W. E. SNOW.

ELASTIC FLUID TURBINE.

APPLICATION FILED MAR. 7, 1906.

1,007,249.

Patented Oct. 31, 1911.

3 SHEETS—SHEET 1.

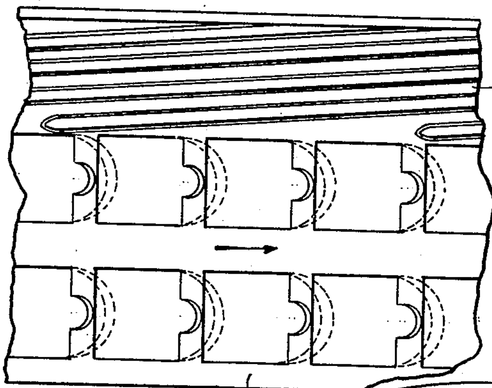


Fig. 4.

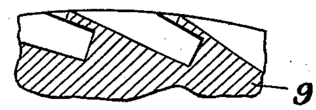
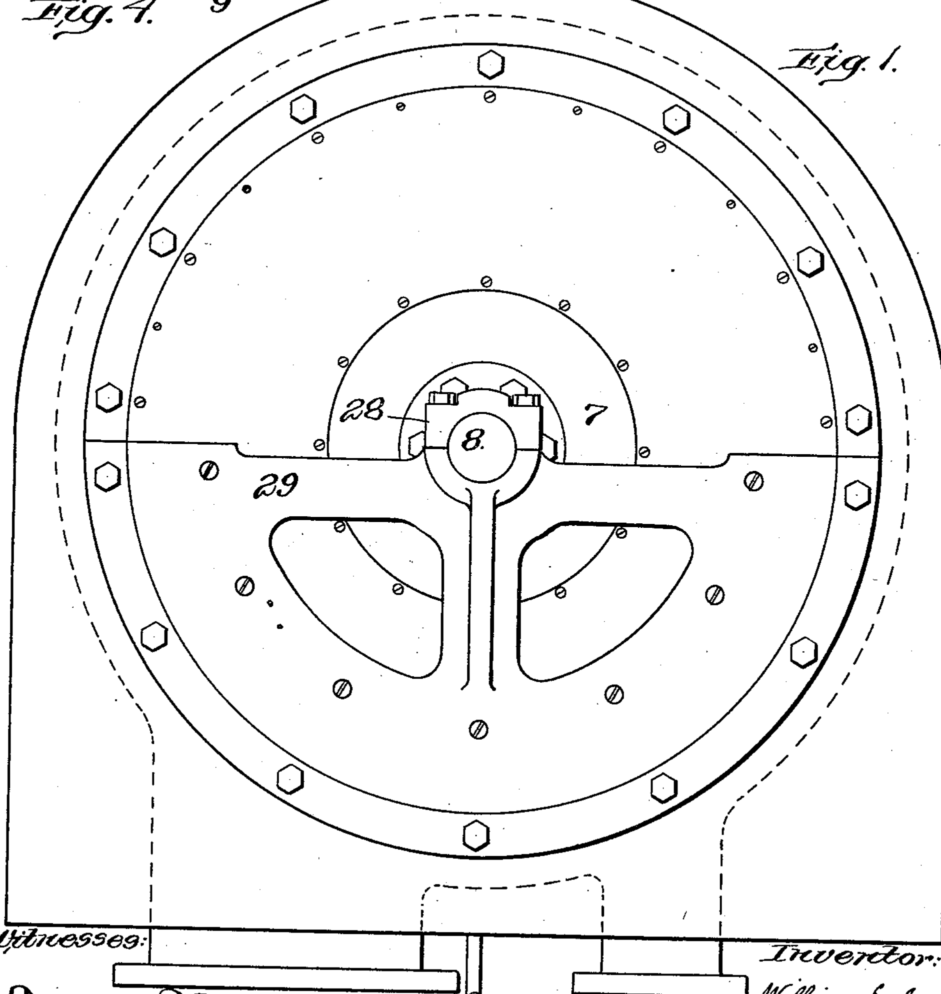


Fig. 5.

