No. 868,569. PATENTED OCT. 15, 1907.

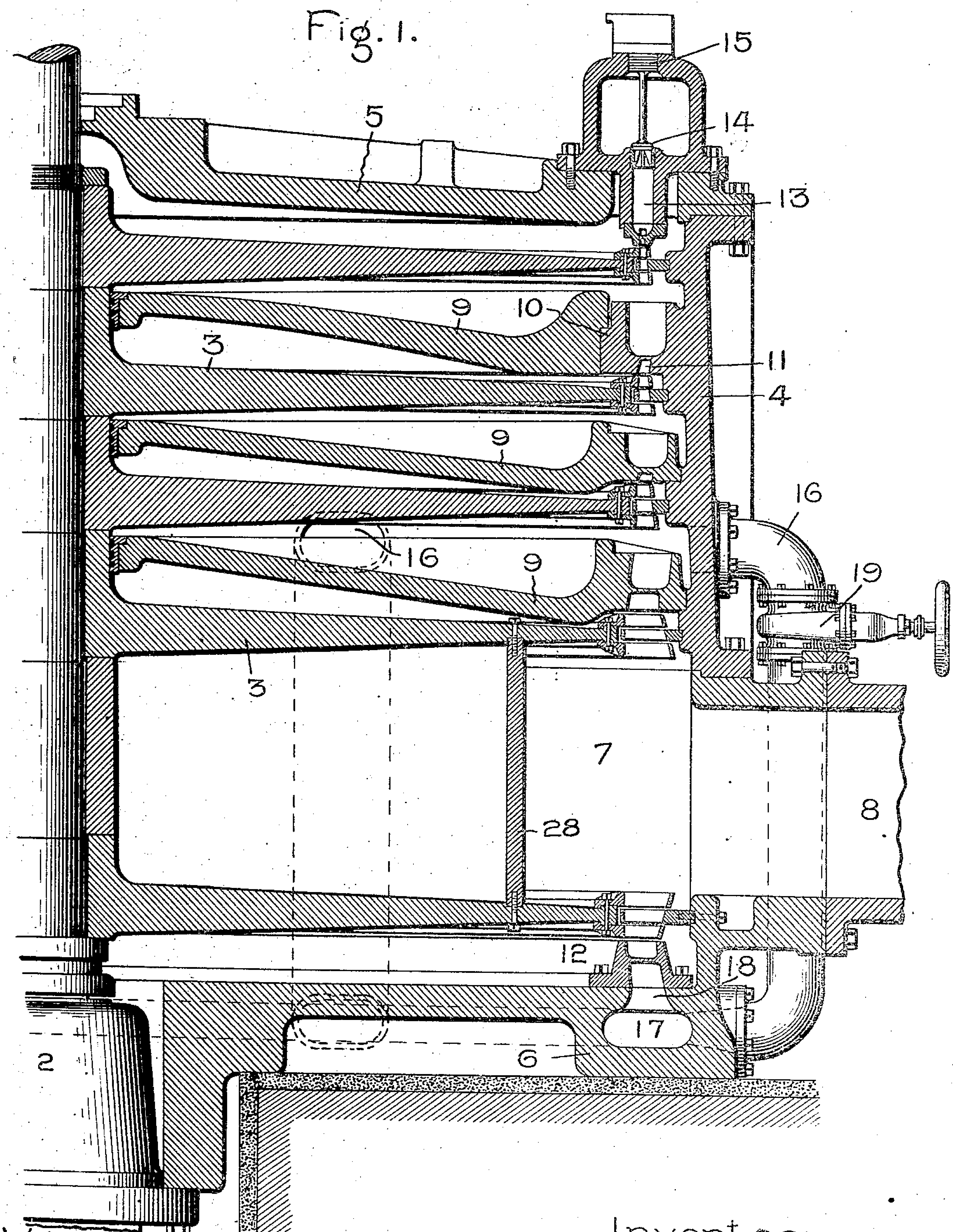
O. JUNGGREN.

ELASTIC FLUID TURBINE.

APPLICATION FILED MAY 26, 1904.

2 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
Marcus L. Byng.
Alex. F. Macdonald.

Inventor:
Oscar Junggren,
by Albert G. Davis
Att'y.

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2 SHEETS—SHEET 2.

