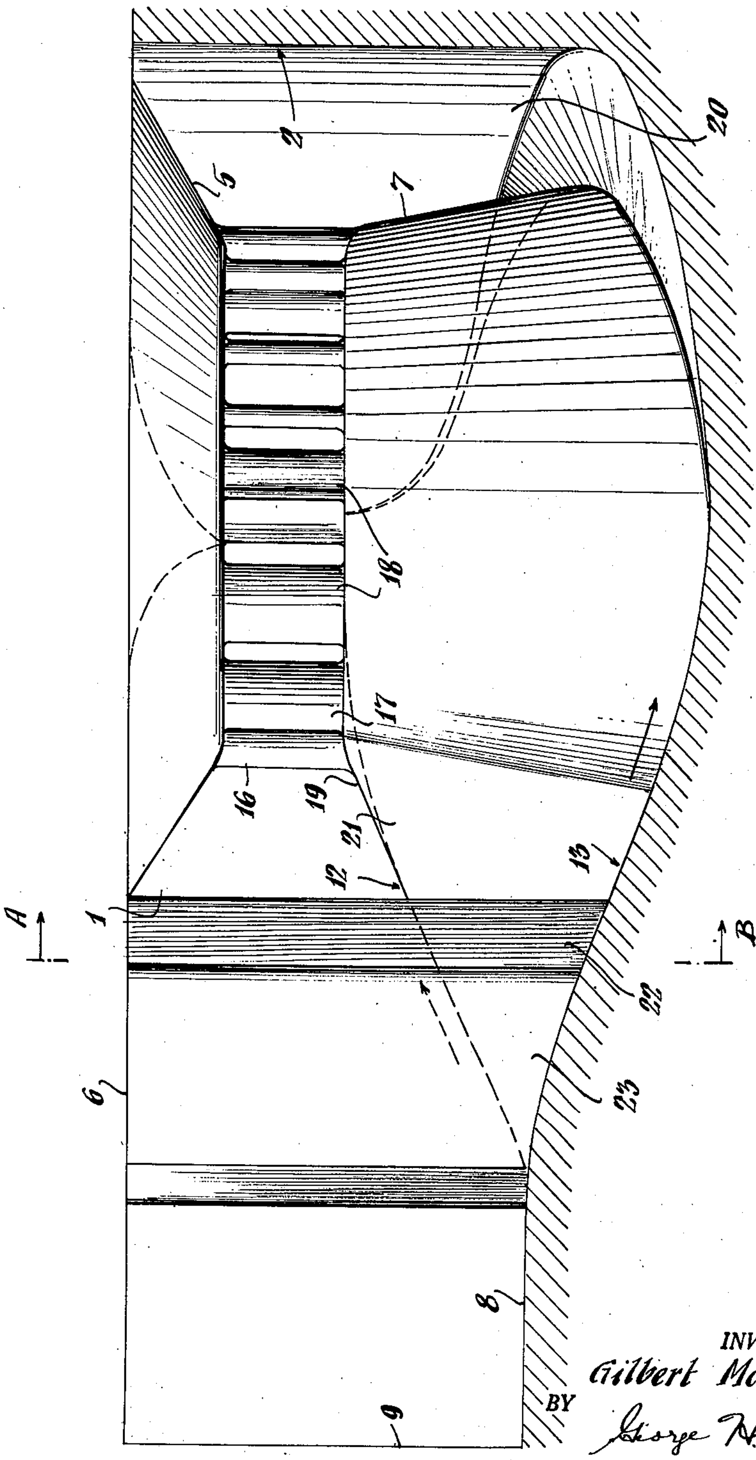
Dec. 11, 1956 G. MARTIN 2,773,666

SEMI-SPIRAL SCROLL CASE

Filed June 10, 1953 3 Sheets-Sheet 1

Fig. 1



INVENTOR.
Gilbert Martin
BY George H. Corey
ATTORNEY

SEMI-SPIRAL SCROLL CASE

Filed June 10, 1953 3 Sheets-Sheet 2

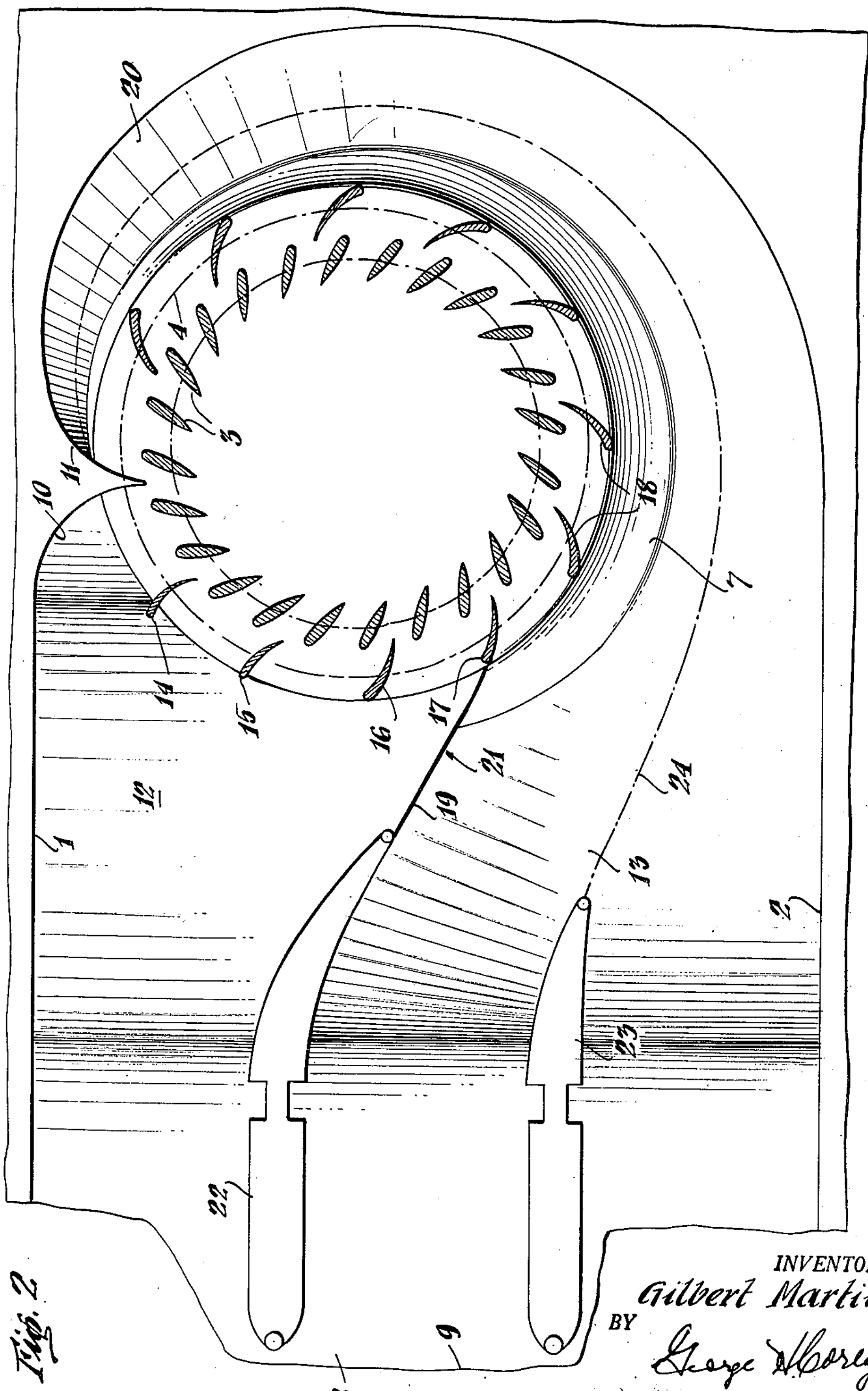


Fig. 2

INVENTOR.
Gilbert Martin
BY George H. Corey
ATTORNEY

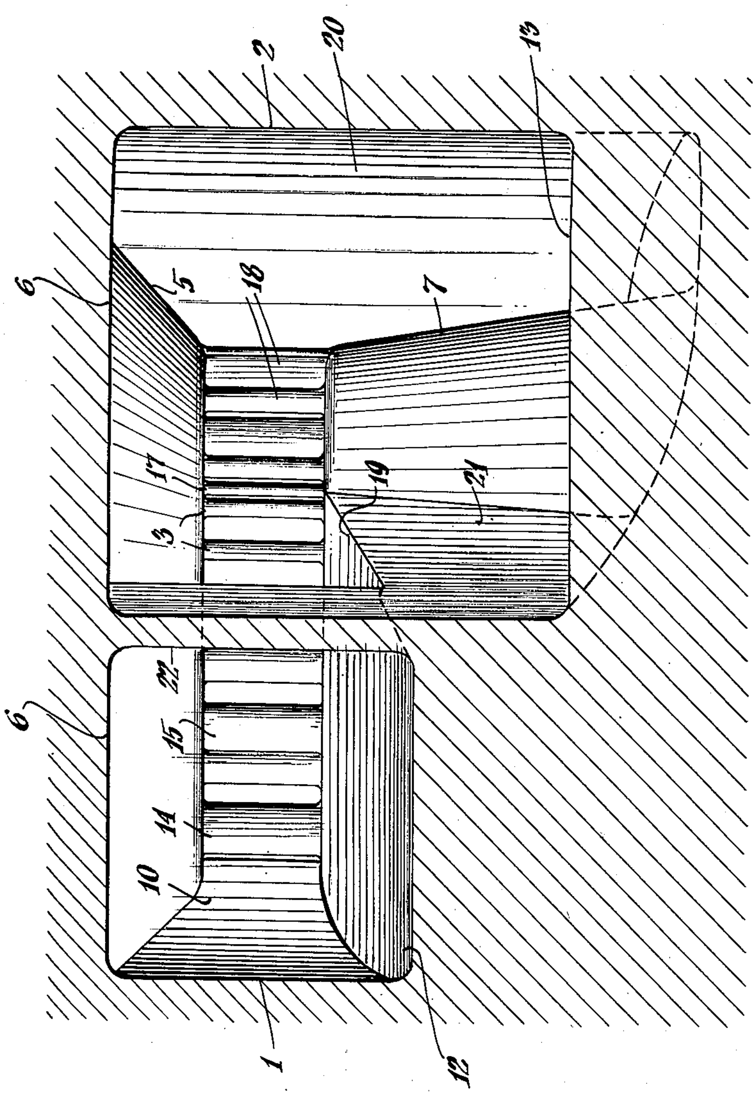


Fig. 3

INVENTOR.
Gilbert Martin
BY George H. Corey
ATTORNEY

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SEMI-SPIRAL SCROLL CASE

Gilbert Martin, Saint-Pierre d'Allevard, France, assignor to Etablissements Neyrpic, Grenoble, France, a corporation of France

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9 Claims. (Cl. 253—26)

This invention relates to hydraulic turbines. More particularly this invention relates to a fluid distribution system for a water turbine. Still more particularly this invention relates to an improved semi-spiral scroll case.

