No. 803,950. PATENTED NOV. 7, 1905.

F. WINDHAUSEN.

ELASTIC FLUID TURBINE.

APPLICATION FILED JAN. 10, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

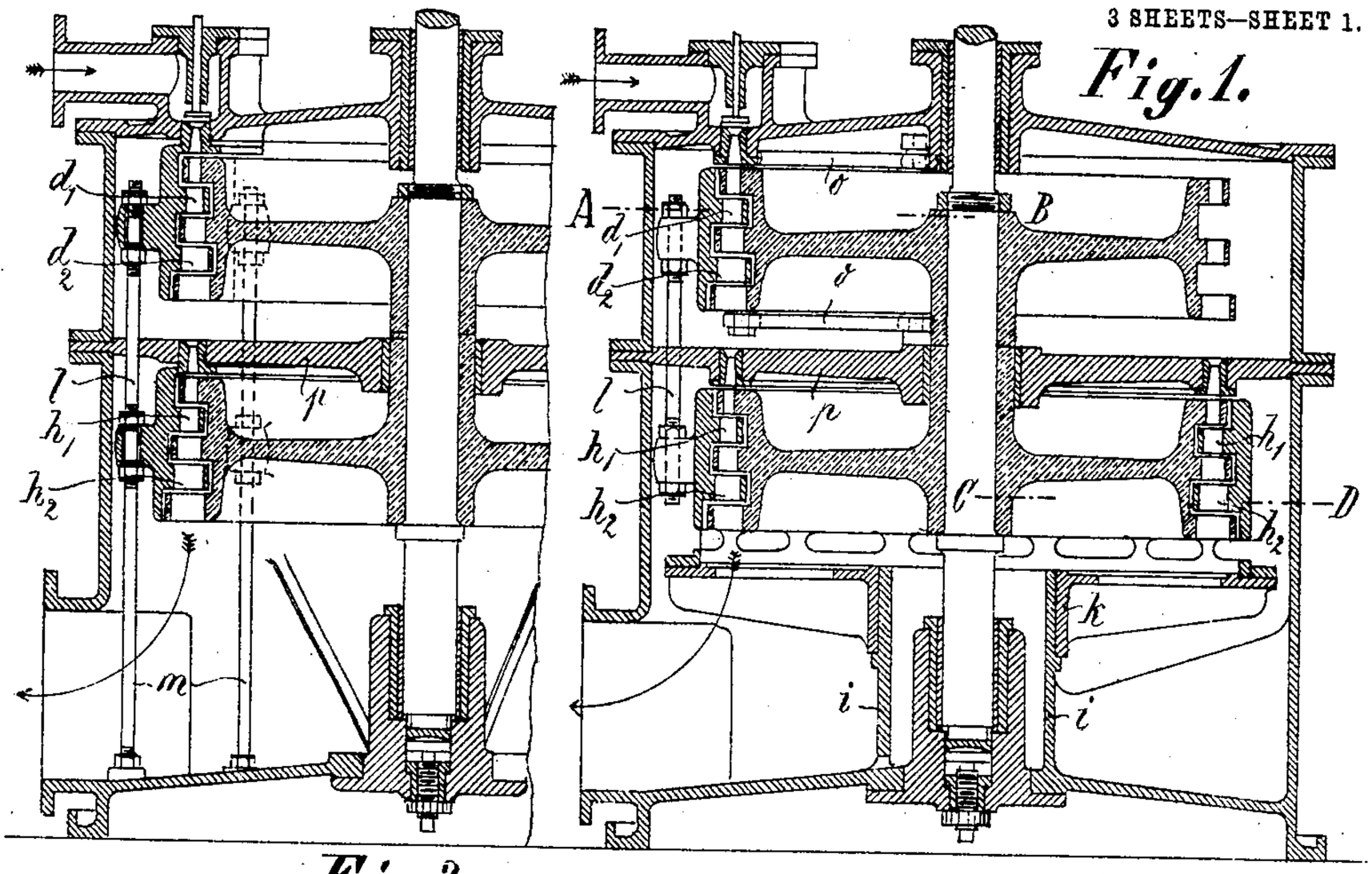


Fig. 3.

