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ELASTIC FLUID TURBINE.

APPLICATION FILED AUG. 2, 1901. RENEWED JULY 14, 1909.

985,982. Patented Mar. 7, 1911.

2 SHEETS—SHEET 1.

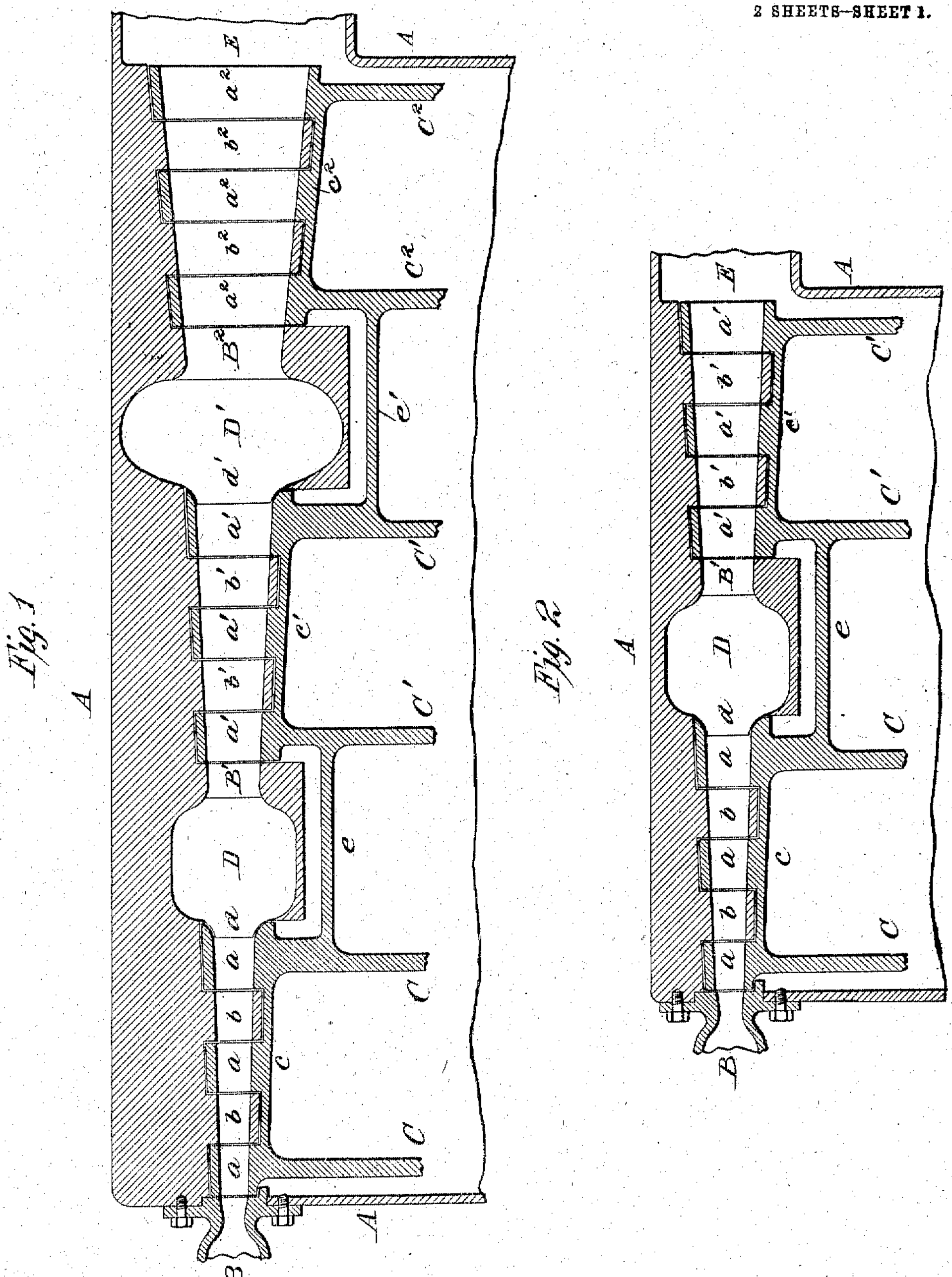

Fig. 1

Fig. 2

Witnesses:

Jas. F. Coleman

Archibald MacReese.