It is known that the water which operates either an axial flow or a centripetal flow water turbine ought to uniformly enter the speed ring and the wickets thereof. The uniform distribution of water between the stay vanes of the speed ring and between the wickets is usually accomplished by employing a spiral scroll case which encompasses these elements. In a spiral scroll case the cross section of the scroll case progressively diminishes in the direction of the flow of water therethrough. The width of a spiral scroll case is approximately equal to the sum of the diameter of the speed ring (stay vane assembly), the width of the intake section of the spiral scroll case through which passes the total flow and the diameter of the conduit of the scroll case diametrically opposite the inlet section of the scroll case and through which passes only a part of the total flow. The great width of a spiral scroll case is a disadvantage when, for example, one wishes to install a spiral scroll case together with a water turbine because the size or width of the scroll case limits the number of turbines capable of being installed in a dam of a given length.

In order to reduce the width of a hydroelectric power installation such as a turbine-generator unit, as well as that of the scroll case, which is usually the determining factor, it has been suggested that the spiral scroll case of the type suitable for use with a turbine of the Kaplan type, be replaced by the well-known semi-spiral scroll case. In a semi-spiral scroll case, the inlet or entrance of the scroll case opposite the distributor or wickets is limited laterally on one side by a first wall which extends almost tangentially to the speed ring (stay vane ring) and on the other side by a second wall which turns in a spiral around the speed ring and joins the first wall at about the place where it meets the speed ring.