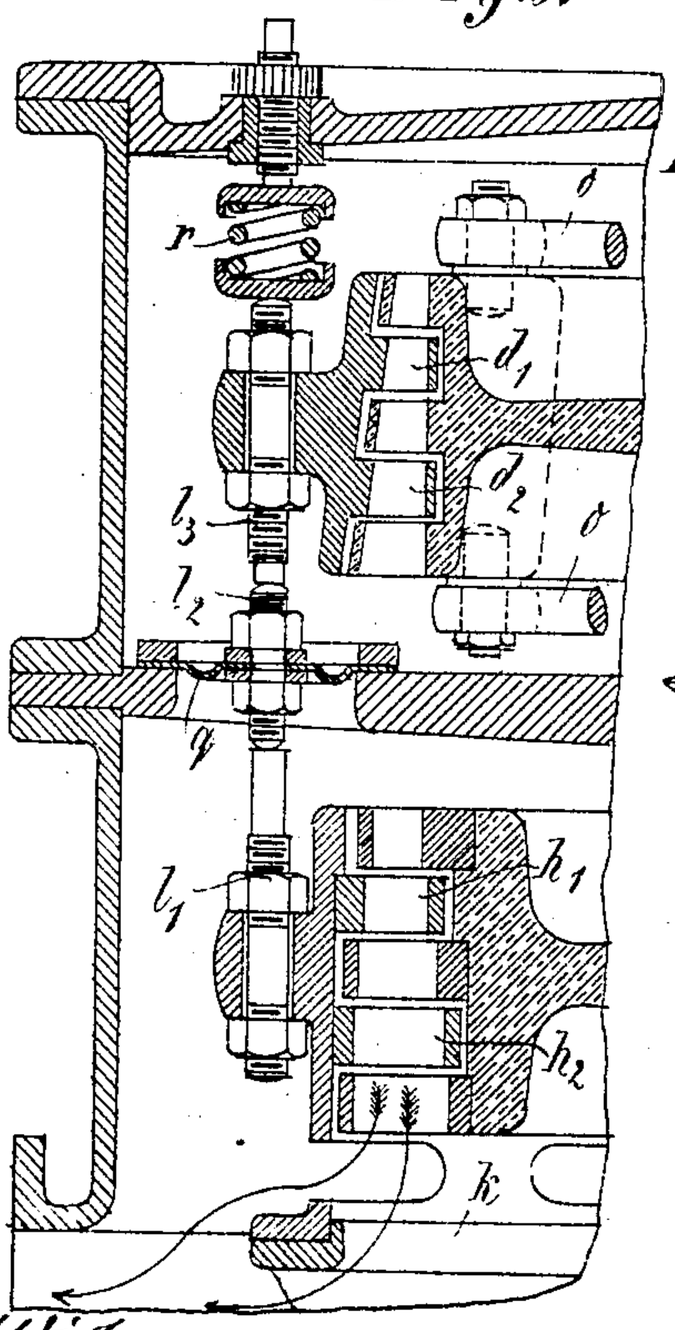
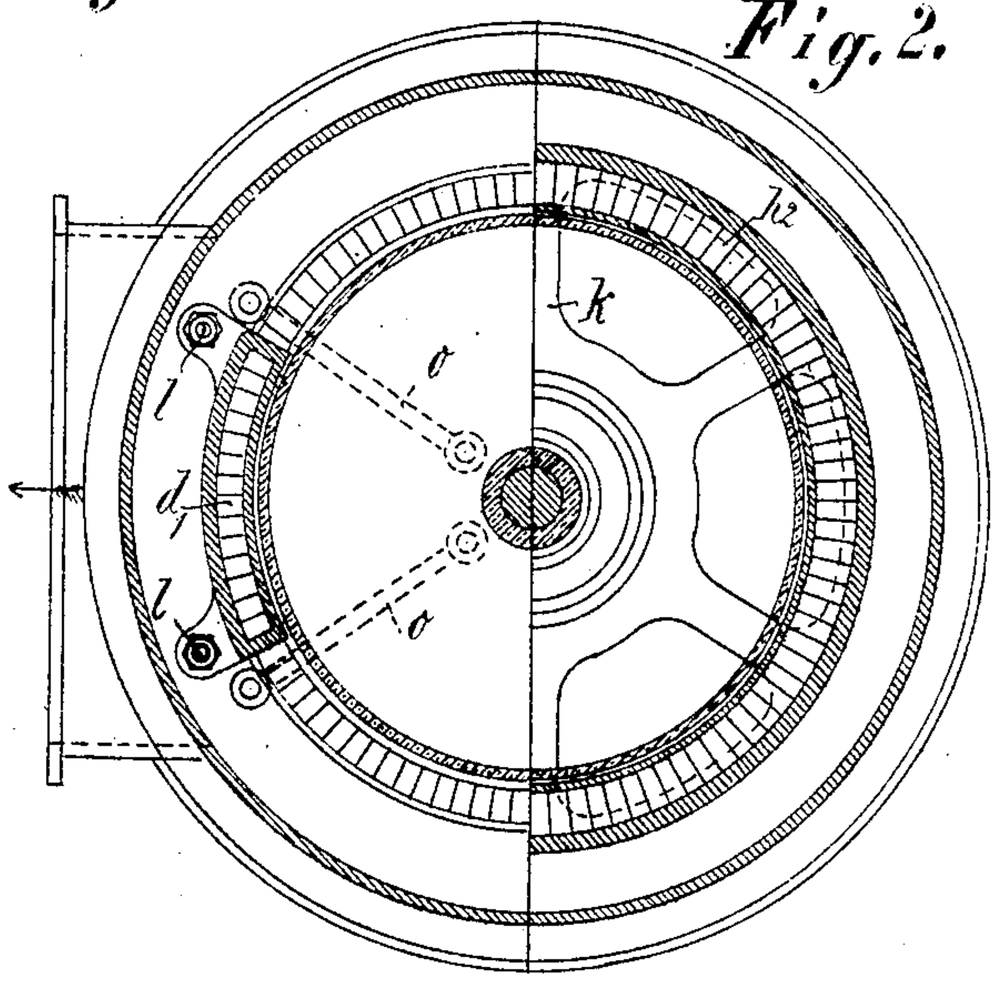


Fig. 4.

Fig. 2.



Witnesses:
James L. Norris, Jr.
C. D. Kesler

Inventor:
Franz Windhausen
By
James L. Norris
Atty.

No. 803,950. PATENTED NOV. 7, 1905.

F. WINDHAUSEN.

ELASTIC FLUID TURBINE.

APPLICATION FILED JAN. 10, 1905.

3 SHEETS—SHEET 2.

Fig. 5.