Fig. 1.



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3 SHEETS—SHEET 2.

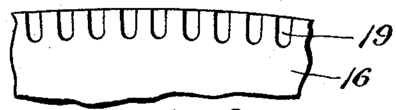
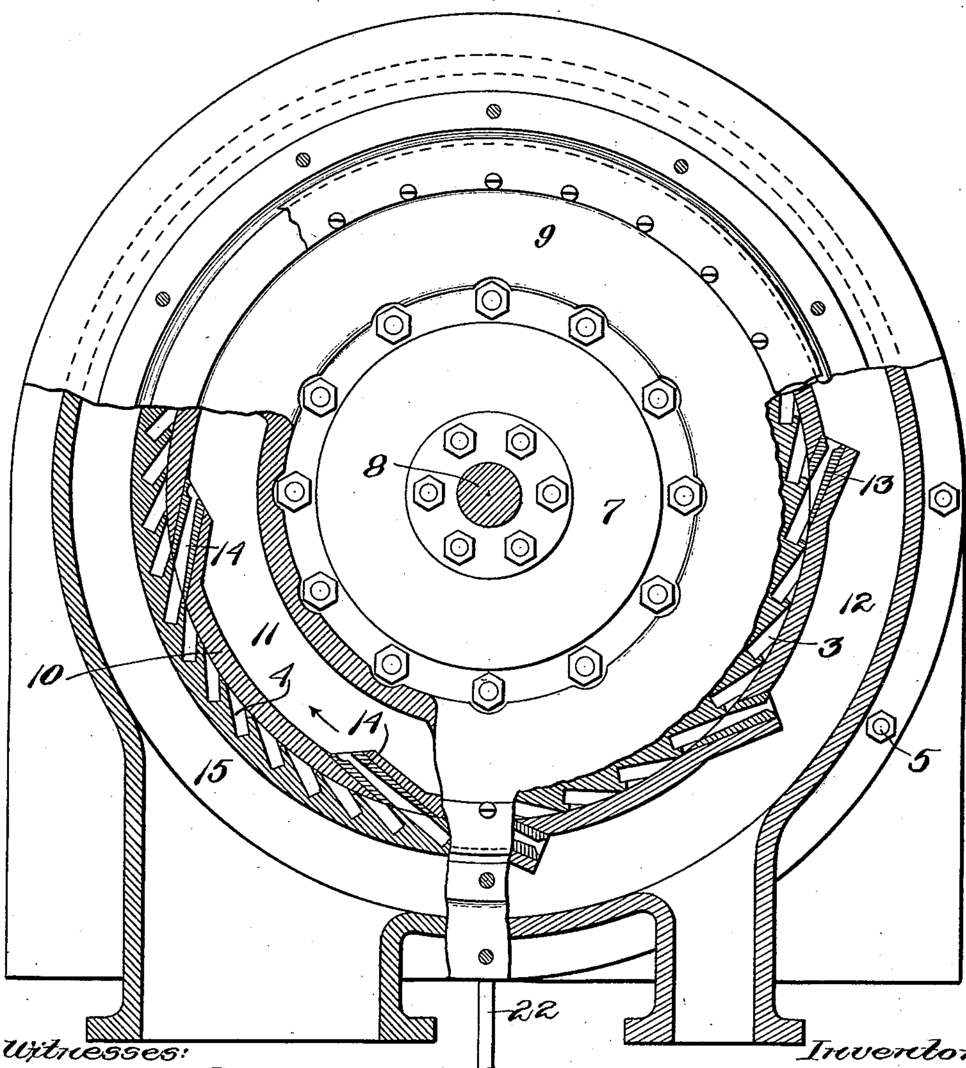


Fig. 6

Fig. 2



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3 SHEETS—SHEET 3.