In the type of semi-spiral scroll case employed heretofore, the water which enters the scroll case takes on a gyratory movement before it reaches the stay vanes due to the fact that the bottom of the scroll case a certain distance from the intake, progressively rises along the length of the wall which runs almost tangent to the speed ring, and from its junction with this wall the bottom of the scroll case takes on a transverse, downward slope extending in the direction of the other wall to about the vicinity where this wall assumes a spiral shape in order to encompass the stay vanes. Although at first it would appear that a semi-spiral scroll case is similar to a spiral scroll case, the flow through a semi-spiral case is different from that through a spiral scroll case. It has been found that the transverse slope of the bottom of the semi-spiral scroll case besides tending to impart a gyratory movement to the water, has the disadvantage of giving rise to or producing a disturbance or eddy extending around the stay vanes up to the spiral part of the scroll case and as a result disturbs the regularity of flow of water through the scroll case and the uniform distribution of the water to the turbine.

It is an object of this invention to provide an improved semi-spiral scroll case. It is another object of this invention to provide an improved semi-spiral scroll case particularly suitable for use with a hydraulic turbine of the Kaplan type. It is still another object of this invention to provide an improved semi-spiral scroll case or fluid distribution system conforming to the theoretical requirements necessary in order to achieve a uniform distribution of water to a water turbine. It is still another object of this invention to provide a semi-spiral scroll case having a reduced width whereby it is possible to install a greater number along a given length of a dam and at the same time to realize a substantial economy in the construction costs and in the equipment required to control the flow through the entrance of the scroll case. These and other objects of this invention and how they are accomplished will become apparent from the accompanying disclosure and drawing.

In accordance with this invention, the bottom of a semi-spiral scroll case or fluid distribution casing to a turbine at a suitable distance from the entrance or intake of the scroll case is divided to form two adjacent ramps of different slopes, one a frontal ramp sloped upwardly toward and terminating at the stay vanes directly in front of the ramp and opposite the entrance of the scroll case, one side of the frontal ramp terminating at the stay vane ring at about the location where its adjacent wall meets the stay vane ring and the other side of the frontal ramp terminating at the stay vane ring in a substantially tangential direction thereto. The frontal ramp encompasses about one-third of the stay vanes or stay vane ring. The other ramp herein called the spiral ramp, slopes downwardly and then upwardly in a spiral direction around the stay vanes and acts as the bottom of a fluid conduit supplying water to the remainder of the stay vanes. Thus, each ramp acts as the bottom of a fluid conduit, or path, the frontal ramp, generally more steeply sloped than the spiral ramp, serving as the bottom of a first fluid conduit which supplies water to about one-third of the stay vanes and wickets and the spiral ramp serving as the bottom of a second fluid conduit which spirals around the remaining two-thirds of the speed ring and supplies the water to the remaining two-thirds of the stay vanes and wickets. The difference in slope between these two adjacent ramps gives rise to the formation therebetween of a wall of increasing height which acts at its beginning as the inner wall of the spiral ramp and which is substantially perpendicular to both ramps.

Preferably, the frontal ramp approaches the stay vanes and spreads out in width, as indicated hereinabove, in the direction of the spiral ramp in such a manner that the edge of the frontal ramp adjacent the spiral ramp side ends in a direction tangent to the last of the stay vanes encompassed by the side of the frontal ramp. This last stay vane acts in a sense as a prolongation of the frontal ramp. On the other hand, the spiral ramp at first slopes downwardly or descends in order to compensate by an increase in height of the spiral fluid conduit for the decrease in width which was brought about by the enlargement or increase in width of the frontal ramp (frontal conduit). The increase in width of the frontal ramp gives rise to an obliquity of the inner wall of the spiral ramp, the upper end of the inner wall as indicated hereinabove, acts as the inside edge of the frontal ramp.