Inventor

Charles G. Curtis

By Dyer Edmonds & Dyer

Att'ys.

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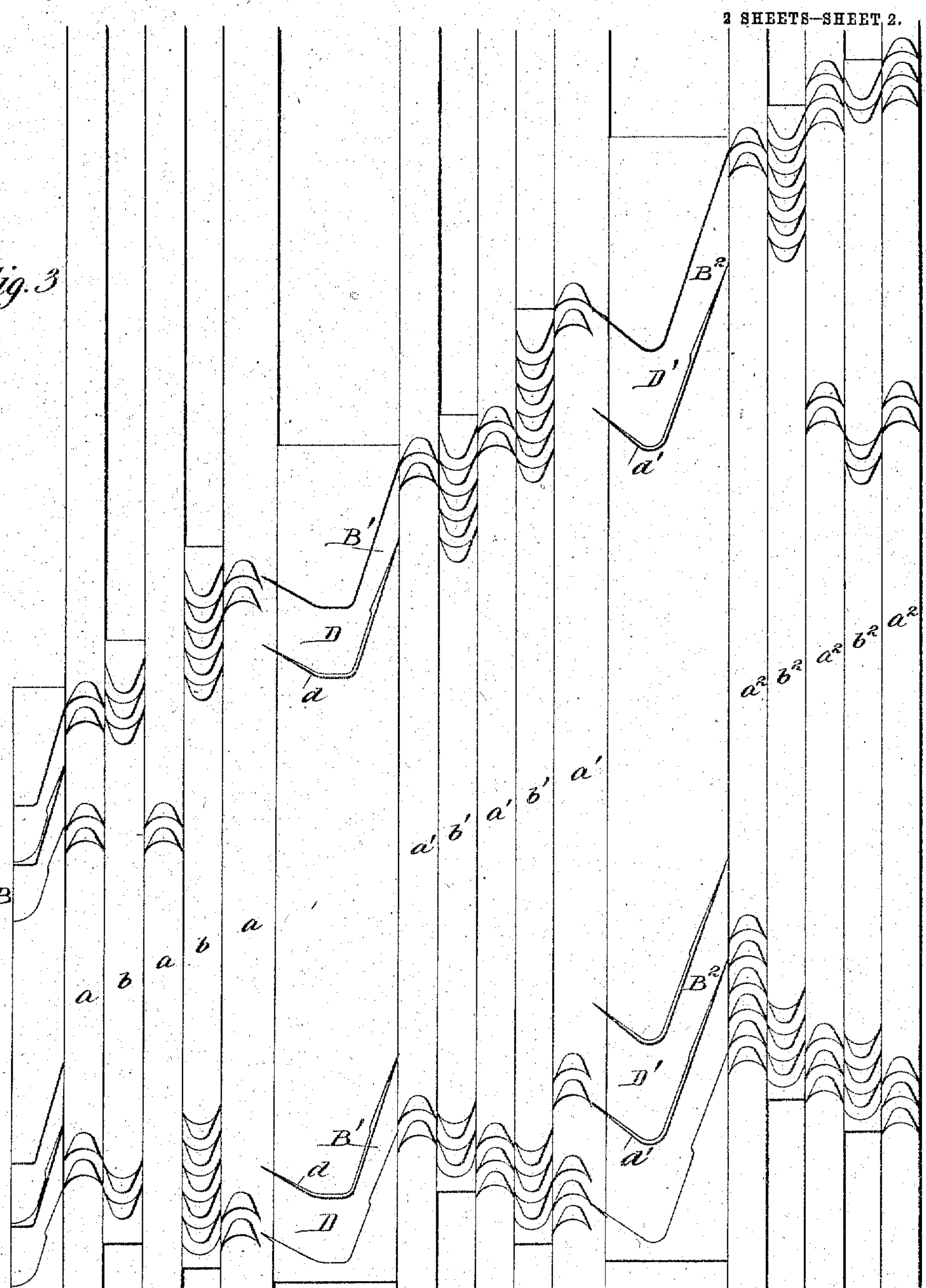
Fig. 3



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UNITED STATES PATENT OFFICE.