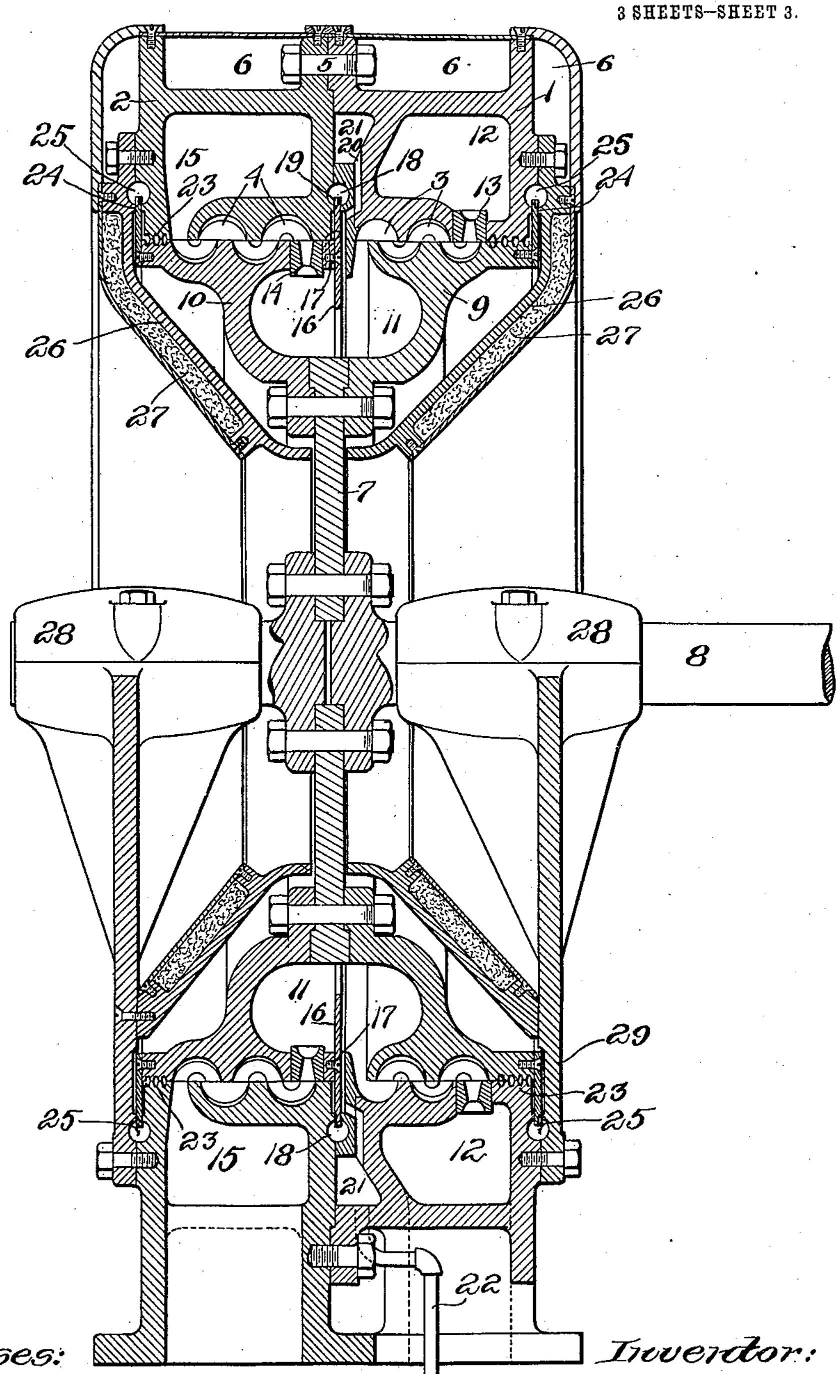

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Fig. 3.

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UNITED STATES PATENT OFFICE.

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ELASTIC-FLUID TURBINE.

1,007,249. Specification of Letters Patent. Patented Oct. 31, 1911.

Application filed March 7, 1906. Serial No. 304,624.

To all whom it may concern:

Be it known that I, William E. Snow, a citizen of the United States, residing at Hyde Park, in the county of Norfolk and State of Massachusetts, have invented certain new and useful Improvements in Elastic-Fluid Turbines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in elastic-fluid turbines.