The lateral, outside wall of the frontal ramp curves inwardly and terminates at the speed ring in a horizontal curve of a relatively small radius giving rise, in effect, thereby, to a first stay vane. The curvature of this outside wall is such that the wall extends sharply inwardly toward the center of the stay vane ring and presents a substantially concave surface to the water moving up the frontal ramp. The remaining stay vanes intersected by the frontal ramp in the direction toward the other side of the frontal ramp from the outside wall of the frontal ramp gradually change in shape from a concave surface to a convex surface so that the last of the said vanes intersected by the inside edge of the frontal ramp assumes a shape which is substantially the converse of that formed by the lateral outside wall of the frontal ramp at the position where it projects into the stay vane ring. This last intersected stay vane can be considered a prolongation of the inside edge of the frontal ramp since it is substantially tangent thereto. The remaining two-thirds of the stay vanes have a shape which is substantially the same as said last intersected stay vane.

In a preferred embodiment of the improved semi-spiral scroll case of this invention, particularly suitable for use with a Kaplan type turbine, the rectangular entrance or intake of the scroll case is divided or partitioned along its width into three sections. The frontal ramp makes up one-third of the width of the entrance and the spiral ramp makes up the other two-thirds of the entrance width. In this arrangement the stay vane ring is supported on a truncated conical foundation having walls which are almost vertical. The foundation provides the inside wall of the spiral ramp and also part of the wall dividing the frontal ramp from the spiral ramp. Two vertical guides or partitions are provided at the entrance of the scroll case to divide the entrance into three sections of equal width, one of said guides extends along the boundary between the frontal and spiral ramps and the other guide is located along the center line of the spiral ramp or conduit. Both guides extend only a limited distance downstream in the direction of flow from the entrance of the scroll case.

As a result of this arrangement of the scroll case, a complete and definite separation of two fluid paths or streams, at first contiguous, takes place. The paths follow the two ramps and serve to supply the water to the two conduits of the scroll case, i. e. the frontal and the spiral conduits. Contrary to the usual semi-spiral scroll case, the bottom of a scroll case made in accordance with this invention does not interfere with any part of the fluid flow, such as would occur by interposing an oblique surface in the fluid stream thereby giving rise to a disturbance in the fluid flow. A semi-spiral scroll case in accordance with this invention, does not give rise to the formation of a disturbance such as an eddy in the fluid streams even though the two fluid streams are adjacent at the entrance of the scroll case and are actually contiguous where both meet the stay vanes.

The invention will now be described with reference to an installation suitable for employing a Kaplan-type turbine and to the accompanying drawing wherein:

Fig. 1 is a side view partly in section taken along the side of the spiral ramp, the lateral exterior wall of the spiral ramp having been removed;

Fig. 2 is a plan view of the semi-spiral scroll case in accordance with the invention as shown in Fig. 1; and

Fig. 3 is a vertical view partly in section of the scroll case taken along the line A—B of Fig. 1.

Referring now to the drawing, wherein like parts are designated by the same reference numerals, the width of the scroll case is defined by the distance between lateral walls 1 and 2. In order to simplify the drawing of this invention, the turbine rotor has not been illustrated and only the wickets 3 of the distributor have been shown.

The scroll case encompasses the stay vanes, the center line of which is indicated at 4, said stay vanes being designated as 14, 15, 16, 17 and 18. The stay vanes connect the opposed terminal surfaces of truncated conical projections 5 and 7. Projection 5 extends downwardly from the plane of the upper horizontal wall 6 of the scroll case and projection 7 has outwardly flaring lateral walls which are somewhat inclined from the vertical, usually by a minor amount, say 10° more or less. Projection 7 as illustrated in Fig. 1, projects upwardly beyond the plane of the horizontal bottom section 8 of the inlet of the scroll case.

Starting from the entrance of inlet 9 of the scroll case, which inlet is rectangular in cross section, vertical exterior wall 1 which is closer to the center of stay vane circle 4 than wall 2, extends inwardly toward the stay vanes and wickets and terminates with a sharply curved, inwardly extending surface 10, within the space defined between the adjacent ends of projections 5 and 7. The inwardly extending section 10 of wall 1 presents a concave surface toward the inlet of the scroll case and acts as a first stay vane. The other lateral wall 2 extends around the stay vanes in a spiral and joins wall 1 at 11, thereby forming at 11 the rear surface of lateral wall-stay vane 10. Bottom 8 of the entrance of the scroll case is divided along its width into three sections of equal width by partitions 22 and 23. Also in accordance with this invention, bottom 8 is divided into two ramps 12 and 13 of different slopes.