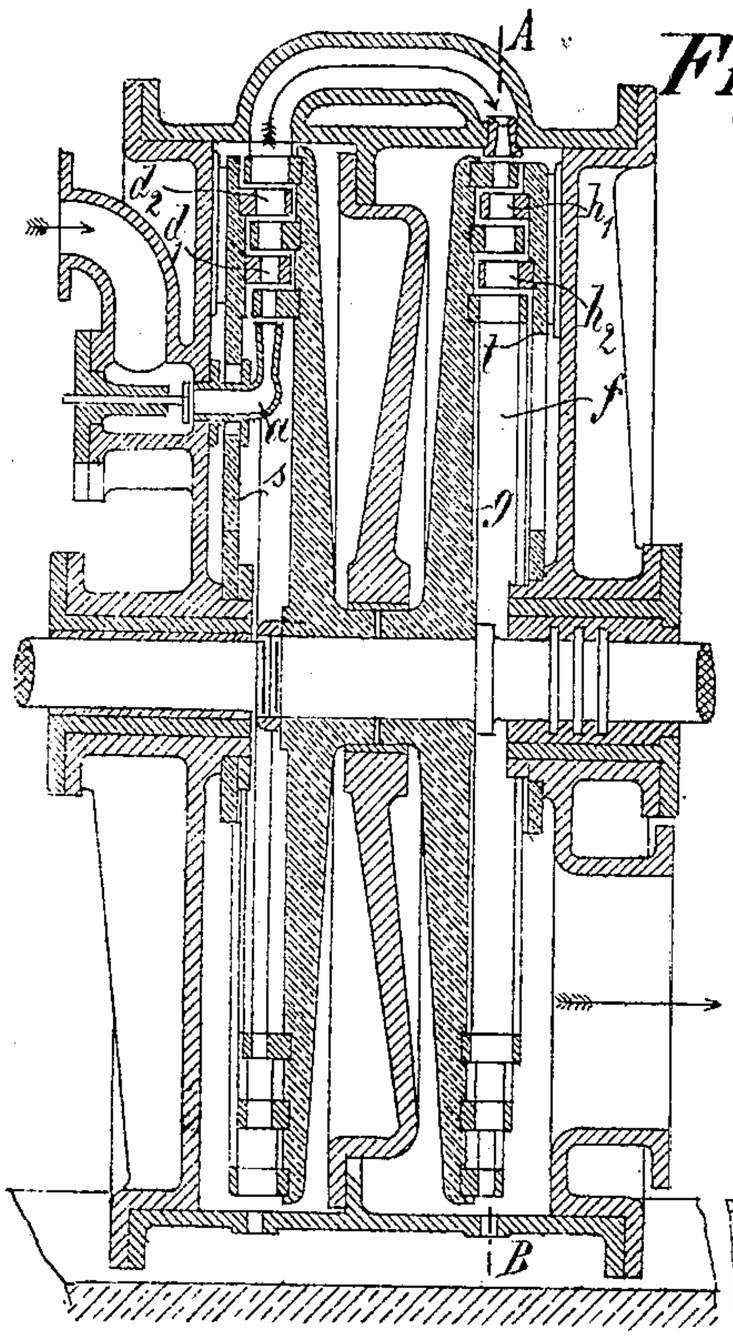


Fig. 6.

