Dec. 16, 1930. G. A. SCHLOTTER 1,785,460

PUMP OR THE LIKE

Filed Feb. 27, 1926 3 Sheets-Sheet 1

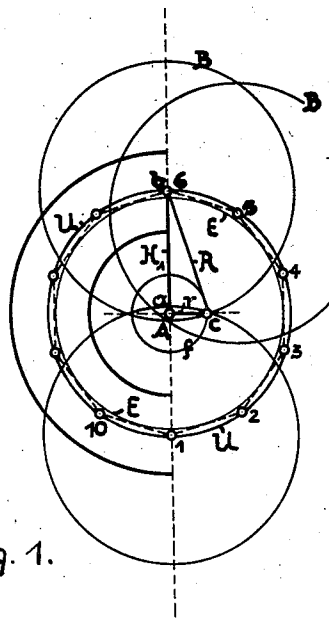


Fig. 1.

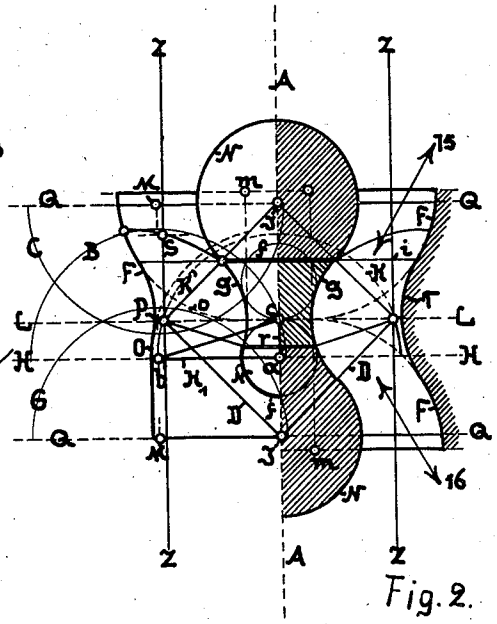


Fig. 2.

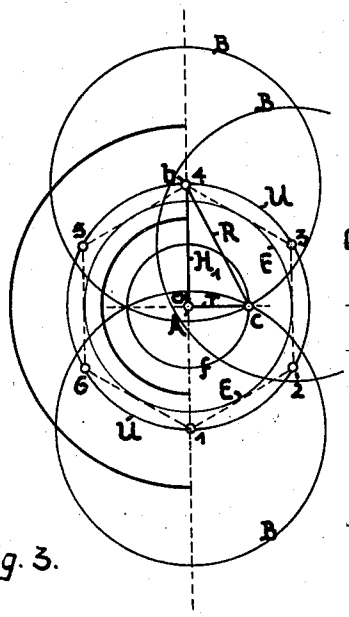


Fig. 3.

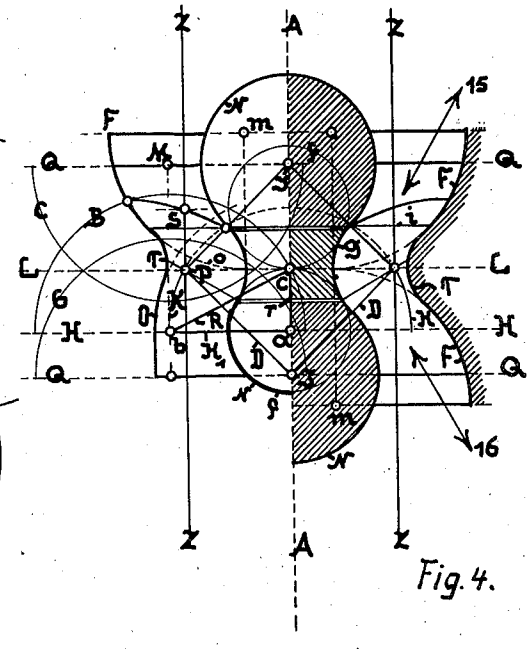


Fig. 4.

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Dec. 16, 1930. G. A. SCHLOTTER 1,785,460

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Filed Feb. 27, 1926 3 Sheets-Sheet 2