Ramp 12 adjacent wall 1 extends upwardly from bottom 8 to the top of projection 7 and is sloped in the manner of an inclined plane and increases in width as it approaches the passages between stay vanes 14, 15, 16 and 17. Ramp 12 intersects about one-third of the circumference of the stay vane ring, the center line of which is designated at 4, which is equivalent to about one-third of the circumference of the upper end of projection 7. Ramp 12, therefore, directs about one-third of the total amount of water entering the scroll case into the openings between wall-stay vane 10 and the first four stay vanes 14, 15, 16 and 17. The stay vane 14 extending toward the entrance is strongly curved inwardly in the manner of wall-stay vane 10 so as to present a concave surface in the direction of the entrance. The cross-sectional contours of the stay vanes 15, 16 and 17 change progressively in shape from concave to convex until stay vane 17, which has the same form as the remaining stay vanes 18. The edge 19 of ramp 12 ends at stay vane 17.

The other ramp 13 at first descends and then ascends and forms the bottom of spiral conduit 20. Ramp 13 has at first a relatively small slope downward and then upward until it approaches the end of conduit 20 where the slope of ramp 13 sharply increases. Ramp 13 terminates at the upper surface of projection 7. The difference in slope between the two contiguous ramps 12 and 13 gives rise to wall 21, the top 19 of which is the inside edge of ramp 12. Wall 21 gradually increases in height and terminates by junction with projection 7. Wall 21 is substantially vertical and extends downwardly, substantially perpendicular to ramp 13 and substantially perpendicular to or slightly inclined with respect to vertical projection 7. Conduit 20 acts somewhat as a freeboard canal. As illustrated, conduit 20 compensates by an increase in height for the reduction in width brought about by the enlarged end of ramp 12. This increase in height of conduit 20 takes place substantially along the straight line length of vertical wall 21, to about the point diametrically opposite the position where lateral wall 1 curves sharply inwardly to form wall-stay vane 10.

The progressive widening of ramp 12 does not compensate for the progressive decrease in the available vertical space above ramp 12 and accordingly influences the velocity of the fluid along this ramp. The profile of ramp 13 is designed in such a manner as to assure the same acceleration of the fluid flow therealong as along frontal ramp 12. The surfaces of ramps 12 and 13 in transverse cross section are horizontal and parallel to the plane of the distributor.

It should be noted that ramps 12 and 13 supply in effect two different parts of the distributor (stay vane ring). Ramp 12 directly serves to supply stay vanes 14, 15, 16 and 17 with a fluid stream which enters between the stay vanes in a substantially parallel direction. Ramp 13 supplies the rest of the stay vanes in much the same manner as a conventional spiral scroll case or a conventional semi-spiral scroll case.

The frontal distribution of the water to only a few of the stay vanes is a characteristic of this invention and eliminates providing in front of the stay vanes a bottom having a transverse slope in order to increase the gyratory motion of the entering water stream so as to assure, as in a semi-spiral scroll case, a fluid distribution equal to that effected by a spiral scroll case. In the arrangement according to this invention, the eddies which arise when a fluid stream impinges and flows upon an oblique surface and which give rise to an irregular fluid flow and distribution are eliminated.

Accordingly, in a scroll case in accordance with this invention, the water is led up to the stay vanes by conduits, the bottoms of which are substantially straight and horizontal and the lateral walls of which are substantially perpendicular. A correct design or proportioning of the successive portions or sections of these conduits assures a regular and even fluid flow therethrough, those conditions which normally give rise to a disturbance in the regularity of fluid flow having been eliminated by this invention.

As indicated hereinbefore, the entrance of the scroll case can be divided along its width by the usual guides, for example, guide **22**, defining the border between ramps **12** and **13** and guide **23** extending along the center line **24** of conduit **20**.