Fig. 2.

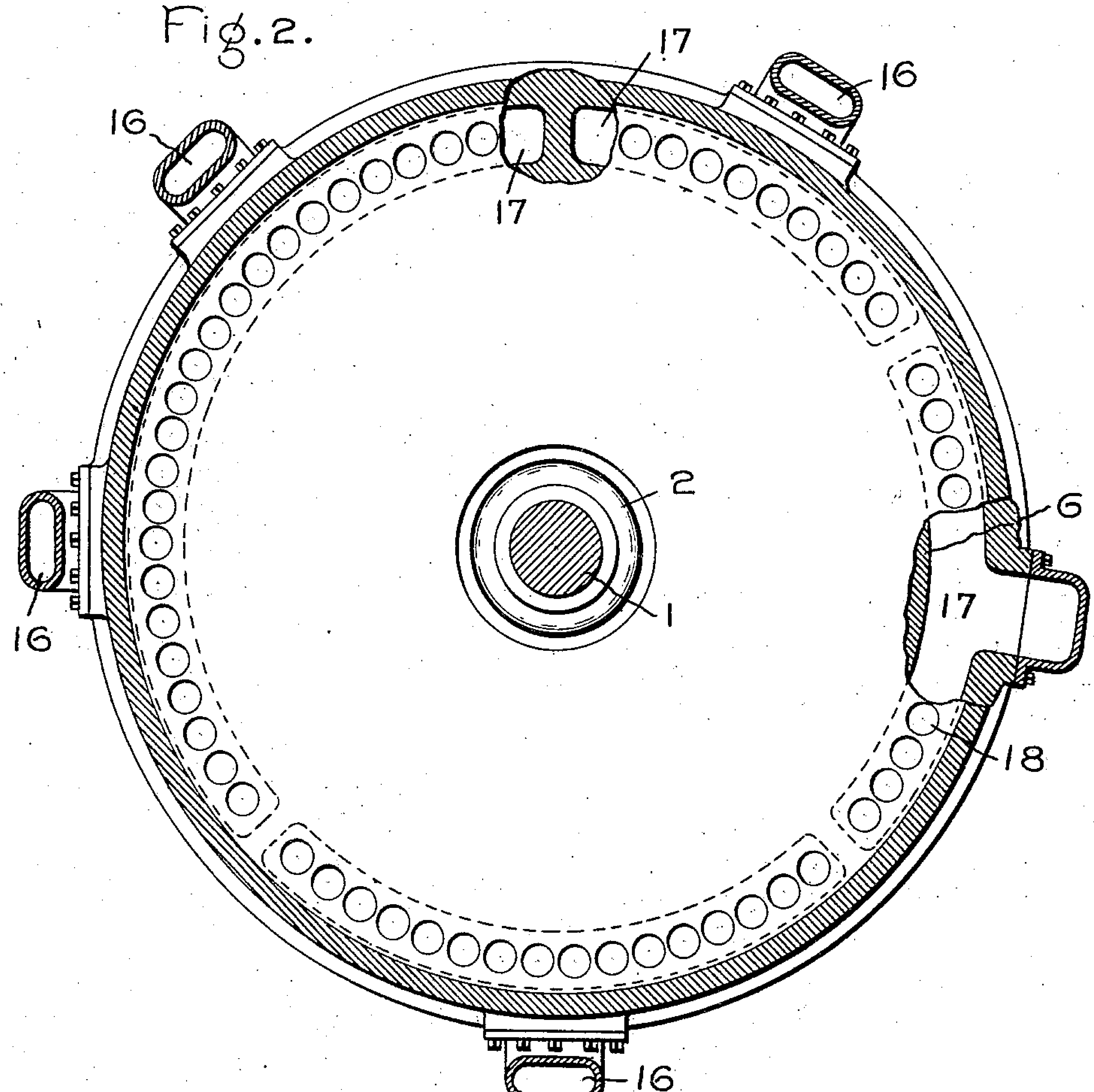