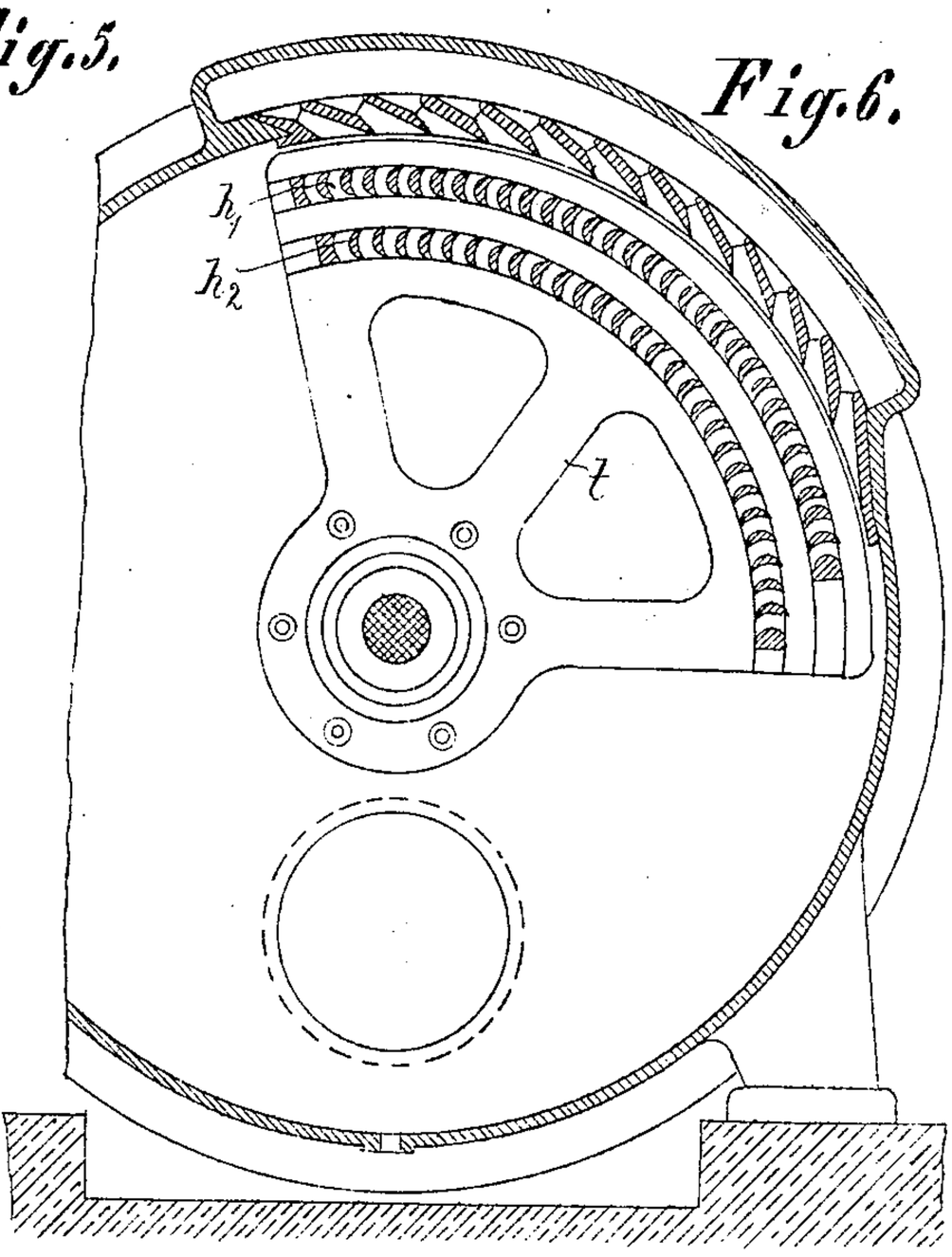


Fig. 7.