The scroll case of this invention allows for a reduction in width of a semi-spiral scroll case and at the same time achieves a more uniform and equal distribution of water through the stay vanes and wickets to the turbine. A uniform distribution of water to the turbine is particularly desirable since it improves the operating efficiency of the turbine.

Although this invention has been described as particularly applicable to a semi-spiral scroll case and has been described with reference to an installation suitable for a Kaplan-type turbine, it is pointed out that similar improvements in accordance with this invention, may be made and incorporated into a spiral scroll case and that this invention is applicable to installations and scroll cases for use with other types of turbines such as the Francis-type turbine.

I claim:

1. An improved semi-spiral scroll case comprising a frontal fluid conduit having a bottom surface that increases in width and slopes upwardly downstream along its longitudinal axis, said frontal conduit carrying about one third of the total fluid flow through said scroll case, and a separate spiral fluid conduit carrying the remaining fluid flow through said scroll case and having an upstream portion adjacent said frontal conduit and a downstream portion extending therebeyond, said upstream portion having a bottom surface that slopes downwardly downstream along its longitudinal axis, said downstream portion having a bottom surface that slopes upwardly downstream along its longitudinal axis.

2. An improved semi-spiral scroll case comprising an inlet orifice, a frontal fluid conduit leading from said inlet orifice and having a bottom surface that slopes upwardly downstream along its longitudinal axis, and a separate spiral fluid conduit leading from said inlet orifice and having an upstream portion adjacent said frontal conduit and a downstream portion extending therebeyond, said upstream portion having a bottom surface that slopes downwardly downstream along its longitudinal axis, said downstream portion having a bottom surface that slopes upwardly downstream along its longitudinal axis.

3. A fluid distribution system for a water turbine comprising in combination a semi-spiral scroll case, an inlet passage to said scroll case and a speed ring together with stay vanes associated therewith enclosed by said scroll case, said inlet passage having a bottom portion formed of two adjacent ramps of different slope, one constituting the bottom of a linear frontal fluid conduit and the other constituting the upstream portion of an adjacent spiral fluid conduit, said frontal conduit being defined on one side by an outside lateral wall which is curved inwardly adjacent the downstream end thereof toward said speed ring with its terminal portion presenting a convex surface positioned to guide fluid toward said speed ring and constituting one of the members of the stay vane assembly, said frontal conduit having its bottom ramp portion sloping upwardly and increasing in width toward said speed ring, said adjacent upstream portion of the spiral fluid conduit having its bottom ramp portion sloping downwardly and decreasing in width toward said speed ring and said spiral fluid conduit having a continuation of said bottom surface that slopes upwardly downstream along its longitudinal axis, and a vertical partition wall extending longitudinally of said inlet passage from adjacent the entrance thereof toward said speed ring along the dividing line between said bottom ramps.

4. An improved semi-spiral scroll case wherein the water flowing through the inlet of said scroll case is substantially equally distributed to the turbine runner through passages between the stay vanes within said scroll case, comprising an entrance passage having a bottom portion divided to form two adjacent ramps of different slope, one increasing in width and sloping upwardly downstream along its longitudinal axis to the level of the stay vanes to define the bottom wall of a frontal fluid conduit leading from said inlet toward said runner to encompass about one-third of said stay vanes and the other sloping downwardly and decreasing in width downstream along its longitudinal axis to a point adjacent the medium line of said runner, said spiral conduit including a downstream portion having a bottom surface that slopes upwardly and decreases in width downstream along its longitudinal axis in a spiral path around and toward the level of said runner.