In elastic-fluid turbines of the axial-flow impulse type the motive fluid is usually delivered from nozzles arranged at a slight angle, in practice about 20°, to the plane of motion of the buckets, and the fluid is exhausted after turning through approximately 140° retaining an objectionably high residual velocity which cannot be utilized. To overcome this objection turbines have been constructed in which the buckets are formed to cause the fluid to turn through 180° so that it is discharged in a direction opposite and parallel to its original direction, the motive fluid being delivered by nozzles located outside of the periphery of the wheel and lying in the plane of motion of the buckets so that the exhaust steam is discharged from each bucket in a direction opposite to the direction of rotation of the wheel and in a line substantially tangent to the portion of the wheel on which the bucket is located. Buckets of this type, which may conveniently, and will hereinafter be termed, " parallel return buckets " are found in the well-known Pelton water wheel and in the Riedler-Stumpf steam turbine. It has been found that in order to secure the greatest economy in turbines operating with elastic motive fluid the buckets should be arranged in a plurality of stages, with successive expansions, either with or without intermediate receivers for the motive fluid. It has heretofore been proposed to utilize this principle in a turbine with parallel-return buckets, as, for example, in the patent to Stumpf, No. 783,153, but no satisfactory arrangement of parallel-return buckets for this purpose has yet been proposed, so far as the inventor is aware, the arrangement in the patent referred to being defective in that each stage comprises only one set of buckets, and the steam after its passage through each set is discharged into a casing inclosing the entire wheel, from which it is conducted to another set of nozzles acting on a second wheel inclosed in a separate compartment of the casing. Other proposed arrangements of parallel-return buckets in multiple-stage turbines have been defective for other reasons which need not be here enumerated.

One object of the present invention is to produce an elastic-fluid turbine in which parallel-return buckets are used in a plurality of stages on a single wheel, and in which the motive fluid, in passing from one stage to another, is not discharged into a casing inclosing the entire wheel, and to this end the invention comprises a turbine in which parallel-return buckets are arranged in two or more sets on the periphery of a single wheel, the turbine being of the axial-flow type, and the motive fluid being confined, in passing from one set of buckets to another, to the periphery of the wheel or to intermediate pressure-chambers adjacent thereto.

Another object of the invention is to produce a turbine in which the motive fluid is entirely confined to the periphery of the wheel, not only between the stages but also before and after delivery to and discharge from the buckets, and to this end the invention comprises a turbine having sealing joints of novel form between the wheel and the casing by which leakage of motive fluid is entirely prevented without use of packed or sliding joints.

Other objects of the invention will be noted in connection with the description of the illustrated embodiment.

The invention consists in the improved turbine hereinafter described, as defined in the claims.

In the drawings Figure 1 is a side elevation of a turbine embodying the present invention. Fig. 2 is a side elevation partly in section to show the arrangement of the nozzles and the buckets. Fig. 3 is a vertical axial section. Figs. 4 and 5 are detail views showing the form of the buckets, and Fig. 6 is a detail view of a portion of one of the plates forming the sealing joints.

The illustrated embodiment of the invention is a steam turbine comprising a casing in which are mounted fixed buckets, and a rotary member or wheel carrying coöperating buckets. The turbine is of the two-stage type, having buckets arranged to operate in two stages with an intermediate pressure chamber in which the steam is freed from water of condensation and is then, by means of suitable nozzles, further expanded and then discharged into the second-stage buckets.

The casing comprises two annular portions 1 and 2, the portion 1 containing the fixed buckets 3 of the first stage, and the portion 2 containing the fixed buckets 4 of the second stage. The buckets in both the wheel and the casing are of the parallel-return type above described, being formed to deflect the steam through 180°, and the steam in passing through them follows a helicoidal course, being deflected alternately from the fixed buckets to the rotating buckets and back until it has passed through one stage. The casing members 1 and 2 are secured together by bolts 5, as shown in Fig. 3, and are provided upon their sides and periphery with lagging 6 to prevent the escape of heat.