CHARLES G. CURTIS, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELASTIC-FLUID TURBINE.

985,982. Specification of Letters Patent. **Patented Mar. 7, 1911.**

Application filed August 2, 1901, Serial No. 70,615. Renewed July 14, 1909. Serial No. 507,586.

To all whom it may concern:

Be it known that I, CHARLES G. CURTIS, a citizen of the United States, residing in the borough of Manhattan, city of New York, State of New York, have invented a certain new and useful Improvement in Elastic-Fluid Turbines, of which the following is a description.

The invention relates to elastic fluid turbines operating on the principle of stage expansion, as described in my Patent No. 566,969 dated September 1, 1896.

The object of my invention is to enable the expansion to be carried on in a considerable number of stages, and to enable this to be done in an apparatus which is as compact and simple as possible in construction. This I accomplish by employing what I term "internal staging", *i. e.* the provision of means for producing and utilizing within a single shell one or more stages of expansion in addition to that produced by the nozzle external to the shell, as distinguished from providing a separate shell for each stage of the expansion.

In carrying out my invention I may employ a jet nozzle, preferably of the sectional character described in my application Serial No. 666,379 filed January 12, 1898, for producing the first stage of expansion. This nozzle is applied to the head of the shell, and delivers the elastic fluid jet to movable vanes within the shell, which largely or substantially abstract the velocity produced by the first stage of expansion. The steam jet, instead of being discharged from the shell and delivered to a second nozzle external thereto and producing a second stage of expansion which is utilized in another shell, is delivered to a stage expansion device located within the same shell. This device includes a stationary chamber supported from the shell in line with the movable vanes from which the steam jet is discharged in the utilization of the first stage of expansion. The length of this chamber, *i. e.* its dimensions circumstantially in relation to the turbine wheel, is great enough to cover all the movable vanes from which the steam is discharged. The chamber is enlarged in its height, or radially with relation to the turbine wheel, on curved lines from its receiving end in the direction of the flow of the steam, until a sufficiently enlarged cross section is secured to form a receiving chamber or bowl adapted to deliver the fluid to the next element of the combination. This chamber I call an "intermediate chamber". It receives and largely confines the steam delivered from the preceding stage, and delivers it in turn to the nozzle of the succeeding stage. The intermediate chamber is divided by radial partitions into sections, so that portions of the steam jet having different pressures may be kept separated and effectively utilized in the subsequent passages of the apparatus. The intermediate chamber, from its enlarged center, contracts on curved lines on its discharging side, where it is connected with the throats of the sections of a second sectional nozzle, which delivers the steam jet to a second set of movable vanes. The contracting side of the intermediate chamber, divided by its partitions into sections which correspond and register with the sections of the second sectional nozzle, forms a series of bowls or enlarged portions anterior to the throats for the sections of the second nozzle, and hence the discharging side of the intermediate chamber may be regarded as a part of the nozzle into which it delivers the steam, because on this side of that chamber, the steam, as it flows toward the throats of the nozzle sections, has its pressure converted into velocity. The intermediate chamber may therefore be regarded as terminating, and the second nozzle as beginning, at the point where the intermediate chamber begins to contract toward the throats of the nozzle sections. The second nozzle is made sufficiently larger than the first nozzle to convey the steam at the increased volume due to its lower pressure, and is designed so as to convert a further portion of the pressure of the steam into velocity, which velocity is abstracted by one or more sets of movable vanes within the same shell to which the steam jet is delivered by the second nozzle. In this same manner a second, or even a third, stage expansion device may be put within the same shell. To reduce the losses due to leakage, the clearances on the two sides of each internal stage expansion device are cut off from the interior of the shell and connected together by a solid circular band connecting the wheels which support the adjacent movable vanes. This feature of internal staging may be employed to produce a stage expansion turbine having all the stages of expansion utilized in a single shell, or the turbine may have two or more shells in each of which the internal staging feature will be employed; but this method of construction is particularly applicable to the low pressure shell of large stage expansion turbines, the stages of which are divided between two or more shells, because the loss due to the additional leakage which the internal staging involves would be small, owing to the fact that the steam passages of the low pressure shell are large, and the clearances consequently become small relative to the size of the steam passages.