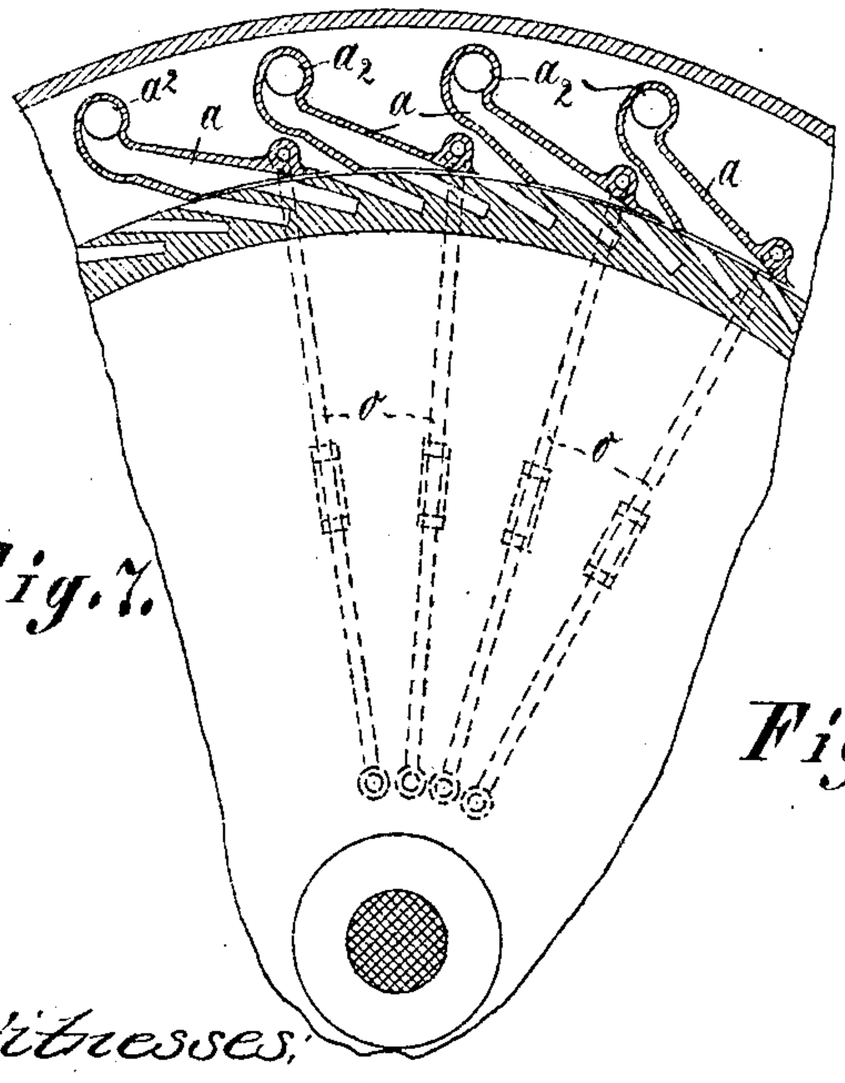
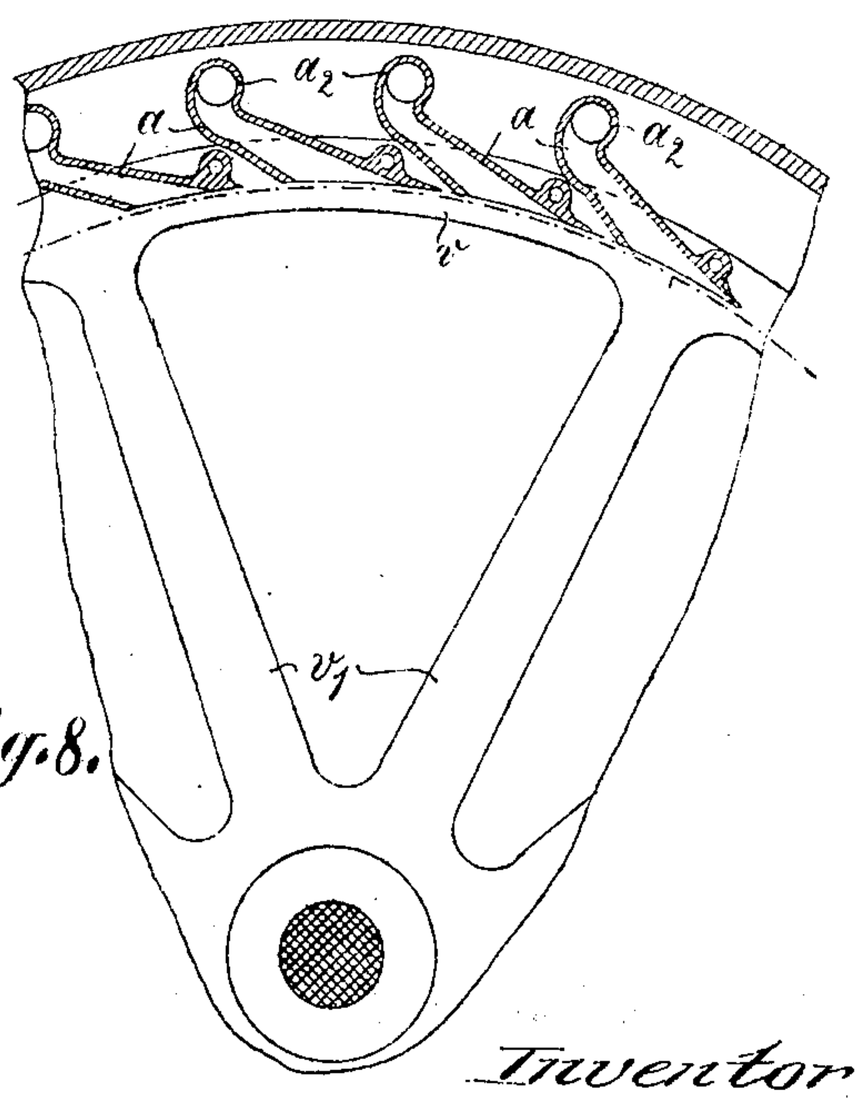