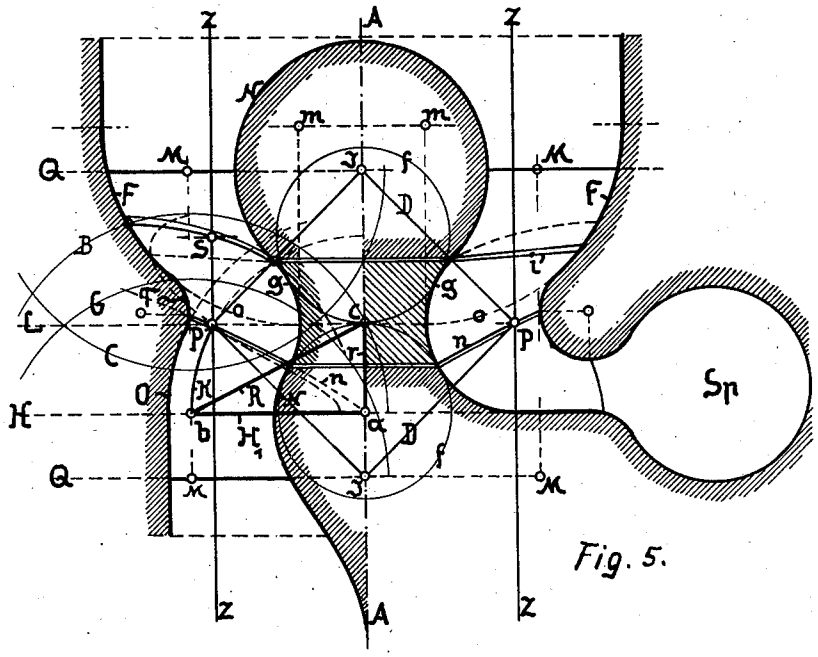


Fig. 5.

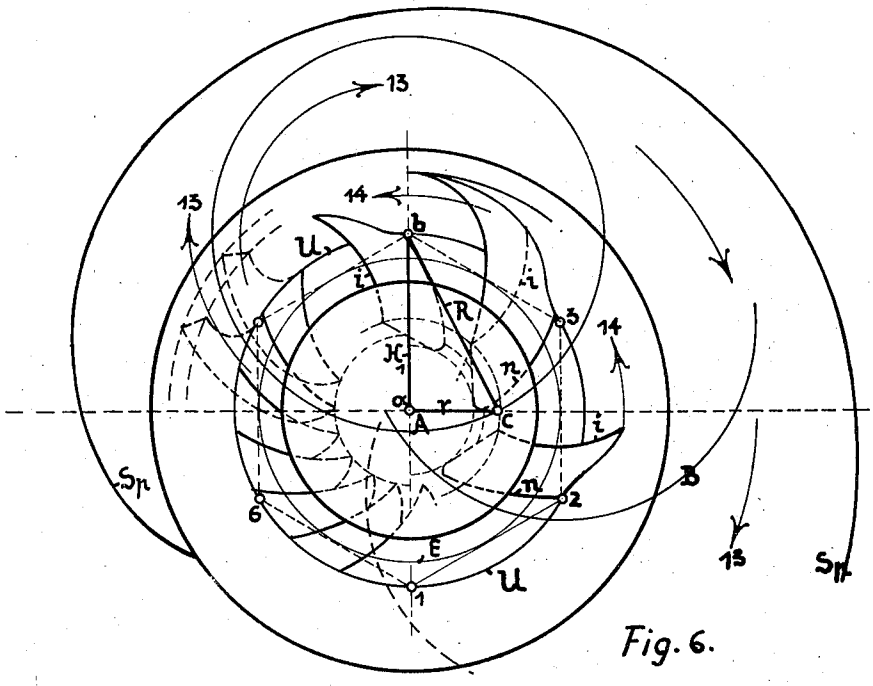


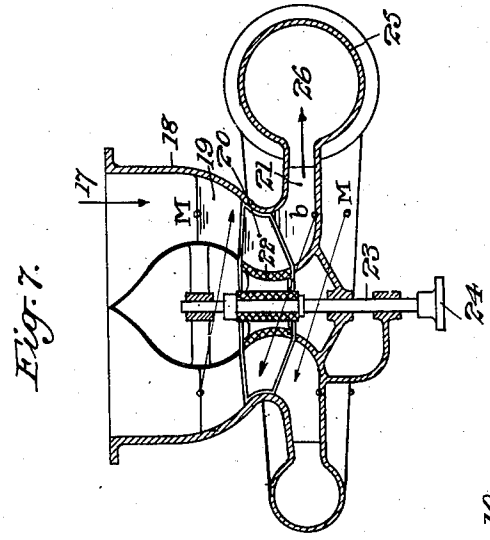
Fig. 6.