The wheel comprises a web portion 7 clamped between the two members of the shaft 8, as shown in Fig. 3, and a rim portion comprising two annular members 9 and 10. The rim members 9 and 10 carry respectively the first and second-stage rotating buckets which are formed in the peripheries of these members. The intermediate pressure-chamber 11 is formed in the wheel itself between the adjacent concave sides of the rim members 9 and 10, as shown in Fig. 3. The live steam, which is contained in an annular chamber 12 in the casing member 1, passes through nozzles 13, in which it is expanded and acquires high velocity, into the first stage buckets 3, whence it is delivered into the pressure chamber 11, from which it is expanded again through nozzles 14 mounted in the wheel member 10, and delivered to the second-stage buckets 4.

The steam, on entering the chamber, has still a considerable velocity in the direction of rotation of the wheel and the resulting rotation of the steam has to some extent the effect of increasing the pressure of the steam at the delivery nozzles 14, owing to centrifugal force whereby its available energy is increased. After passing through the second-stage buckets the steam issues into an annular exhaust chamber 15 formed in the casing member 2, whence it is discharged into a condenser or otherwise disposed of.

The embodiment of the intermediate pressure chamber in the wheel secures compactness in the turbine, since in this arrangement the pressure chamber does not increase the over-all dimensions of the turbine.

In order that the steam may not pass directly from the first-stage buckets to the second-stage buckets between the adjacent surfaces of the casing and the wheel, a novel form of sealing joint is introduced at this point. An annular plate 16 secured to the wheel rim member 10 by screws 17 projects beyond the periphery of the wheel into an annular pocket 18 formed between the adjacent surfaces of the casing members 1 and 2, the plate 16 being closely embraced by these surfaces at a point near its margin.

The plate 16 extends inwardly some distance in the intermediate chamber and constitutes a device for separating water of condensation from the steam, since it forms a baffle by which drops of moisture in the entering steam are arrested. The moisture so arrested, and the moisture collecting on the walls of the chamber, is thrown by centrifugal force into the pocket 18, small drain passages, shown dotted in Fig. 3, being provided for this purpose on the left-hand side of the plate 16 and passing through the plate, and this water of condensation fills the pocket. The water continues in rapid rotation in the pocket, owing to the drag of the plate 16, and is thus retained in the pocket under pressure by the centrifugal action. The water thus operates to seal the joint between the plate 16 and the casing. The plate is provided with small radial depressions, 19, as shown in Fig. 6 on the left-hand side of its marginal portion, so that the centrifugal action on this side is greater and acts to counterbalance the greater steam pressure on the other side of the plate, where the water is exposed to the pressure in the intermediate chamber. The pocket 18 is provided with an overflow passage 20 delivering into an annular passage 21 in the casing, and the passage 21 is connected with a drain pipe 22 by which it is emptied of water. By this arrangement the amount of water in the pocket is kept constant and the surplus water of condensation separated from the steam or delivered from the first stage buckets is constantly carried off.

Although the sealing joint is maintained, in the machine of the drawings, by water, it is within the contemplation of the inventor to use other fluids for this purpose, such as oil for example, but in a turbine in which steam is used as a motive fluid the water of condensation answers the purpose, and is considered preferable.

To confine the steam to the periphery alone of the wheel, sealing joints are located between the wheel and the casing at each edge of the wheel rim. These joints are of two kinds, as shown in Figs. 3 and 4. The wheel rim and the casing are provided with helical grooves 23 in the adjacent surfaces. These grooves are inclined in opposite directions and not only operate as baffles to retard the flow of steam between the surfaces but also have a screwing action tending to return steam to the buckets. Outside of the grooves 23 the wheel is provided with plates 24 similar to the plate 16 in construction and operation and pockets 25 similar to the pocket 18. These pockets are connected with the drip pipe by overflows as in the case of the pocket 18.