Fig. 8.



Witnesses:

James L. Norris, Jr.

C. D. Kesler

Inventor

Franz Windhausen

By James L. Norris

Atty.

No. 803,950. PATENTED NOV. 7, 1905.

F. WINDHAUSEN.

ELASTIC FLUID TURBINE.

APPLICATION FILED JAN. 10, 1905.

3 SHEETS—SHEET 3.

Fig. 9.

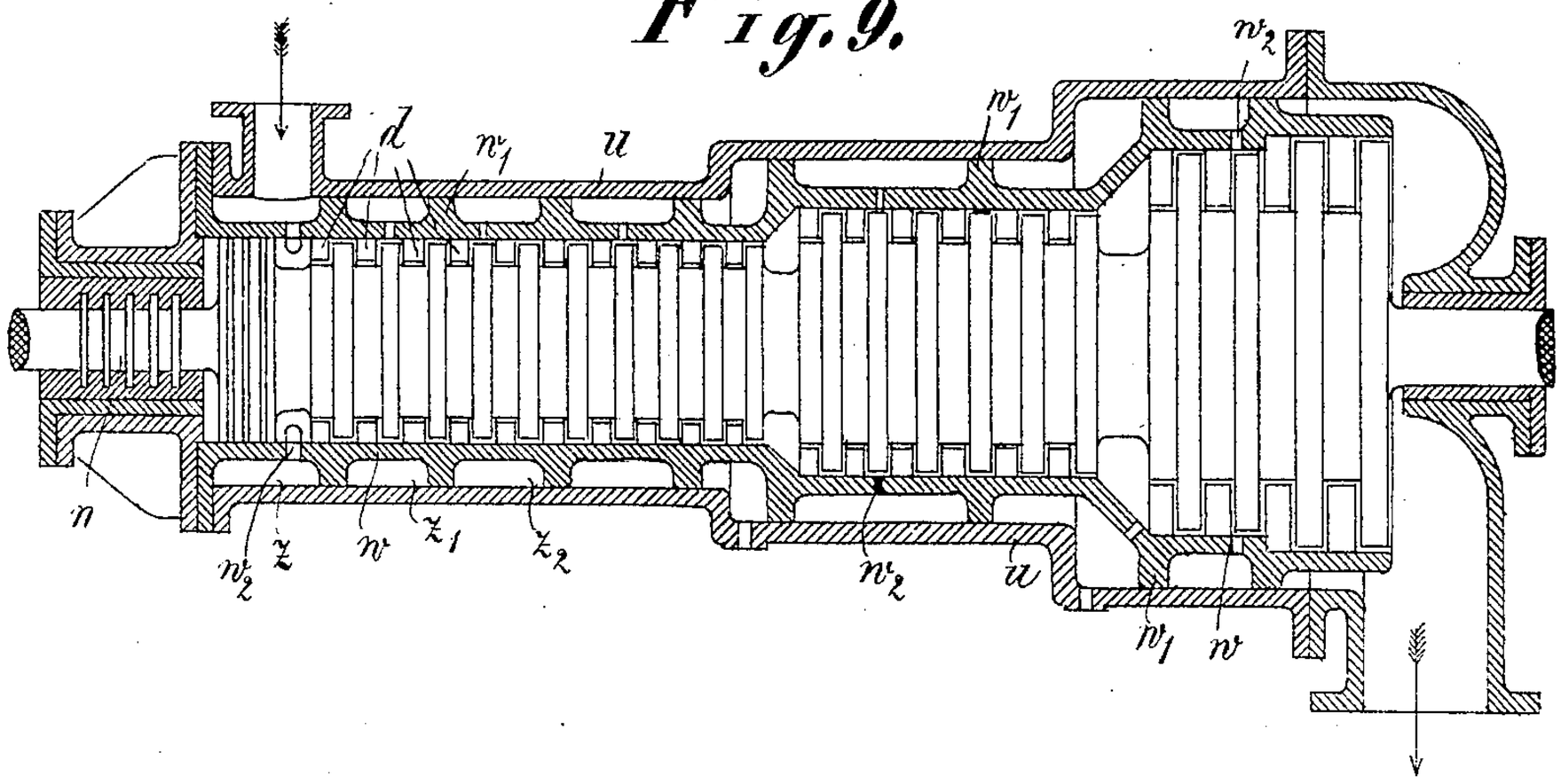
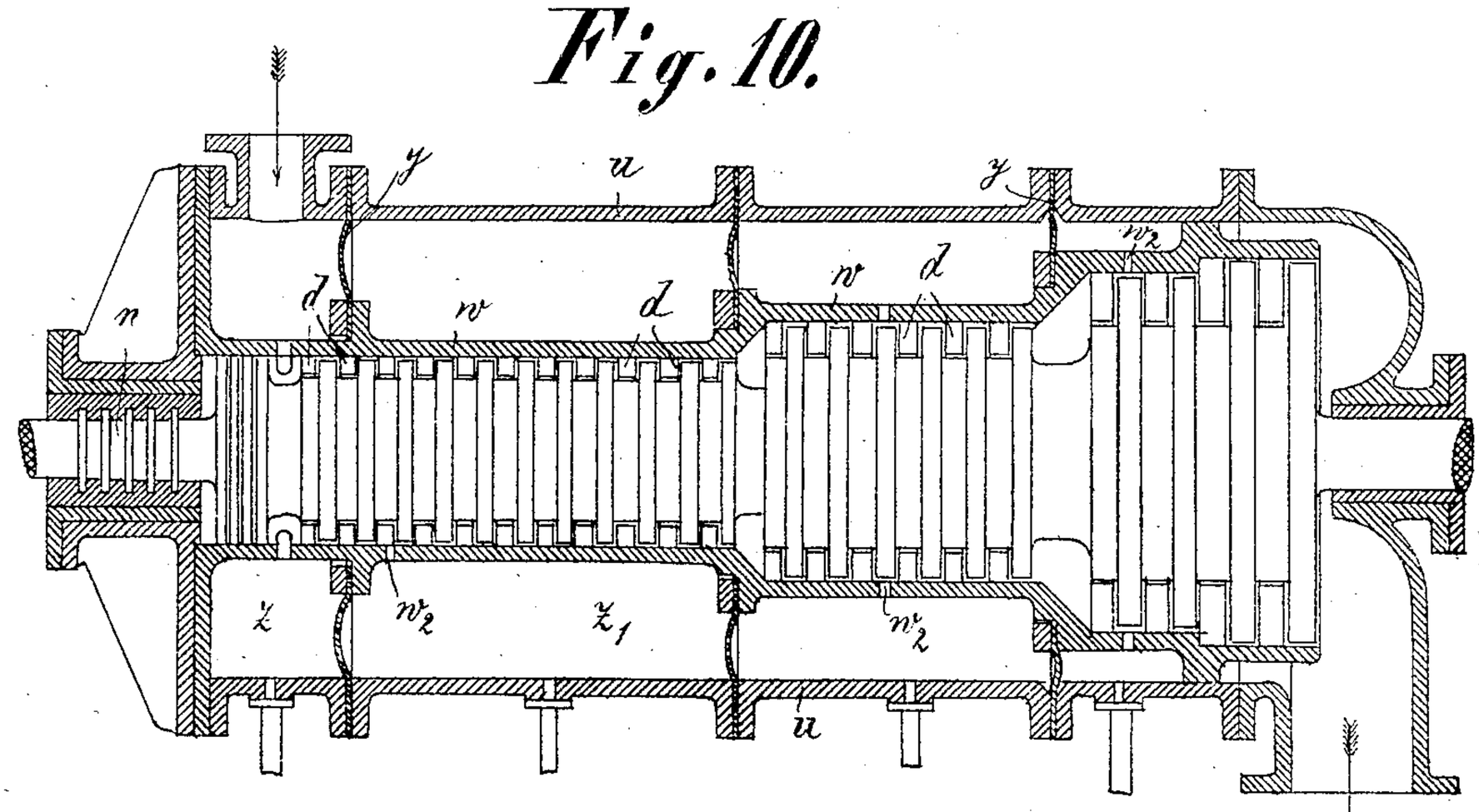


Fig. 10.



Witnesses:

James L. Norris, Jr.

C. D. Kesler

Inventor

Franz Windhausen

By James L. Norris.

Atty

UNITED STATES PATENT OFFICE.

FRANZ WINDHAUSEN, OF BERLIN, GERMANY.

ELASTIC-FLUID TURBINE.

No. 803,950. Specification of Letters Patent. Patented Nov. 7, 1905.

Application filed January 10, 1905. Serial No. 240,459.

To all whom it may concern:

Be it known that I, FRANZ WINDHAUSEN, engineer, of 1 Corneliusstrasse, Berlin, Germany, have invented certain new and useful Improvements in Elastic-Fluid Turbines, such as Steam-Turbines, Gas-Turbines, of which the following is a clear and perfect specification.