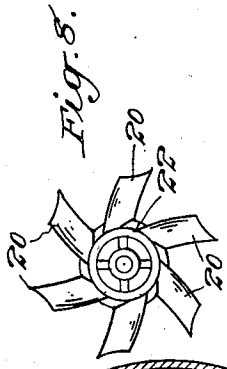
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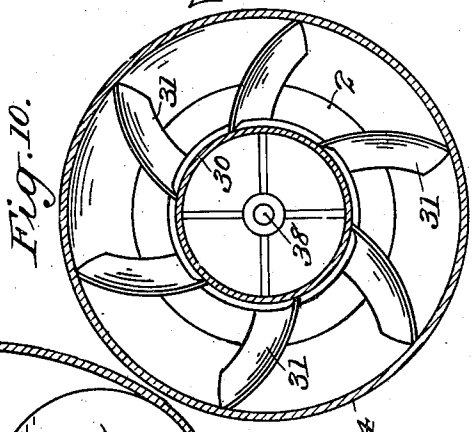
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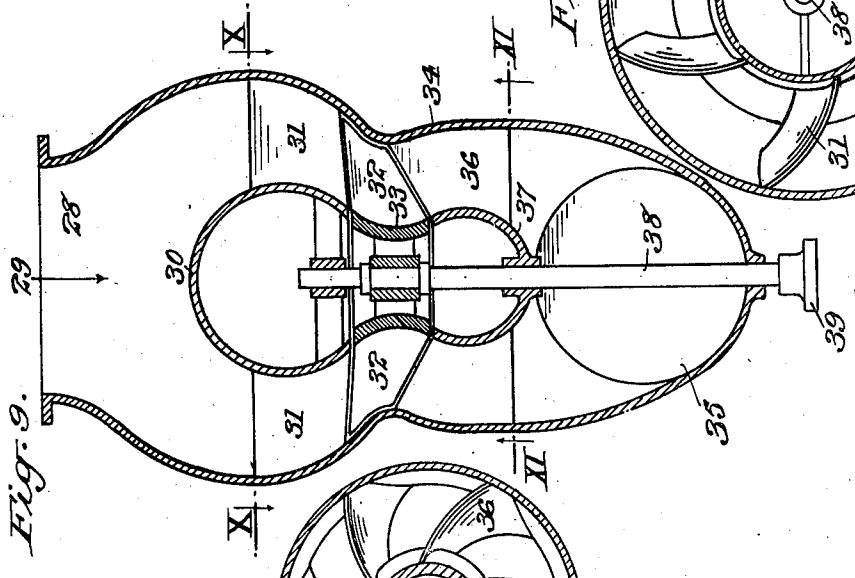
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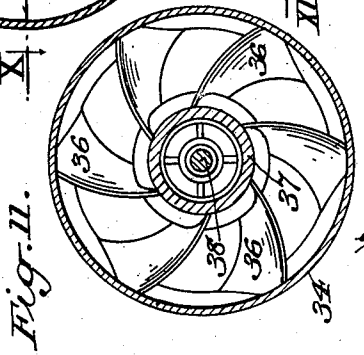
Filed Feb. 27, 1926 3 Sheets-Sheet 3











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Patented Dec. 16, 1930

1,785,460

UNITED STATES PATENT OFFICE

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PUMP OR THE LIKE

Application filed February 27, 1926, Serial No. 91,112, and in Germany March 2, 1925.

The present invention has for its object an axial turbine system arranged with a nozzle-like casing enlarging to both sides, in other words a turbine system in which the working medium is axially moved. The novelty of the invention consists in that the blades of the running wheel and the leading-surfaces of the apparatus for the admission and issue of the medium or fluid are formed by parts of the spherical or elliptic surfaces and said surfaces are arranged within the conduit of the annular nozzle in such a manner that their circular surfaces are situated within transversal planes of the longitudinal axes of the annular nozzles in such a manner that their centers or centres of gravity are situated round the axes of the nozzle in concentric circles of a radius smaller than the radius of their largest circle.

According to the present invention a type of unit accompanied by all advantages of the centrifugal and screw-wheels is created, said type utilizing at the radial and axial conduit of the current the large masses of the series-wheels together with the over-pressure of the centrifugal-wheels, and in consequence being suitable especially for screw-propellers in ships, as well as for screws for aerial navigation, pumps and ventilators or fans and also for turbines driven by steam, gas or water.

The invention characterized above is based on the idea to overcome or avoid the difficulties arising in the construction of calculation of turbines, especially of the screw-propellers used for driving ships and mainly resulting, besides transformations of energy, by the impossibility of an exact mathematic pursuance of these current-phenomenons by making for all parts of the turbine-system use of spherical or elliptic surfaces which will appear in nature as best possible forms of surfaces (optimate surface).

In conformity with the principle of the axial turbine-wheels performing the transformation of energy by a circulating movement of the working surfaces arranged around the axis of rotation, the conduit for the current must be formed on both sides as an annular nozzle and the hub of the running-wheel being part of the walls of the conduit must be formed as a catenoid surface, in other words a rotating surface in which the two main radii of curvature are contrarily equal at all points.

Owing to the formation of the current-conduit in the shape of an annular nozzle situated on both sides, the zone of the highest current-speed within the smallest section of passage of the current-conduit coincides with the average of section of the surface of the blade of the running-wheel.

In consequence of the formation of the running-wheel hub as a catenoid-surface and the same corresponding form of the outer nozzle-casing a retardation of the current-speed will, by the centrifugal and centripetal admission and issue of the liquid, result on both sides of the zone of the maximum of speed within the surface of the running wheel so that the twofold change of the speed of current is obtained. Hereby a decrease of the pitch-angle of the surface of the blade of the running-wheel is provided in the section of the resulting current-way towards both edges of the running-wheel, said pitch-angle being of an essentially smaller value than that of the axial pitch-angle which results in the same point with the transversal plane within the section of the cylinder.