While the sealing joints above described entirely eliminate actual contact between the wheel and the casing they afford a hermetical closure which absolutely prevents the escape of steam so long as the speed of the wheel is high enough to maintain the necessary centrifugal action. Although it is preferred, in the illustrated embodiment of the invention, to rotate the flanges while the members containing the pockets are stationary, it will be apparent that this arrangement may be reversed, the flanges being fixed while the pockets rotate, the motion of the sealing fluid being, in this case, caused by the drag of the pockets.

By confining the steam to the rim alone of the wheel several serious defects of the usual form of turbine are avoided, among which may be mentioned unnecessary area of cooling surface, heating of the wheel journals, lateral pressure on the wheel causing end thrust, warping of the large surfaces exposed to heavy steam pressure and to differences of temperature, and increased skin friction on the wheel resulting from contact with the comparatively dense motive fluid in place of air.

Although, by the use of sealing joints, contact between the sides or the web portions of the wheel and the steam is obviated, it is considered desirable to inclose the rim portion of the wheel in a part of the casing in order that a body of air may be inclosed and maintained in contact with the rim. This body of air acquires a rotative movement within the casing, thereby reducing the skin friction against the rim, and it also becomes warmed by the heat radiated from the rim and limits the heat lost through such radiation, which would be much greater if the atmosphere had unrestricted access to the rim. To the above ends the casing is provided with concave conical extensions or end plates 26 which inclose the rim portion of the wheel and closely approximate the web portion 7, although it is not necessary that there be an air tight joint between the casing and the web. In order to retain the heat in the body of air inclosed by the end plates 26 these plates are provided with lagging 27.

It has been found to be highly advantageous in steam-engine construction to maintain the heat of the chambers in which the steam is expanded by means of steam jackets surrounding such chambers. In the present invention this principle is utilized by so forming the live-steam chamber 12 and the exhaust chamber 15 that they surround and inclose respectively the first and second stage buckets in the casing members 1 and 2, as shown in Fig. 3. The intermediate pressure chamber 11 in the wheel serves to some extent as a steam jacket for the wheel buckets.

The wheel shaft 8 is supported in bearings 28 formed integral with semicircular segments 29 bolted to the casing members 1 and 2. The segments 29 and the upper halves of the end plates 27 form, as shown in Fig. 3, cover plates to close the annular buckets 25.

The use, in an axial-flow multiple-stage turbine, of nozzles delivering and buckets discharging in a generally tangential direction secures an important advantage over axial-flow turbines of other types in the small clearance between the rotating and fixed buckets. Where the buckets are in the form of sets of radial rotating vanes alternating with fixed vanes projecting inwardly between the rotating vanes considerable lateral clearance is necessary to avoid interference between the vanes, owing to the serious warping effect of the pressure and temperature of the steam on the wheel, but in the present invention the only clearance necessary is the annular clearance between the contiguous surfaces of the periphery of the wheel and the inside of the casing, and this may be made as small as convenience in the mechanical construction of the apparatus will permit, so that the leakage between successive stages or sets of buckets is much less than in turbines of other types, and the economy of operation is thereby enhanced.

Owing to the arrangement of the parts of the wheel and the casing and the manner in which they are secured together the wheel may be conveniently assembled or taken apart and either half of the apparatus may be opened without disturbing the other half.

The inventor is aware that it has previously been proposed to confine the motive fluid to the rim alone of a turbine, but it is believed that such construction, as previously proposed, has been impractical owing to the lack of suitable sealing joints between the wheel and the casing, and that the present invention is the first in which suitable sealing joints are embodied. The invention is not limited, however, in some of its aspects, to the form of sealing joint described, nor, in general to the details of construction and operation specifically described, but may be embodied in other forms broadly defined in the claims.

Having now described the invention what is claimed is:

1. An elastic-fluid turbine having, in combination, a wheel provided with peripheral parallel-return buckets in a plurality of stages, and a casing provided with coöperating parallel-return buckets, an intermediate pressure chamber being provided in the wheel between two adjacent stages of buckets, substantially as described.