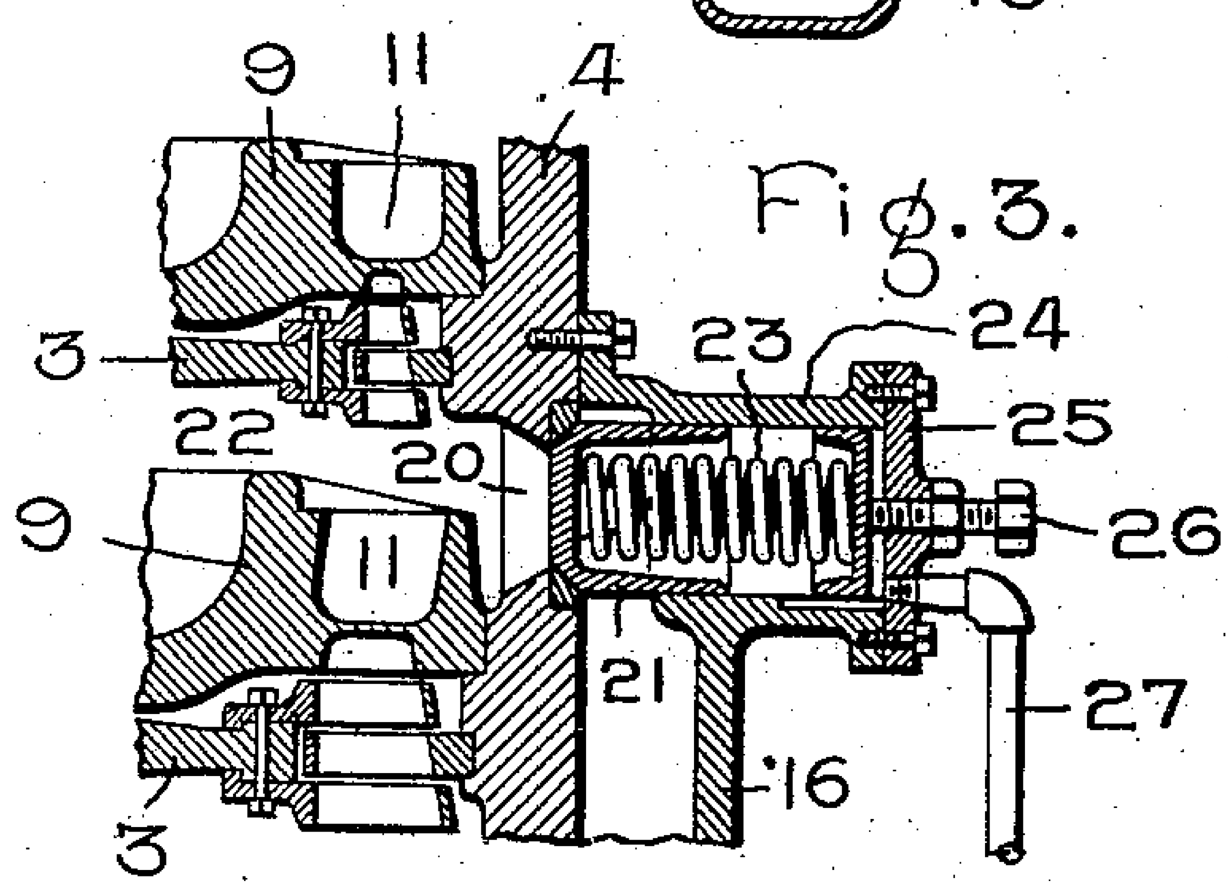