The spherical rotating surface for the blades of the running-wheel being within the nozzle-conduit are situated within the transversal plane marked as a main-section and the centers of the rotating surface grouped around the axis of rotation form a regular polygon in said transversal plane. The axial distance of the transversal plane marked as a main section up to the section of the zone of the maximum of speed is given by the projection of the circle enclosed by the polygon onto a semicircular surface formed above the main section in the diameter of the circle enclosing the polygon; within said circle last mentioned the circular surface of projection represents the section of the zone of maximum of speed of the conduit, marked as the leading-section.

The point of intersection of the leading transversal plane defined in the manner de-

scribed by the number of blades with the axis of rotation of the system results in the third point for a right-angle triangle, the right angle of which is situated within the transversal and longitudinal sections of the system in the center of the polygon of the rotating axis of the running-wheel; in the triangle mentioned the large side presents the radius of the circle enclosing the polygon, the hypotenuse the radius of the largest circle of the surface of the running and leading-wheels and the small side, measured in the length of half side of the polygon, the radius for two spherical surfaces touching each other in the longitudinal axis of the nozzle and used for the fixation of the size of the catenoid of the hub of the running wheel.

This triangle is marked as the pitch-triangle for the reason that the two angles situated near the hypotenuse simultaneously correspond to the pitch-angles of the running-wheel surfaces resulting within a defined section of cylinder; the curvatures serving to limit the blades of the running-wheel will pass through said surfaces of the running-wheel mentioned.

The form of the conduit of the annular nozzle as well as the limitation and position of the surfaces of the running and leading wheels is dependent upon an ideal geometrical system of reference being represented by a cylinder, penetrating through all surfaces of the leading and running wheels parallel to the longitudinal axis of the nozzle and the projection of which is in section the circle enclosed by the polygon, and by a double circular cone having as its height situated in the axis of the nozzle and the diameter of the cylinder and as its base the cylinder section situated in the leading transversal plane.

Fig. 1 represents diagrammatically a ten sided figure illustrating the number of blades on the moving element of my improved axial turbine system;

Fig. 2 represents a view taken at right angles to Fig. 1 showing portions of the structure in section;

Fig. 3 represents a view similar to Fig. 1 and illustrating a hexagonal figure which designates the number of blades on the moving element;

Fig. 4 represents a view taken at right angles to Fig. 3 showing portions of the structure in section;

Fig. 5 represents a detail longitudinal section of the structure showing the passage through which the fluid is admitted and passed;

Fig. 6 represents diagrammatically a view of the same taken in the plane transverse to Fig. 5;

Fig. 7 represents a horizontal section, on a small scale of a turbine corresponding to one-half of the right side of Fig. 5;

Fig. 8 represents a detail elevation of the running wheel showing the blades formed by portions of curved surfaces;

Fig. 9 represents a horizontal section, on a large scale, of the turbine corresponding to the left half of Fig. 5;

Fig. 10 represents a vertical section taken in the plane of the line X—X of Fig. 9, looking in the direction of the arrows;

Fig. 11 represents a vertical section taken in the plane of the line XI—XI of Fig. 9, looking in the direction of the arrows.

The arrangements of the spherical or elliptic surfaces are represented by an ideal system of reference according to the rules of Euclid; in other words, surfaces and bodies corresponding to Euclid have been used for the geometrical representation.

The corner-points 1 to 10 and 1 to 6 of the regular polygons are grouped around the rotation axis A. The circle U enclosing the polygons is visible in the longitudinal sections, Figs. 2 and 4, as the line L marked as the main-section. The hemispheroids K form vaults over said main section and are of the radius H of the circles embracing the polygons. The circle E enclosed by the polygons is projected onto the circle mentioned and results the line L marked as the leading section. The points of intersection *a* and *c* shown in the longitudinal sections, Figs. 2 and 4, form, together with the point *b* being the corner-point of the polygons, the corner-points of the so-called pitch-triangle, in which the hypotenuse R shown in Figs. 1 to 4 represents the radius of the largest circles of the spherical or elliptic surfaces B, the large cathete the radius H_1 of the circles surrounding the polygons and the small cathete the radius *r* for two spherical surfaces *f* contacting in the longitudinal axis of the nozzle; the arc *g* of the circle of the hub-catenoid is in contact with the spherical surfaces mentioned.

The system of reference is formed by the cylinder Z represented in Figs. 2 and 4 and passing through the system mentioned parallel to the rotation axis. Said cylinder results as a projection in the sections. Figs. 1 and 3 the circle E enclosed by the polygons, and a double circle cone D in Figs. 2 and 4, the height of which situated in the rotation-axis of the system is equal to the diameter of the base situated within the directing section and forming the section of the cylinder of reference Z.