In the drawing, Figure 1 is a vertical section illustrating the employment of two stages of internal expansion within a single shell, Fig. 2 is a similar view showing one stage of internal expansion, and Fig. 3 is a view of the steam passages of Fig. 1 developed.

A is the shell of the turbine, to the head of which is attached the nozzle B, which is preferably a sectional nozzle, as before described, and may or may not be an expansion nozzle. This nozzle converts a portion of the pressure of the elastic fluid into velocity, as described in my Patent No. 566,969 before referred to, and the velocity of the steam jet is abstracted or converted into wheel motion by directing it through one or more sets of movable vanes *a*. I prefer to employ two or more sets of such movable vanes, with suitable intermediate stationary vanes *b*. In the construction illustrated, there are three sets of movable vanes *a* mounted upon wheels C C and a connecting circular band *c*, and there are two sets of intermediate stationary vanes *b* mounted upon the shell.

D is the intermediate chamber, divided by radial partitions *d* and receiving the steam on one side from the last set of movable buckets *a* and delivering it on the other side to the sections of a sectional nozzle B′. The intermediate chamber D, as already described, enlarges radially away from the last set of movable vanes *a*, and on the other side contracts toward the throats of the nozzle sections of the nozzle B′ so as to form the bowls for such nozzle sections. The second stage of expansion produced by the expansion device D B′ is utilized in the movable vanes *a*′, of which there are preferably two or more sets supported on wheels C′ C′ and a connecting circular band *c*′, suitable stationary vanes *b*′ being employed to change the direction of the steam jet between the sets of movable vanes. The clearances at the sides of the expansion device D B′ are cut off from the interior of the shell and are connected together by a circular band *e* connecting the wheels C C′ upon which the movable vanes *a a*′ adjoining the stage expansion device are mounted. The space between the band *e* and the bottom wall of the chamber D may be as small as permissible or it may be enlarged, as shown, and be protected by end ribs.

As illustrated in Figs. 1 and 3, a second internal staging device may be employed, consisting of an intermediate chamber D′ divided by partitions *d*′ and delivering the elastic fluid to the sections of the nozzle B^2, which in turn delivers the steam jet to the movable and stationary vanes a^2 b^2, the movable vanes being supported upon wheels C^2 C^2 and a circular band c^2, and the clearances on opposite sides of the stage expansion device being connected by a circular band *e*′. E represents the exhaust opening of the shell. Regarding Fig. 3 of the drawing, it should be understood that only a few of the movable and stationary vanes are illustrated, and only a few of the sections are shown of the initial nozzle and of the internal stage expansion devices. The end sections, however, are shown in each case. It is not thought necessary for clearness of illustration to multiply the sections of the nozzle and internal stage expansion devices or the illustrations of the movable and stationary vanes.

What I claim is:

1. In an elastic fluid turbine operating by stage expansion, the combination with a single shell, of two or more sets of velocity utilizing vanes therein, means for delivering the elastic fluid to the first set of vanes to produce a partial conversion of the pressure of the elastic fluid into velocity, and a stage expansion device located within the same shell between each set of vanes and the next, the said device being so arranged as to receive the elastic fluid from the preceding set of vanes without substantial velocity and deliver such elastic fluid to the succeeding set of vanes with a velocity produced by a further conversion of pressure into velocity.

2. In an elastic fluid turbine operating by stage expansion, the combination with a single shell, of two or more sets of velocity utilizing vanes therein, each set comprising two or more sets of movable vanes and one or more sets of intermediate stationary vanes, a means for delivering the elastic fluid to the first set of vanes and producing a partial conversion of the pressure of the elastic fluid into velocity, and a stage expansion device located within the same shell between each set of vanes and the next, the said device being so arranged as to receive the elastic fluid from the preceding set of vanes without substantial velocity and deliver such elastic fluid to the succeeding set of vanes with a velocity produced by a further conversion of pressure into velocity.