Fig. 3.



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UNITED STATES PATENT OFFICE.

OSCAR JUNGGREN, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELASTIC-FLUID TURBINE.

No. 868,569. Specification of Letters Patent. Patented Oct. 15, 1907.

Application filed May 26, 1904. Serial No. 209,887.

To all whom it may concern:

Be it known that I, OSCAR JUNGGREN, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Means for Increasing the Capacity of Elastic-Fluid Turbines, of which the following is a specification.

The limiting feature in prior existing turbines of the multi-stage jet type is the last stage wherein the nozzles cover the entire or substantially the entire wheel, and it is impracticable for many reasons to increase the dimensions of the nozzles and buckets above a certain point. The chief reason resides in the fact that if the buckets are unduly deep they will not be strong enough to withstand the centrifugal strains. The capacity can be increased by increasing the pressure of the motive fluid, but this is accompanied by a sacrifice in economy, because the percentage of energy abstracted is less than under normal conditions.

The object of the present invention is to increase the capacty of multi-stage elastic-fluid turbines, and more especially those of the jet type without increasing the the bucket speed.

At the present time, in order to obtain a maximum output with a minimum size machine, one wheel, the last one, is so arranged that the motive fluid acts on all or substantially all of its buckets. There may be a few idle buckets in certain cases, but practically speaking, all of the buckets are relied upon to perform useful work. The preceding stage of higher pressure has a less number of active buckets which receive fluid from nozzles or other discharging devices preferably arranged in one or more groups. The active area of the wheel represented by a certain number of buckets varies with the number of stages of which the turbine is composed, and also with the volume of motive fluid to be handled, but in any case it should be great enough to handle the total volume of motive fluid discharged by the preceding nozzle or nozzle sections without undue restriction, yet small enough to prevent an excess supply to the last stage. To state the matter differently, since the last stage can only handle a certain amount of fluid due to its limitation in size, both as to diameter and cross-sectional area of the bucket spaces or working passage or passages, it follows that if there is to be no restriction to the fluid flow, the stage preceding the last must only accommodate such an amount of fluid, when properly renozzled by the last stage nozzles, as will be sufficient to fill the bucket spaces of said last stage, and no more.

The same relation between one stage and the next exists irrespective of the terminal pressures, whether they be high or low. For example, in the case of a four-stage machine, the active area of the second stage wheel is somewhat greater than of the first, the active area of the third stage wheel is greater than the second, and the active area of the fourth stage wheel is still greater and includes all or substantially all of the buckets. In other words, there is an ever increasing active wheel area from the inlet to the last wheel where all of the buckets are active. In using the term "substantially all", I mean that the major portion of the buckets is normally active under full load conditions.

In carrying out my invention, the same general stage arrangement above specified is followed except that I double the capacity of the turbine by providing the last stage with two or more wheels whose buckets are all or substantially all active. This means that the wheel or wheels in the stage immediately preceding the last, instead of having only a fraction of their area utilized, have their entire area utilized, which means a corresponding increase in the work performed. To state the matter in a different way, the limitation on turbines of the multi-stage jet type as constructed prior to my invention is the last wheel wherein all of the buckets are active, the other wheels being only partially active.

According to my invention I double the capacity of the last stage by adding a wheel, both of said wheels being arranged to perform equal or substantially equal amounts of work. Since the capacity of the last stage is doubled, the preceding stage should also be doubled, and the wheel which was only partially active before now becomes fully active. The next preceding wheel, where such a wheel is employed, also has its active area increased, and so on through as many stages as are desired. The motive fluid passes from one stage to another through suitable nozzles arranged to convert thermal energy into kinetic energy in the form of velocity until the last stage is reached, wherein two or more wheels are fed in multiple from a preceding stage of higher pressure. Under most conditions it would be preferable to employ two wheels in the last stage, but in certain cases more may be provided. Arrangements are provided whereby the supply of motive fluid to one wheel in the last stage can be reduced or cut off entirely, depending upon the load conditions. When one wheel is cut out of service it offers very little opposition to rotation because of the fact that it is moving in a vacuum, or in a fluid medium whose density is low. One or more valved conduits or passages are employed to convey the motive fluid from a preceding stage of higher pressure to one of the wheels located within the exhaust chamber, which chamber is or may be subjected to the influence of a condenser. The other wheel of the last stage may be fed by nozzles in the usual way from the adjacent stage, or it may be supplied by valved or unvalved conduits.

The wheels in the last stage are preferably but not necessarily opposed to each other, so that the fluid exhausting therefrom enters the common chamber between them before passing to the condenser. This means in a vertical machine,—and it may be said that the invention includes horizontal machines also,—that the nozzles supplying one wheel discharge downwardly, while the nozzles for the other wheel discharge upwardly. When the wheels are mounted on the same shaft and therefore revolve in the same direction, the angle of discharge of the lower nozzles must be reversed with respect to the others. When the wheels rotate in opposite directions, the angle of discharge would be the same.

The last or what may be termed the additional or auxiliary wheel is mounted in the lower part of the base of the machine, and since this chamber is normally of ample proportions, it does not have to be enlarged, or at least enlarged by any considerable amount, hence the longitudinal dimension of the turbine is not changed, or at least only slightly.