The centers M for the spherical and elliptic surfaces C and G are situated in the transverse planes Q passing through the points of the double cone D, Figs. 2 and 4. The directing wheel areas are formed from said surfaces C and G; the longitudinal section of said surfaces C and G is equal to the longitudinal section of the spherical or elliptic surfaces B for the running wheel and the centers or gravity points of said surfaces C and

G forming regular polygons are situated in circles which may have as their radius the radius of the circle U embracing the polygon of the running-wheel area or of the circle E enclosed.

In Figs. 2 and 4 the centers M of the surfaces C and G are situated in circles with a radius equal to that of the centers of the running wheel surfaces. The edges for the entrance and exit of the running wheel which are visible in the section of embracing surface and in the longitudinal section of the system, Figs. 2 and 4, as curvatures or sectional lines, pass through the intersection of the cylinder of reference Z with two transversal planes laid from off the main section H to the one side. The first transversal surface results in the intersection P marked as directing point and situated at the distance of the length of the small cathete of the pitch circle r, and the second transversal surface at the distance of the length H of the large cathete results the intersection $ marked as vertex.

Owing to the fact that the limitation of the running wheel blades and the size of the running wheel hub is fixed by the pitch-triangle dependent on the number of the blades, it results that said system of construction has two extremes, viz. the polygon with infinitely many corners, in which the hub will disappear and the two-angled figure in which the blade-surface will disappear and a hub results only.

The most favorable and natural form of the system being the object of the present invention is situated between these two extreme possibilities of construction, said form being found in the hexagon, in which the large cathete of the pitch triangle is equal to one side of the triangle or is of the double length of the small cathete.

In view of the fact that the pitch-triangle in this mutual ratio of the cathetes result in the known ratio of division of the "golden section," according to which the larger section in proportion to the total area and the other portion of the latter is the geometric average, the standard area-sections of the ring-nozzle-conduit are, within the hexagon system also, in the ratio of the golden section to the current speeds and the running wheel periphery considered in the diameter of the cylinder of reference in said ratio to the axial admission and issue pitches.

The other constructive arrangements shown in the figures have, therefore, been executed within the hexagon-system.

The hub of the running wheel represents a catenoid area the generatrix is the arc g in Figs. 2 and 4 which touches the two hub-spheroids f and slides by its center within the section-circle of the cylinder of reference with the directing transversal plane for the generation of the catenoid-area.

The hubs of the directing wheels form spherical areas N which join with the hub of the running wheel within the section-circle of the catenoid area with the double circle-area and have their center, on both sides of the main section, in the points J of the double-cone, Figs. 2 and 4; or one of the said spherical areas has its center in the intersection of the main section with the longitudinal axis and is of the dimension of the hubs spherical bodies f.

The outer periphery of the nozzle-conduit is produced by rotating section-surfaces F of spherical or elliptic bodies, Figs. 2 to 6, being similar to the longitudinal section of the running-wheel-surfaces the centers m of which are guided in transversal planes around the nozzle-axis A and on directing-circles in the smallest diameter of the area of the hub catenoid. Said transversal planes are distanced on both sides of the directing plane in the length equal to the height of the curvature-apex or an area O rotates with its center in the intersection a of the main transversal plane H with the longitudinal axis.

Said two curvatures F and O are connected together at their mutual intersecting point by arcs T which touch said curvatures F and O on the outside in such a manner that the catenoid casing surface generated with the rotation of said arc around the nozzle axis results in a circle-section equal to the surface or area of the circle U surrounding the polygon of the running wheel.

The nozzle conduit is, by this principle of construction, so formed that it admits and issues the fluid under an acute angle to the longitudinal axis of the system and in the direction of the arrows 15 and 16, Figs. 2 and 4. By said alteration or change of the direction of the system the fluid is admitted or supplied to the running wheel in such a manner that the axial pitch admission and issue angles are, within the section of the resulting current-way essentially smaller than those pitch-angles resulting in the same intersection of the running-wheel edges within the cylindrical section of the transversal plane.

For the purpose of using the axial turbine system for fans, pumps, turbines for air, steam and water, a radial admission and issue of the medium on one side or on both sides of the running wheel can advantageously be arranged for the turbine. For this purpose the catenoid surfaces of the running-wheel as well as of the nozzle casing are continued, in correspondence with the necessary section surfaces, up to the connection with the transverse plane. Said construction is shown in Fig. 5 in longitudinal section and in Fig. 6 in transversal section and is arranged with a screw-casing Sp for the admission and issue of the fluid. In said casing the fluid flows, in a rotary direction marked by the arrow 13,

opposite to the rotation of the running wheel 14 and around the longitudinal axis.

The curvatures for limiting the blades of the running wheel in the apex-point $ and in the directing point P, Figs. 2, 4 and 5 can be constructed according to the principle of a screw surface and in correspondence with the alteration of the pitch-angle in proportion to the circumferential speed, referred to in a similar manner to the pitch-angle of the points situated in the cylinder of reference, so that the curvature passing through the apex $, passes in the longitudinal section of the nozzle, Figs. 2, 4 and 5 on the periphery through the intersection of the generatrix of the casing with the circle of the running-wheel surface and passes at the hub through the intersection of the hub-catenoid *g* with the double cone D.