2. An elastic-fluid turbine having, in combination, a wheel provided with peripheral parallel-return buckets in two stages, and a casing provided with nozzles, an intermediate pressure chamber being provided in the wheel between the two stages of buckets, substantially as described.

3. An elastic-fluid turbine having, in combination, a casing, a plurality of sets of buckets mounted therein, a wheel and a plurality of sets of buckets carried thereby, the wheel having an annular pressure chamber formed in its rim portion between two adjacent sets of buckets and adapted to receive fluid in its passage from the buckets on one side of said chamber to the buckets on the other side, substantially as described.

4. An elastic-fluid turbine having, in combination, a casing, a plurality of sets of buckets mounted therein and arranged to act in several stages, a wheel formed with an annular pressure chamber, a set of buckets carried by the wheel on each side of the pressure chamber, expansion nozzles carried by the casing and directed against the first set of buckets on the wheel on one side of the pressure chamber, and expansion nozzles carried by the wheel and arranged to deliver fluid from the pressure chamber against the succeeding set of fixed buckets on the opposite side of the pressure chamber, substantially as described.

5. An elastic-fluid turbine having, in combination, a casing and a wheel provided with a plurality of stages of buckets, and means intermediate the stages for separating condensed moisture from the motive fluid, substantially as described.

6. An elastic-fluid turbine having, in combination, a casing, fixed buckets mounted therein, a wheel provided with buckets and with an intermediate pressure chamber, and means for separating condensed moisture from the motive fluid on the pressure chamber, substantially as described.

7. An elastic-fluid turbine having, in combination, a casing and a wheel provided with buckets, and a device secured to the wheel for separating condensed moisture, by centrifugal action, from the motive fluid passing through the wheel buckets, the casing being provided with a channel to receive and drain away the moisture so separated, substantially as described.

8. An elastic-fluid turbine having, in combination, a casing and a wheel provided with buckets, and an annular plate carried by the wheel and acting to arrest condensed moisture in the motive fluid and discharge it by centrifugal action, substantially as described.

9. An elastic-fluid turbine having, in combination, a casing and a wheel provided with coöperating buckets arranged in a plurality of stages, an annular plate carried by the wheel and located between two adjacent stages of buckets so as to arrest condensed moisture, and means embodied in the casing and coöperating with the annular plate to prevent the passage of motive fluid around the edge of the plate, substantially as described.

10. An elastic-fluid turbine having, in combination, a wheel provided with peripheral buckets, and a casing provided with coöperating buckets and having steam jackets surrounding the buckets on all sides to prevent condensation therein, substantially as described.

11. An elastic-fluid turbine having, in combination, a wheel and a casing provided with buckets operating in two stages, the casing being provided with steam jackets surrounding the first and second stages of buckets and supplied, respectively, with live and exhaust steam, substantially as described.

12. An elastic-fluid turbine having, in combination, a fixed member and a rotating wheel, said members having oppositely disposed surfaces provided with grooves inclined to the direction of motion of the surfaces and acting as baffles to prevent the passage of motive fluid between the surfaces, substantially as described.

13. An elastic-fluid turbine having, in combination, a fixed casing and a rotating wheel having oppositely disposed surfaces provided with helical grooves inclined in opposite directions and acting as baffles to obstruct the passage of motive fluid between the surfaces, substantially as described.

14. A sealing joint for elastic-fluid turbines comprising, in combination with a fixed and a rotatory member of the turbine an annular projection carried by and rotating with the rotatory member, and an annular pocket formed in the fixed member inclosing the margin of the annular projec-

tion and having surfaces closely embracing the projection near its margin, substantially as described.

15. A sealing joint for elastic-fluid turbines having, in combination with a fixed member and a rotatory member of the turbine, an annular projection carried by and rotating with the rotatory member, an annular pocket formed in the fixed member embracing the margin of the annular projection and having surfaces close to the surface of the projection near its margin, and means for forcing a sealing liquid under pressure into the pocket, substantially as described.