By reason of my improved construction I can double the capacity of a given machine. In other words, the active bucket area has been doubled, and this by the addition of a single wheel placed in a chamber which normally contains only exhaust fluid.

The base is or may be cored out to form a supply chamber for supplying fluid to the nozzles or nozzle passages of the last wheel. The supply chamber may be divided into sections, each section connected by a conduit with the source of supply, which conduit is bolted to the casing or is formed as a part thereof. In some cases the supply chamber is made continuous and one or more conduits employed to convey fluid thereto. The valves in the conduits may be operated automatically or by hand. When automatic they may respond to changes in position of a governor, or to variations in stage pressure.

Another advantage of my improved construction resides in the fact that the two last wheels discharge into a common chamber, hence the necessity of a partition, wall or diaphragm between them is obviated. In this way I obtain in the present embodiment the effect of five wheels with only three diaphragms. By closing the chamber in which the upwardly extending nozzles and last wheel are located to a greater or less extent, I can compensate to a greater or less degree for any downward thrust which may be exerted by the other parts of the turbine. In other words a certain pressure may exist under the last wheel which tends to oppose any pressure in the preceding stage or stages, and which tends to relieve the weight on the step or thrust bearing when the invention is applied to vertical constructions.

Motive fluid may be admitted to the first stage by any suitable means responding to an automatic governor. I prefer to use separately actuated valves, each controlling a nozzle or nozzle section, which have an open and a closed position but no intermediate, since by so doing all tendency to throttle the fluid is avoided. I may also use this same arrangement for controlling the supply of fluid to the last wheel. The feature of the separately actuated valves is more fully set forth in my application S. N. 121,110, filed Aug. 26, 1902 and issued June 26, 1906, as Patent 824,546.

When the turbine occupies a vertical position, the weight of the revolving parts is carried by a step or thrust bearing located at any convenient point.

In using the term bucket wheel I do not confine myself to the construction shown wherein two rows of buckets are mounted on a common support for fractionally abstracting the velocity of the motive fluid since one or more rows can be employed, and where more than a single row is employed, each row can have its own individual support.

It has been demonstrated in connection with certain types of turbines employing large wheels that the admission side of the wheels is heated to a greater degree than the exhaust side, which causes a distortion of the wheel. That is to say, the admission side expands more than the exhaust side and bends the wheel so that the wheel buckets either rub on the stationary parts or on the parts rotating in an opposite direction or cut down the clearance abnormally on one side and increase it on the other. I am able to prevent this objectionable distortion by so arranging the wheels or parts that the tendency to distortion by one wheel or part is counteracted or neutralized by another wheel or part. In carrying out this feature of my invention the wheels are suitably mounted on the shaft, and the nozzles or discharging devices arranged to discharge steam or other elastic fluid against the buckets in the proper manner. As a broad proposition, the fluid flows through one wheel of a pair in one direction, and through the other wheel in the opposite direction. This arrangement is also desirable in that it reduces the tendency to end thrust. The admission side of each wheel will operate at a somewhat higher temperature than the exhaust side, and between the wheels is placed a means whereby the tendency to distortion by one wheel is resisted by one or more wheels. It is a satisfactory construction to arrange the wheels in pairs or to treat them as pairs, and to locate between each pair a connecting device, wall bridge or strut so that the tendency of one wheel to distort is opposed by an equal or substantially equal and opposite tendency on the part of the other wheel or wheels.

In the accompanying drawings which illustrate one embodiment of my invention, Figure 1 is a partial vertical section of an elastic fluid turbine of the jet type; Fig. 2 is a cross-section of the same on a reduced scale and taken on the line of division between the base and the lower set of nozzles; and Fig. 3 is a detailed view in section of the automatic valve for controlling the admission of fluid to the last wheel.