The curvature passing through the directing point and constructed in the same manner approximately runs as to its direction and form like the curvature passing through the apex-point $. Owing to the fact that the running-wheel-blades obtained by this construction are very acute ones, it is necessary that the running wheels are provided at the periphery with rings rotating also in the full width of the blade. For the purpose of obviating said rings, the blades of the running wheels can be cut at the side of the apex-point according to a section through the hub-point, so that the curvature in the longitudinal section, Figs. 2, 4 and 5 results in a straight section-line *i* and in the transversal section, Fig. 6 in a corresponding arc.

The limiting curvatures through the directing point P, Fig. 5, can be obtained by the projection of a constant screw-pitch onto the running wheel surfaces, said pitch running with the smallest angle of the pitch-triangle around a cylinder of the diameter equal to the circle of the running-wheel, said projection resulting then in a curvature *n* beginning in the axis-point A, Figs. 5 and 6 and very similar to the ordinary screw construction, Figs. 5 and 6.

The limiting curvatures of the directing wheel blades on both sides of the running wheel edges are formed by the penetration of the casing surface of the running wheel with the spherical or elliptic surfaces for the directing wheel, whereas the limitation is produced at the sides of the admission and issue of the fluid with an axial current running through those sections in which the centers M of the directing surfaces, Figs. 2, 4 and 5, lie.

For a radial admission and issue of the fluid the limitation depends on the way of the nozzle-conduit and the necessary size of the tangential angle of the admission and issue. The direction of issue of the directing blades for the radial current-guide results by itself in a current within the screw-casing, said current being in an opposite direction to the rotation of the running wheel, as shown in Fig. 6.

The back surface of the running wheel blades can be formed above the apex-point $ by arranging or laying a spherical or elliptic surface with a smaller curvation-dimension or larger radius whereas the surface connecting with opposed edge of the running wheel is produced in that the intersection curvature at the point of intersection of the running wheel-edge and resulting by the penetration of two running wheel spherical surfaces rotating in opposite direction around the axis of the nozzle and equally arranged represents sections of said connecting surface. The total shape of the generated connection-edge results then in the arc *o* represented in longitudinal section, Figs. 2, 4 and 5 within the section-surface of the covering-surface of the running-wheel blades.

Constructions performed according to the hexagonal system with an axial and radial guide of the current have fully stated the assumed mode of working of the turbines. Efficiency and effects have been obtained which surpass all systems known up to the present.

Referring to Fig. 7, the fluid medium when working as a pump or blower enters the casing 18 in the direction indicated by the arrow 17, passes through the guide vanes 19 into the impeller blades 20, carried and rotated with the hub 22, from whence it is delivered between guide vanes 21 in the casing and passes therethrough in a radial direction, into the volute 25 as indicated by the arrow 26. The outer end of the shaft 23 carrying the running wheel is provided with a coupling 24 to which may be connected a motor, as a turbine or an electrically driven motor (not shown). When the apparatus is operated as a turbine, the flow of the fluid medium will pass in a course opposite to that indicated by the arrow 17. The centers of the guide vanes which are spherical surfaces or parts of spherical surfaces are denoted by M M. The center of the sphere of which the rotating vanes are portions is denoted by *b*.

The structure shown in Fig. 9 is similar in operation to that described with respect to Fig. 7. When the apparatus is operated to work as a pump, blower or propeller, the fluid medium enters at 28 in the direction of the arrow 29, passes around the sphere 30, thence through the guide vanes 31 into the impeller vanes 32, thence between the vanes 36 in the casing 34 around the sphere 37 and through the opening 35. A shaft 38 is provided with a hub 33 which carries the vanes 32, forming the running wheel. This shaft 38 is provided with a coupling 39 which may be connected to a motor (not shown). When the apparatus is operated as a turbine, gen-

erating power, the fluid medium enters at 35, passes through guide vanes 36 and impeller vanes 32, thence through guide vanes 31 and is exhausted through the casing at 28 in the opposite direction to that shown by the arrow. In this form the shaft and coupling may be coupled to a machine that is to be driven by the turbine. The impeller vanes 32 are spaced from the guide vanes 31, 38. The tips of the impeller vanes are also spaced from the casing 34.

While I have shown six vanes on the impeller and also six guide vanes, I wish it understood that any number of vanes may be used effectively.

What I claim is:

1. A turbine system comprising, a casing provided with an inlet and an outlet, a running wheel interposed in said casing between said inlet and outlet, said wheel having blades, blades located in the casing adjacent said running wheel, all of said blades formed by portions of curved surfaces, whereby the curved surfaces are portions of surfaces of bodies generated by rotation of a conical section line as of a sphere, ellipsoid, paraboloid or hyperboloid.

2. A turbine system comprising, a nozzle-like casing provided with a diminishing inlet and an expanding outlet, a running wheel interposed in said casing between said inlet and outlet, said wheel having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on a concentric circle around said axis.

