inclined forward relatively to a plane containing the axis of the runner in a direction suited to a backward relative whirl of the entering water.

27. In an impulse turbine the combination of a runner with means for forming a jet extending around substantially the entire circumference of said runner, said runner containing buckets the jet receiving surfaces of which are curved in sections cut by planes containing the runner axis.

HARVEY BIRCHARD TAYLOR.