1 represents the vertical shaft of a turbine which is supported by a step bearing 2. Mounted on the shaft are wheels 3 having one or more rows of peripheral buckets. Surrounding the wheel is a casing 4 made up in suitable sections. The upper end of the casing is closed in by a cover or head 5. The casing is mounted upon a base 6, which rests on a masonry or other suitable foundation. The base is provided with a chamber 7, which forms a part of a condenser or is connected to a separate condenser by the conduit 8. Situated between the wheels, with the exception of the last two, are diaphragms 9 which divide the turbine into stages. The upper diaphragm may be made smaller than the rest on account of the heavy pressure to which it is subjected. This diaphragm is supported by a shoulder 10

formed on the inside of the casing. The shoulder portion is also provided with nozzle passages 11 for supplying motive fluid to the adjacent bucket wheels. The other diaphragms are also supported on shoulders carried by the casing, but the nozzles instead of being a part of the shoulder are formed in or are attached to the diaphragms. The last two wheels are situated at opposite ends of the chamber 7 in the base, and discharge in opposite directions. That is to say, the fluid exhausting from the upper wheel passes downward while the exhaust from the lower wheel passes upward. Situated below the last wheel is a nozzle 12 which extends entirely around the wheel. This nozzle is provided with a plurality of discharge passages and each passage has the same character as every other passage. The nozzle passages for the preceding wheel also cover the entire bucket area, and so also do the nozzle passages in the preceding stage. The nozzles in the first and second stages cover only a fraction of the total bucket area, but the fraction so covered is greater in the second than in the first stage.

Motive fluid is supplied to the first stage wheel by a plurality of nozzle sections or passages 13 each of which is or may be controlled by a separate nozzle valve 14, the latter being actuated by the piston 15 located in a suitable cylinder. The action of these fluid motors may be controlled by electrical or mechanical means or by a combination of both. In the preferred arrangement these motors are controlled by relay valves and the latter are controlled by a shaft governor.

As the motive fluid passes through the nozzles a certain amount of pressure is converted into velocity which velocity is abstracted wholly or in part by the bucket wheels. The wheel exhausts into its chamber or stage and the steam is then renozzled and the action repeated. In order to supply the last two wheels with motive fluid means are provided which are arranged in multiple. As the motive fluid is discharged from the third wheel in the present embodiment of the invention a part of it passes directly through the nozzles in the adjacent diaphragm and the remainder passes through the conduits 16 which are connected to the chamber or passage 17 formed in the base. The latter communicates with the bowls of the nozzle 12 by means of passages 18. In the conduits 16 are located valves which may be operated by hand or by automatic means as desired. In certain instances one or more of the conduits may be unvalved. In Fig. 1 is shown a manually actuated stop valve 19 for controlling the passage of fluid through the right-hand conduit. The left-hand conduit shown in dotted lines is unvalved.

Referring to Fig. 2, I have shown an arrangement for supplying motive fluid to a portion, or to the entire bucket area of the last wheel depending upon the load conditions. The chamber 17 instead of extending entirely around the base as shown in Fig. 1 is divided into sections and the several sections cover different areas. It is preferable although not absolutely necessary to have these sections successively increased in area. For example the first section supplies fluid to a certain number of nozzle bowls and the second section to a certain greater number and so on. It will be sufficient to use one conduit for supplying the small sections while two or more should be employed for supplying the large sections. When all of the conduits 16 are shut off no fluid will be supplied to the last wheel, and it will therefore be idle, but owing to the fact that it is rotating in a rarefied medium it will offer only a limited resistance to the rotation of the shaft, and hence the machine will have a high efficiency at light loads.

In Fig. 3, is shown one form of automatic valve which may be used for controlling the passage of motive fluid from one stage to the next. This valve in addition to controlling the passage of fluid also tends to maintain an even pressure in the stage from which the fluid is received. I may employ one or more of these valves and when more than one is provided, the preferred arrangement, they should be arranged to operate successively, since by so doing a more nearly constant stage pressure will be maintained. These valves may be weighted in any suitable manner, either by a constant or by a variable weight depending upon the conditions of operation. In the present illustration I have shown a spring as indicating a suitable form of weight. 3 represents the bucket wheels, 4 the wheel casing, 9 the diaphragms between stages and 11 the nozzles. The casing is provided with an opening 20 opposite the valve 21. The valve is of the piston type and is moved in one direction by the fluid pressure in the wheel compartment or stage 22, and in an opposite direction by a spring or other weight 23. The piston 21 is provided with a tapered end so that it will present a greater area when opened than when closed. This arrangement imparts stability to the operation of the valve. Surrounding the piston is a cylinder 24 which is or may be formed integral with the wall of the conduit 16. The end of the cylinder is provided with a head 25 which is bored centrally to receive the adjusting screw 26, the latter engaging an adjustable abutment located inside of the cylinder which receives one end of the spring and is employed to change its tension. In order to balance the opposing pressure to which the valve parts are subjected to a greater or less extent, a conduit 27 is provided which is connected to the cylinder at one end and to a stage of lower pressure than that to which the valve is subjected. When the pressure in the stage 22 exceeds a predetermined amount one or more of the valves will open against the action of their weights and discharge fluid into one or more conduits 16. These conduits will in turn deliver fluid to the sections of the chamber 17, and from these sections fluid will pass through the passages 18 into the nozzle bowls, thence through the nozzle passages against the lower wheel.