3. A turbine system comprising, a nozzle-like casing provided with a diminishing inlet and an expanding outlet, said inlet and outlet having blades formed by portions of curved surfaces, a running wheel interposed in said casing between said inlet and outlet, said wheel having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces of the blades are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on concentric circles around said axis.

4. A turbine system comprising, a nozzle-like casing provided with an inlet diminishing inwardly toward the longitudinal axis of said casing and an outlet expanding outwardly from the longitudinal axis of the casing, a running wheel interposed between said inlet and outlet, said wheel having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on a concentric circle around said axis.

5. A turbine system comprising, a nozzle-like casing provided with an inlet diminishing inwardly toward the longitudinal axis of the casing and an outlet expanding outwardly from the longitudinal axis of the casing, said inlet and outlet having blades formed by portions of curved surfaces, a running wheel interposed in said casing between the inlet and outlet, said wheel having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces of the blades are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on concentric circles around said axis.

6. A turbine system comprising, a nozzle-like casing provided with an inlet diminishing inwardly toward the longitudinal axis of said casing and an outlet expanding outwardly from the longitudinal axis of the casing, the walls of the inlet and outlet being curved inwardly and outwardly respectively, a running wheel interposed between said inlet and outlet, said wheel having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on a concentric circle around said axis.

7. A turbine system comprising, a nozzle-like casing provided with an inlet diminishing inwardly toward the longitudinal axis of the casing and an outlet expanding outwardly from the longitudinal axis of the casing, the walls of the inlet and outlet being curved inwardly and outwardly respectively, said inlet and outlet having blades formed by portions of curved surfaces, a running wheel interposed in said casing between the inlet and outlet, said wheel having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle,

whereby the curved surfaces of the blades are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spherees, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on concentric circles around said axis.

8. A turbine system comprising, a nozzle-like casing provided with an inlet diminishing inwardly toward the longitudinal axis of said casing and an outlet expanding outwardly from the longitudinal axis of the casing, the walls of the inlet and outlet being curved inwardly and outwardly respectively, a running wheel interposed in said casing between the inlet and outlet, said wheel being provided with a hub having a curved exterior wall to coact with the walls of the inlet and outlet and having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on a concentric circle around said axis.

9. A turbine system comprising, a nozzle like casing provided with an inlet diminishing inwardly toward the longitudinal axis of the casing and an outlet expanding outwardly from the longitudinal axis of the casing, the walls of the inlet and outlet being curved inwardly and outwardly respectively, said inlet and outlet having blades formed by portions of curved surfaces, a running wheel interposed in said casing between the inlet and outlet, said wheel being provided with a hub having a curved exterior wall to coact with the walls of the inlet and outlet and having blades formed by portions of curved surfaces, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces of the blades are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids, paraboloids or hyperboloids and having their centers of gravity on concentric circles around said axis.

10. A turbine system comprising, a nozzle-like casing provided with an inlet diminishing inwardly toward the longitudinal axis of said casing and an outlet expanding outwardly from the longitudinal axis of the casing, the walls of the inlet and outlet being curved inwardly and outwardly respectively, a running wheel interposed in said casing between the inlet and outlet, said wneel being provided with a hub having a diameter diminished for a predetermined length away from the inlet and having blades formed by portions of curved surfaces, said hub being arranged to coact with the walls of the inlet and outlet, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids paraboloids or hyperboloids and having their centers of gravity on a concentric circle around said axis.

11. A turbine system comprising, a nozzle-like casing provided with an inlet diminishing inwardly toward the longitudinal axis of the casing and an outlet expanding outwardly from the longitudinal axis of the casing, the walls of the inlet and outlet being curved inwardly and outwardly respectively, said inlet and outlet having blades formed by portions of curved surfaces, a running wheel interposed in said casing between the inlet and outlet, said wheel being provided with a hub having a diameter diminished for a predetermined length away from the inlet and having blades formed by portions of curved surfaces, said hub being arranged to coact with the walls of the inlet and outlet, said blades being so disposed that any plane transverse to the longitudinal axis of the running wheel will cut said curved surfaces in a circle, whereby the curved surfaces of the blades are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids paraboloids or hyperboloids and having their centers of gravity on concentric circles around said axis.

12. A turbine system comprising, a casing provided with a passage therethrough, said passage having axially and radially directed portions, stationary and movable blades located in said passage, certain of said blades extending into said radial portion, said blades being formed by portions of curved surfaces and disposed so that any plane transverse to the longitudinal axis of the movable blades will cut said curved surfaces in a circle, whereby the curved surfaces are portions of surfaces of bodies generated by rotation of conical section lines, said bodies being spheres, ellipsoids paraboloids or hyperboloids and having their centers of gravity on concentric circles around said axis.