16. A sealing joint for elastic-fluid turbines having, in combination, a fixed member and a rotatory member of the turbine, an annular projection carried by and rotating with the rotatory member, an annular pocket formed in the fixed member and embracing the margin of the annular projection, and an overflow for limiting the amount of liquid contained in the pocket, substantially as described.

17. A sealing joint for elastic-fluid turbines having, in combination with a fixed member and a rotatory member of the turbine, an annular pocket formed in the fixed member, and an annular projection carried by and rotating with the rotary member, the projection being embraced by the pocket and having one side serrated or roughened to increase its effect on the liquid in the pocket, substantially as described.

18. A sealing joint for elastic-fluid turbines having, in combination with a fixed member and a rotatory member of the turbine, an annular pocket formed in the fixed member, and an annular projection carried by and rotating with the rotatory member, the projection being embraced by the pocket and having on one side radial grooves to increase its effect on the liquid in the pocket, substantially as described.

19. A sealing joint for elastic-fluid turbines having, in combination with two relatively rotating members of the turbine, an annular pocket and a concentric ring entering the pocket through a restricted slot, the pocket and ring being carried by said members respectively, substantially as described.

20. A sealing joint for elastic-fluid turbines having, in combination with a fixed member and a rotatory member of the turbine, an annular flange carried by and rotating with the rotatory member, and an annular pocket formed in the fixed member and having surfaces closely approximating the lateral surfaces of the flange, so as to confine a film of sealing liquid thereagainst, substantially as described.

21. An elastic-fluid turbine having, in combination, a wheel carrying peripheral buckets, an annular flange mounted on the wheel at one side of the buckets and projecting radially beyond the buckets so that moisture condensed in the buckets will be impelled by centrifugal force to the margin of the flange, and a casing inclosing the periphery of the wheel and provided with buckets and with an annular pocket inclosing the margin of the flange, substantially as described.

22. An elastic-fluid turbine having, in combination, a wheel having a web-portion and a rim provided with buckets, a casing provided with fixed buckets and surrounding the wheel, the casing and wheel being provided with sealing joints to confine the motive fluid to the periphery of the wheel, and the casing being provided with extensions inclosing the body of air in contact with the rim while leaving the web portion exposed, substantially as described.

23. An elastic-fluid turbine having, in combination, a wheel having a web-portion and a rim provided with buckets, a casing provided with buckets, and sealing joints between the wheel rim and the casing outside of the buckets, the casing having portions inclosing the rim outside of the sealing joints and provided with lagging, so as to inclose a warm body of air at atmospheric pressure in contact with the wheel rim, substantially as described.

24. An elastic-fluid turbine having, in combination, a casing and a wheel provided with a plurality of buckets operating in several stages, a pressure chamber in the wheel between two sets of buckets and adapted to receive fluid in its passage from the buckets on one side of said pressure chamber to the buckets on the other side, and a sealing joint between the wheel and the casing to prevent the passage of motive fluid from one set of buckets directly to the other, substantially as described.

25. An elastic-fluid turbine having, in combination, a casing provided with buckets in two stages, and a wheel comprising a web-portion and two rim portions having buckets coöperating with said casing buckets and removably secured to the web portion and forming between them an intermediate pressure chamber, substantially as described.

26. An elastic fluid turbine, having, in combination, a wheel provided with peripheral parallel return buckets in a plurality of stages, a casing provided with coöperating parallel return buckets, an intermediate pressure chamber in the wheel between two adjacent stages of buckets, and nozzles for discharging the steam from the pressure chamber into the buckets, substantially as described.

27. An elastic fluid turbine, having, in

combination, a wheel provided with peripheral parallel return buckets in two stages, a casing provided with coöperating return buckets, nozzles mounted on the casing for directing steam into one stage of buckets, nozzles mounted on the wheel for directing steam into the other stage of buckets, and an intermediate pressure chamber arranged to receive the steam from one stage of buckets and deliver it to one of the series of nozzles, and means for supplying steam to the other series of nozzles, substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

WILLIAM E. SNOW.

Witnesses:
FARNUM F. DORSEY,
ALFRED H. HILDRETH.