Referring to Fig. 1, 28 represents the connection between the two lower wheels for preventing distortion. In the present illustration of my invention the connection is used between the last two wheels only, but it is to be understood that the invention is applicable to wheels located in other stages and working at different pressures. In the present illustration the connection takes the form of a cylindrical wall. The under side of the lower wheel, when in operation, is hotter than the upper side, hence there is a tendency for the wheel to bend upward. On the other hand, the upper side of the upper wheel is hotter than the lower, hence there is a tendency for the wheel to bend downward. It will thus be seen that both wheels receive steam or other fluid from the same compartment or shell, hence the tendency to distortion of both wheels is equal or substantially so, but in opposite directions, and the cylindrical wall 28 transfers the tendency of one wheel to distort to the other and the effect of both is thereby neutralized.

The turbine illustrated is of the Curtis type and the nozzles shown are of the divergent or expanding type, but in its broader aspects the invention is not limited to the use of any particular kind of nozzles or other fluid-discharging devices.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In an elastic-fluid turbine, the combination of a high-pressure wheel whose active bucket area is a fraction of the total, a wheel of lower pressure whose entire bucket area is substantially active, wheels of similar but lower pressure whose entire bucket areas are substantially active, means for conducting fluid to the several wheels, a casing for the wheels, and diaphragms dividing the casing into wheel compartments.

2. In an elastic-fluid turbine, the combination of a high-pressure wheel whose active bucket area is a fraction of the total, a wheel of lower pressure whose total bucket area is active, a pair of wheels of still lower pressure whose total bucket areas are active, stationary means arranged in multiple for supplying the pair of wheels of lowest pressure from the same source, and a casing that is common to the wheels.

3. In a multi-stage elastic-fluid turbine, the combination of a casing, a bucket wheel, a means for discharging fluid to a portion of the wheel, a number of additional bucket wheels, a diaphragm between the first and last mentioned wheels, and fluid-discharging devices which discharge fluid simultaneously and in multiple to substantially the entire area of the last-mentioned wheels.

4. In a multi-stage elastic-fluid turbine, the combination of a casing, a bucket wheel, a means for discharging fluid to a portion of the wheel, a number of additional bucket wheels operating in separate compartments, and stationary fluid-discharging devices receiving fluid in multiple which are arranged in sets, each set surrounding a bucket wheel and discharging fluid against it.

5. In a multi-stage turbine, the combination of a number of wheels, each arranged in a separate stage or compartment, nozzles which discharge motive fluid to a portion only of one wheel and to the whole of another, an auxiliary wheel, and stationary nozzles which discharge fluid in multiple to the whole of said wheel.

6. In a multi-stage turbine, the combination of a number of wheels, nozzles which discharge fluid to a portion of the high-pressure wheel, stationary nozzles in the low-pressure stage, which discharge fluid so that it will act on all of the buckets of that stage, and an additional low-pressure wheel in multiple with the first, all of the buckets of which are acted upon by the motive fluid.

7. An elastic-fluid turbine comprising a bucket wheel, a casing, and a condenser chamber, in combination with a pair of bucket wheels located in said chamber and discharging into it; and stationary discharge devices delivering fluid to said wheels.

8. An elastic-fluid turbine comprising a bucket wheel, a casing, and a condenser chamber, in combination with a pair of bucket wheels located in said chamber and discharging toward each other, and fluid-discharging means located on opposite sides of the wheels for discharging fluid against the buckets.

9. An elastic-fluid turbine comprising bucket wheels, some of which are partially active and the remainder fully active, in combination with a condenser chamber located between adjacent wheels which are fully active, and means for conveying fluid discharged from a wheel around a given wheel and discharging it against another.