The present invention relates to elastic-fluid turbines, and especially to the arrangement of the guide-blades and nozzles therein. When working such turbines, the different parts thereof—such as the vane-wheels, the shaft, the turbine-casing—dilate, especially in consequence of the increase of temperature by means of the action of the heat of the steam or hot gases. The dilatations of the different parts of the turbine, as is known, are different on account of the temperatures of the different parts being different during the working of the turbine. From this reason, for instance, those parts rotating in a turbine-chamber—such as vane-wheels, shaft, and the like—will assume very nearly the temperature of the steam in the said space, whereas the fixed parts, especially the turbine-casing, in consequence of radiation of heat or of other causes, assume other (generally lower) temperatures than that of the steam or of the rotating parts. The said differences of temperature may also be increased by the rotating parts in consequence of steam or mechanical friction showing a somewhat higher temperature than that of the surrounding steam. Hitherto the nozzles and the different guide-blades arranged in a circle or in a segment (or the overflow channels for the steam) have been fastened single or in groups to the walls of the turbine or chamber casing either rigidly or in such a manner that they could be regulated from outside. As, on the one hand, the spaces between the vane-wheels and the nozzles or guide-blades in axial or in radial direction should be as small as possible and, on the other hand, the dilatations of the rotating parts (vane-wheels and shaft) are different from the dilatation of the casing, it may happen when working turbines in which the guide-blades and nozzles are fastened, either rigidly or so as to be regulated, that the vane-wheels and guide-blades come in contact, thereby giving cause to the destruction of the turbine or of parts of it.

Now the object of the present invention is to obviate these disadvantages as much as possible by not fastening the nozzles and the guide-blades directly to the turbine-casing, but to one or more bodies, such as rods or tubes, arranged inside the turbine and surrounded as much as possible by the steam in the chamber. The length of these bodies to which the guide-blades are fastened may be regulated, as may be seen (by way of example) from the bodies *o*. (Shown in Fig. 7.) By this arrangement I attain that the bodies to which the guide-blades and nozzles are fastened assume the same temperatures, and therefore are subjected to the same or nearly the same dilatations as the rotating parts, (vane-wheels, shaft,) surrounded by the same steam, so that the spaces between the guide-blades or nozzles and the vane-wheels may be very small and nevertheless any danger may be avoided of the guide-blades or nozzles and vane-wheels coming in contact in consequence of unequal dilatation during the working of the turbine.

The body or bodies to which the guide-blades and nozzles are fastened may be arranged radially, nearly radially, or ring-like around the middle axis of the turbine, so that the bodies may follow in radial direction the dilatations of the rotating parts, especially of the vane-wheels. The bodies may also be arranged axially or parallel or nearly parallel to the middle axis of the turbine in order to obtain in axial direction the same dilatations as those of the rotating parts, especially of the shaft. Finally, the body or bodies may be constructed in the form of hollow cylinders having in radial and in axial direction the same dilatations as the rotating parts of the turbine.

The bodies may suitably be arranged in the turbine-casing at places as neutral as possible with regard to the dilatation. Thus, for instance, the radially-disposed bodies may be fastened to the casing near the middle of the shaft, the axially-arranged bodies near the pressure-bearing.

Very often it is sufficient to fasten the nozzles and guide-blades or the segmental guide-blades only to a body which regulates them during the action of the heat either only radially or only axially.

On the accompanying drawings I have diagrammatically represented some forms in which my invention may be carried out.

Figure 1 shows a vertical axial sectional view of a multiple-expansion multiple-chamber axial turbine provided with my said im-

provements. Fig. 2 is a horizontal section according to lines A B, C D of Fig. 1. Fig. 3 is a vertical sectional view of a simpler arrangement of the guide-blades. Fig. 4 shows another modified form in a vertical sectional view. Fig. 5 is a vertical longitudinal sectional view of my improvements in combination with a multiple-expansion multiple-chamber radial turbine. Fig. 6 is a sectional view according to line A B of Fig. 5, the vane-wheel being omitted. Fig. 7 is a part of a sectional view of a tangential turbine provided with my said improvements. Fig. 8 is a similar view, the vane-wheel being omitted and its periphery being shown in dotted lines. Fig. 9 is a sectional longitudinal view of a multiple-expansion axial turbine (Parson's turbine) provided with my improved arrangements. Fig. 10 is a modification of the turbine shown in Fig. 9.

Referring to Figs. 1 to 4, the steam passes in the direction of the arrow 1 to the nozzles *a*, expands in the same, acts on the first vane-row *c'*, passes the guide-blades *d'*, acts on the second vane-row c^2, and so on. The steam flows from the last vane-row c^3 to the nozzles *e* of the second chamber *f*, acts on the vane-row *g'*, passes the guide-blades *h'*, acts on the vane-row g^2, and so on, and exhausts from the turbine in the direction of the arrow 2. The guide-blades d' d^2 of the first chamber form only segments, whereas the guide-blades h' h^2 of the second chamber are arranged in a full circle. The guide-blades are not fastened rigidly to the turbine-casing, but to ring or rod like bodies *i k l o*, surrounded on all sides by steam and arranged at places as neutral as possible with regard to the dilatation.

When working the turbine, the rotating parts (shaft and vane-wheels) dilate in axial and in radial direction in consequence of the action of the heat of the steam. The guide-blades *d* and *h* can follow these dilatations as well in axial direction on account of their being fastened to the bodies *i* and *l* as in radial direction on account of their being fastened to the ring-like bodies *k* (provided with radial strengthening-ribs) and to the radial bodies *o*. The body *k* will assume about the same temperature as the vane-wheel *g*, whereas the bodies *o* have the same temperature as the vane-wheel *c*.

In Fig. 3 a simpler arrangement of the guide-blades is diagrammatically represented. During the working of the turbine the guide-blades *h* and *d* may be regulated in axial direction by means of the rods *m l*, parallel to the shaft. A radial regulation of the guide-blades is not provided for in this modification.

The rod 1 of the turbines shown in Figs. 1 to 3 extends through the intermediate bottom *p*, and therefore the necessary tightening is required. As shown in Fig. 4, this tightening is effected by means of a diaphragm *q* or the like. The body *l*, connecting the guide-blades *g* and *d*, further consists of several parts 11 12 13, kept in contact with one another by means of a spring *r* or the like and being able to liberally dilate through the action of the heat. This arrangement facilitates the mounting and the regulation of the parts.