5. An improved semi-spiral scroll case containing an inlet passage comprising a bottom surface, a ceiling and two lateral side walls on either side of said bottom surface extending to said ceiling, two opposed truncated projections, one an upper, truncated, inverted substantially conical projection extending below said ceiling, and the other a lower, truncated, substantially conical projection extending above said bottom surface, a ring of stay vanes connecting the opposed ends of said projections, the center of the ring of stay vanes being displaced from the center line of said bottom surface toward one of said walls, vertical partitions dividing said bottom surface into three sections of substantially equal width, a first section of said bottom surface adjacent the wall toward which the center of the stay vanes is displaced being upwardly inclined toward the top of said lower projection, forming thereby an upwardly inclined linear frontal ramp, said frontal ramp being gradually increased in width to encompass about one third of the circumference of the top of said lower projection upon junction therewith, the lateral wall toward which the center of the stay vanes is displaced extending along the length of said frontal conduit and being curved inwardly to and terminating within the ring of said stay vanes, the other sections of said bottom surface forming a spiral ramp, that portion of said spiral ramp adjacent said frontal ramp being inclined downwardly downstream along its longitudinal axis to about the point diametrically opposed to the point where said lateral wall is curved inwardly within said speed ring, the remaining portion of said spiral ramp being inclined upwardly and decreasing in width as it curves around said lower projection to a point of termination adjacent the point of entry of said lateral wall into said speed ring.

6. An improved semi-spiral scroll case comprising

stay vanes located within said scroll case, a linear frontal conduit leading to said stay vanes, said frontal conduit having a bottom surface that is upwardly sloped and widened along its longitudinal axis toward said stay vanes to encompass about one third of said stay vanes, and a separate spiral fluid conduit leading to and encompassing the remainder of said stay vanes, said spiral conduit having an upstream portion adjacent said frontal conduit and a downstream portion extending therebeyond, said upstream portion having a bottom surface that slopes downwardly downstream along its longitudinal axis, said downstream portion having a bottom surface that slopes upwardly downstream along its longitudinal axis and extends to a point of termination on the level of said stay vanes substantially diametrically opposite that point where said bottom surface of said spiral conduit commenced to slope upwardly.

7. An improved semi-spiral scroll case wherein the water flowing through the inlet of said scroll case is substantially equally distributed to the passages between the stay vanes within said scroll case, comprising a linear frontal fluid conduit carrying about one-third of the total water flow through said scroll case and an adjacent spiral fluid conduit carrying the remaining portion of the total water flow through said scroll case, said frontal conduit being provided with a bottom surface which is upwardly sloped downstream along its longitudinal axis and gradually widened to a width encompassing about one-third of the stay vanes within said scroll case, said spiral fluid conduit being provided with a bottom surface which is downwardly sloped downstream along the portion of the length thereof adjacent said frontal conduit and upwardly sloped downstream along the remaining portion of said bottom surface, said spiral conduit encompassing the remaining stay vanes not encompassed by said frontal conduit.

8. In a semi-spiral scroll case for evenly distributing the water flowing through the inlet of said scroll case between the stay vanes within said scroll case, the combination of a straight, frontal fluid conduit, and an adjacent spiral fluid conduit, said frontal conduit being provided with a bottom surface sloping upwardly from the inlet of said scroll case to said stay vanes and defined on one side by a lateral wall perpendicular to the bottom surface of and extending along the length of said frontal conduit, said frontal conduit being gradually widened in the direction toward and encompassing about one-third of said stay vanes, said spiral conduit being defined on the side remote from said frontal conduit by an outside lateral wall perpendicular to the bottom surface of and extending along the length of said spiral conduit, that portion of the bottom surface of said spiral conduit adjacent said frontal conduit being downwardly sloped downstream along its longitudinal axis and the remaining portion of the bottom surface of said spiral conduit being upwardly sloped downstream along its longitudinal axis to a point of termination adjacent the level of said stay vanes on the side of said scroll case adjacent the lateral wall side of said frontal conduit.

9. An improved semi-spiral scroll case enclosing a turbine speed ring comprising a frontal conduit delivering fluid frontally to said speed ring and having a bottom surface that increases in width and slopes upwardly along its longitudinal axis toward said speed ring, and a separate spiral conduit delivering fluid to the sides and the rearward portion of said speed ring, said spiral conduit having an upstream portion adjacent said frontal conduit and a downstream portion extending therebeyond, said upstream portion having a bottom surface that slopes downwardly and decreases in width downstream along its longitudinal axis to a point adjacent the median line of said speed ring which extends at right angles to the longitudinal axis of said frontal conduit, said downstream portion having a bottom surface that slopes upwardly and decreases in width downstream along its longitudinal axis in a spiral path around and to the level of said speed ring.

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