3. In an elastic fluid turbine operated by stage expansion, the combination with a single shell, of an annular opening therein containing two or more sets of velocity utilizing

vanes, means for delivering the elastic fluid to the first set of vanes to produce a partial conversion of the pressure of the elastic fluid into velocity, and a stage expansion device located within the same shell between each set of vanes and the next, the said device being so arranged as to receive the elastic fluid from the preceding set of vanes without substantial velocity and deliver such elastic fluid into the succeeding set of vanes with a velocity produced by a further conversion of pressure into velocity.

4. In an elastic fluid turbine, the combination with a single shell, of an annular opening therein containing two or more sets of velocity utilizing vanes, each set comprising two or more sets of movable vanes and one or more sets of intermediate stationary vanes, means for delivering the elastic fluid to the first set of vanes to produce a partial conversion of pressure of the elastic fluid into velocity, and a stage expansion device located within the same shell between each set of vanes and the next, the said device being so arranged as to receive the elastic fluid from the preceding set of vanes without substantial velocity, and deliver such elastic fluid to the succeeding set of vanes with a velocity produced by a further conversion of pressure into velocity.

5. An elastic fluid turbine of the axial flow type, having an annular opening and buckets exposed therein, the said opening increasing in radial width to a point nearer to the inlet than to the outlet and then decreasing in width to said outlet.

6. The combination of an elastic fluid turbine of the axial flow type, having an annular opening provided with a contracted inlet and a contracted outlet, parallel buckets exposed in said openings, each of said buckets being curved with the apex of curvature nearer to the inlet than to the outlet of the annular opening.

7. The combination of an elastic fluid turbine of the axial flow type, having an annular opening provided with a contracted inlet and a contracted outlet, parallel buckets exposed in said opening, each of said buckets having straight walls connected by a curved portion, the apex of curvature being nearer to the inlet than to the outlet side of said annular opening.

8. The combination in an elastic fluid turbine of the axial flow type, of a wheel having an annular opening, a wheel casing having a fixed partition parallel to the exhaust side of said wheel, provided with an annular opening having a contracted inlet and a contracted outlet; the inlet of said partition opening registering with the outlet of said wheel opening, buckets in said wheel opening and guide blades in said partition opening, each of said guide blades being curved with the apex of curvature nearer to the inlet than to the outlet of its openings.

9. In an elastic fluid turbine, the combination with a single inclosing shell, of two or more velocity developing and utilizing passages, each such passage being connected with the succeeding one by an intermediate chamber having a larger cross-sectional area than such passage, substantially as described.

10. In an elastic fluid turbine operating by stage expansion, the combination with a single shell and two sets of movable vanes therein, of a stage expansion device located between said sets of movable vanes and comprising an enlarged divided chamber receiving the elastic fluid discharged by one set of vanes, and a sectional nozzle connected with said enlarged chamber on its discharging side and directing the elastic fluid to the second set of vanes, substantially as set forth.

11. In an elastic fluid turbine operating by stage expansion, the combination with a single shell and two sets of movable vanes therein, of a stage expansion device located within said shell between said sets of movable vanes, and a circular band or partition cutting off the clearances at the opposite sides of the internal stage expansion device from the shell and connecting them together, substantially as set forth.

12. In combination with two bucket-wheels of the axial flow type, a passage for working fluid interposed between the said wheels having its cross-sectional area gradually increasing, then gradually decreasing, and then gradually increasing in the direction of flow; the inlet extremity of said passage being equal in radial width to the outlet of one wheel and the outlet extremity of said passage being equal in radial width to the inlet of the other wheel.

13. The combination in an elastic fluid turbine of the axial flow type, of a wheel having an annular opening and buckets exposed therein, and a wheel casing having a fixed partition parallel to the exhaust side of the said wheel, provided with an annular opening having a contracted inlet and a contracted outlet and guid blades in said partition opening, the inlet of said partition opening registering with the outlet of said wheel opening.

This specification signed and witnessed this 30th day of July, 1901.

CHARLES G. CURTIS.

Witnesses:
JNO. ROBT. TAYLOR,
ARCHIBALD GRAY REESE.