With reference to the radial turbines shown in Figs. 5 and 6 the difference of the axial dilatations of the rotating and of the fixed parts is only small, (on account of the small length of a turbine of this kind in axial direction,) so that an extension of the guide-blades in axial direction need not to be taken in consideration. The nozzles *e* and the guide-blades d' d^2 of the first chamber are fastened to the body *s*, which may have the form of a segment. This body is arranged concentrically with regard to the middle axis and is fastened to the casing or cover as near as possible to the middle of the shaft. The guide-blades h' h^2 of the second chamber *f* are fastened in a similar manner to a segment *t*. In the chamber *b* the segment *s* and the vane-wheel *c* are surrounded by the same steam, and therefore will have the same temperature and be subjected to the same dilatation, so that when working the turbine the nozzles *a* and the guide-blades d' d^2 are regulated by the segment *s* in correspondence with the dilatation of the vane-wheel *c*. In a similar manner and in correspondence with the dilatation of the vane-wheel *g* the guide-blades h' h^2 of the chamber *f* are regulated by the body *t*, surrounded at all sides by steam. The length of these bodies to which the guide-blades are fastened may be regulated as may be seen (by way of example) from the bodies *o* shown in Fig. 7.

Referring to the tangential turbine represented in Figs. 7 and 8, the nozzles *a* are not fastened rigidly to the side wall of the casing, but hinged thereto by means of the pin or bolt a^2. The outlet ends of the nozzles *a* are fastened to the bodies *o*, Fig. 7, or *v*, Fig. 8, arranged inside the turbine-chamber and wholly surrounded by the same steam as the vane-wheel *c*. The rods *o*, Fig. 7, and the ring *v*, Fig. 8, provided with radial spokes *v'*, are fastened at *o'* and v^2 to the turbine-casing as near as possible to the middle of the shaft. When working a turbine of this kind, the wheel *c* and the bodies *o* or *v* dilate very nearly in an equal measure by the action of the heat of the steam, so that at all temperatures the distance between the periphery of the wheel and the mouths of the nozzles or overflow-channels remains very nearly the same.

In the axial turbine with full action of the steam on the vane-wheels, as shown in Figs. 9 and 10, the steam enters in the direction of the arrow 1, expands in many stages within

the turbine, and exhausts in the direction of the arrow 2. For sake of simplicity and clearness the turbines are not provided with pistons for equalizing the pressure, but with pressure-bearings *n*, by which the position of the rotating parts in axial direction is regulated. The guide-blades *d* are not fastened directly to the casing *u*, but to hollow bodies *w*, movable within the casing *u*. The said hollow bodies are fastened near to the pressure-bearing *n* (of the place neutral with regard to the axial dilatation) and are surrounded as much as possible on all sides by the same steam as the rotating parts in order to thus obtain the same temperatures and dilatations for the hollow bodies as for the rotating parts. This object may be attained (by way of example) by arranging between the casing *u* and the hollow body *w* a series of spaces $z\ z'\ z^2$, separated from each other and being in connection with the corresponding inner compartments of the turbine through channels or openings w^2, so that the steam in the spaces $z\ z'\ z^2$ has nearly the same pressure and the same temperature as that in the corresponding inner compartments. The different spaces $z\ z'\ z^2$ are separated in the turbine shown in Fig. 9 by means of ribs *w'*. The steam-pressure in the spaces *z z'* being different, the ribs *w'* and the casing *u* should jorm a tight joint. The steam which should pass between the ribs *w'* and the casing *u* of the space *z* does not get lost, but enters the next space *z'* and may flow thence through the opening w^2 to the inner compartment of the turbine and expand therein. In the turbine shown in Fig. 10 the fitted ribs w^2 are substituted by diaphragms *y*. Condensed water may be discharged through the pipes 4 5. When working turbines of this kind, the rotating or movable parts dilate radially or axially very nearly in the same manner as the bodies *w*, to which the guide-blades are fastened.

My invention is not confined to the constructions shown, which are to illustrate the invention only by way of example.

The bodies to which the guide-blades are fastened may consist of the same material. In many cases it might be of advantage to use bodies consisting of a material different from that of the shaft or of the vane-wheels. Thus the latter may be of steel, whereas the bodies carrying the guide-blades may be made of bronze. In this manner I attain that those dilatations are equalized which the vane-wheels undergo by mechanical action—as, for instance, by centrifugal force.

Having now described and ascertained my said invention, I declare that what I claim is—

1. In a turbine, a casing having inlets and outlets, nozzles leading from said inlets to the interior of the casing, annular guide-blades, dilating means interiorly held in the casing for supporting the guide-blades, and a rotating wheel having vanes registering with the guide-blades.

2. In an elastic-fluid turbine, a casing having an inlet and exhaust, a plurality of nozzles communicating with the inlet, guide-blades circumferentially arranged within the casing, expansible means within the casing and arranged a distance therefrom for supporting the guide-blades, and a rotatable wheel having a plurality of rows of vanes registering with the guide-blades in said casing.

3. In an elastic-fluid turbine, a casing having chambers provided with inlets, adjustable nozzles communicating with the latter, guide-blades arranged within the chambers, dilating means held in the casing and supported a distance therefrom for supporting the guide-blades, means for adjusting said dilating means, and a rotatable member having a series of vanes registering with the guide-blades and within the casing.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

FRANZ WINDHAUSEN.

Witnesses:

HENRY HASPER,

WOLDEMAR HAUPT.