10. An elastic-fluid turbine comprising a casing, bucket wheels mounted therein, means discharging motive fluid against the buckets, diaphragms for dividing the casing into compartments, stage nozzles in said diaphragms, a conduit for carrying the motive fluid around a diaphragm, and a nozzle or nozzles which communicates with and receives motive fluid from the conduit and discharges against a wheel.

11. An elastic-fluid turbine comprising a casing, bucket wheels mounted therein, means for discharging motive fluid against the buckets, diaphragms for dividing the casing into compartments, stage nozzles in said diaphragms, a conduit for carrying the motive fluid around a diaphragm, a supply chamber into which the conduit discharges, and nozzle passages which receive their supply of motive fluid from the chamber and discharge it against a wheel.

12. An elastic-fluid turbine comprising a casing, diaphragms forming wheel compartments within the casing, and wheels located in the compartments, in combination with a condenser chamber, wheels within the chamber, one located at one end, the other at the opposite end, and nozzles which surround the wheels and discharge fluid against the buckets.

13. An elastic-fluid turbine comprising a casing having a side wall and heads for closing the ends thereof, in combination with diaphragms dividing the casing into compartments located between them, wheels for the compartments, a wheel situated beyond the diaphragm adjacent to the exhaust, a wheel situated adjacent to the low-pressure head, and a means supported by said head for discharging fluid against the last-mentioned wheel.

14. An elastic-fluid turbine comprising a casing which is divided into wheel compartments by diaphragms, and wheels in the compartments, in combination with nozzles in said diaphragms, a conduit which conveys fluid around a diaphragm to supply a bucket wheel of lower pressure, and a valve in said conduit.

15. In an elastic-fluid turbine of the jet or impact type, the combination of a low-pressure stage containing two or more wheels whose entire bucket area is active, a preceding stage of higher pressure containing a single wheel whose entire bucket area is also active, a stage of still higher pressure containing a wheel whose bucket area is only partially active, nozzles for supplying motive fluid to the turbine, and other nozzles which are stationary for conveying fluid from one stage to the next, and whose discharge orifices gradually increase in area from the high- to the low-pressure stage.

16. In an elastic-fluid turbine, the combination of a casing, a diaphragm or wall for dividing the casing into stages or wheel compartments, a number of chambers delivering fluid to the same wheel, and conduits for supplying the chambers from a stage or compartment of higher pressure.

17. In an elastic-fluid turbine, the combination of a casing, a diaphragm or wall for dividing the casing into stages or wheel compartments, a number of chambers delivering fluid to the same wheel, conduits for supplying the chambers from a stage or compartment of higher pressure, and successively operating valves controlling the passage of fluid through the conduits.

18. In an elastic-fluid turbine, the combination of a casing, a diaphragm or wall for dividing the casing into stages or wheel compartments, a number of chambers of different capacity receiving fluid from a common source and discharging it against the same wheel, and means located between said source and the chambers for controlling the passage of fluid.

19. In an elastic-fluid turbine, the combination of bucket-carrying elements, nozzles or devices for discharging fluid against them in such manner that one side of each element is hotter than the other, and a cylindrical wall located near the buckets for connecting the elements so that their tendency to distortion is neutralized.

20. In an elastic-fluid turbine, the combination of a bucket wheel of large diameter, an inclosing casing, a second wheel also of large diameter and located within the casing, a cylindrical wall located between the wheels and

at a point near their peripheries, and nozzles for discharging fluid to the opposite sides respectively of said bucket wheels.

21. In a multi-stage turbine, the combination of a casing, diaphragms dividing the casing into compartments, internal shoulders to support the diaphragms, high-pressure wheels, nozzles which discharge motive fluid to a portion of each of said wheels, the latter being arranged to receive motive fluid in series, low-pressure wheels arranged to receive motive fluid from the high-pressure wheels, all of the buckets of which are active, and stationary nozzles arranged to direct the motive fluid against the buckets of the low-pressure wheels.

In witness whereof, I have hereunto set my hand this 25th day of May, 1904.

OSCAR JUNGGREN.

Witnesses:
EDWARD WILLIAMS, Jr.,
HELEN ORFORD.