13. An axial fluid turbine system comprising, a casing having a nozzle-like passage, a running wheel interposed in said passage, said wheel including a rotating hub provided with blades, and two stationary hubs axially alined with the running wheel, the inner periphery of the casing and the outer periphery of the hubs forming catenoidal surfaces.

14. A fluid translating device comprising,

a casing having a nozzle-like passage, a running wheel interposed in said passage, said wheel including a rotating hub provided with blades, and two stationary hubs axially alined with the running wheel, the inner periphery of the casing having convex, concave and convex portions, the outer periphery of the hubs being concave and the rotating hub convex.

15. A fluid translating device comprising, a casing having stationary blades therein, a running wheel interposed in said casing, said wheel including a hub provided with blades arranged to coact with said stationary blades in the casing, both the stationary and movable blades being formed of surfaces of spheres.

16. A fluid translating device comprising, a casing having stationary blades therein, a running wheel interposed in said casing, said wheel including a hub provided with blades arranged to coact with said stationary blades in the casing, both the stationary and movable blades being formed of portions of spherical surfaces of equal sphere diameters.

17. A fluid translating device comprising, a casing having an annular passage expanding in opposite directions through said casing, stationary blades in said passage, a running wheel interposed in the passage between the expanded ends, blades on the running wheel, both stationary and movable blades being formed of portions of spherical surfaces having their centers at an equal distance from the axis of rotation of the running wheel.

18. A fluid translating device comprising, a casing having an annular passage expanding in opposite directions through said casing, stationary blades in said passage, a running wheel interposed in the passage between the expanded ends, blades on the running wheel, both stationary and movable blades being formed of portions of spherical surfaces having their centers located on circles concentric to the axis of rotation of the running wheel, the diameter of the concentric circles being smaller than the diameter of the spheres.

19. A fluid translating device comprising, a casing having an annular passage formed with inner and outer catenoidal body surfaces, stationary blades in said passage, a running wheel interposed in the passage and provided with blades, both the stationary and movable blades being formed of portions of spherical surfaces approximating closely to spheres, said blades having the same curvature as the generating lines of the catenoidal outer body surface of the passage.

20. A fluid translating device comprising, a casing having an annular passage formed by catenoidal body surfaces and provided with an inlet and outlet, a running wheel interposed in the casing between said inlet and outlet, said wheel being provided with a hub and a predetermined number of blades, each of said blades being formed of portions of spherical surfaces, the centers of said spherical surfaces forming an equilateral polygon, the periphery of the hub having a curvature whose radius is equal to the smaller cathetus of a rectangular triangle whose other cathetus is the radius of the inscribed polygonal circle and whose hypothenuse is the radius of the circumscribed polygonal circle, said hub forming a part of the annular passage.

21. A fluid translating device comprising, a casing provided with an inlet, an outlet and an annular passage connecting said inlet and outlet, said passage increasing in diameter in opposite directions, a running wheel interposed in said passage between the inlet and outlet, said wheel being provided with a predetermined number of blades, each of said blades being formed of portions of spherical surfaces approximating spheres whose centers form an equilateral polygon, the diameter of the smaller cross section of the passage being approximately equal to the diameter of a circle circumscribed to said equilateral polygon.

22. A fluid translating device comprising a casing provided with an annular passage increasing in diameter in opposite directions, stationary blades disposed in said passage, a running wheel interposed between the increased ends of the passage and having blades thereon, said blades being formed by parts of spherical surfaces approximating spheres whose centers form an equilateral polygon, whereby the radius of the circumscribed polygonal circle is used as larger cathetus for a rectangular comparison—triangle, the hypothenuse of which forms the radius for the spherical surfaces of the stationary and movable blades when the smaller cathetus has the length of half a side of the running wheel surface polygon.

23. A fluid translating device comprising a casing provided with an inlet, an outlet and an annular passage connecting said inlet and outlet, said passage increasing in diameter in opposite directions, a running wheel interposed in said passage between the inlet and outlet, said wheel being provided with a hub and a predetermined number of blades, each of said blades being formed of portions of spherical surfaces approximating spheres whose centers form an equilateral polygon, the diameter of the smaller cross section of the annular passage being approximately equal to the diameter of the circle circumscribed to said equilateral polygor whereby the smallest cross section of the hub of the running wheel is distanced from the polygon plane half a side length of the polygon.

24. A fluid translating device, comprising a casing provided with an inlet, an outlet and an annular passage connecting said inlet and

outlet, said passage increasing in diameter in opposite directions, stationary blades disposed in said passage, a running wheel provided with a hub and interposed between the inlet, outlet and stationary blades, each of said blades being formed of portions of spherical surfaces, whereby the centers of the stationary blades in two planes lying parallel on both sides of the cross plane of the smallest hub section of the running wheel form an equilateral polygon, the distance between which and said hub section is equal to the radius of the inscribed polygon circle of the running wheel plane.

In testimony, that I claim the foregoing as my invention, I have signed my name this twelfth day of February, 1926.

GEORG ARTHUR SCHLOTTER.