No. 726,315. PATENTED APR. 28, 1903.

T. G. E. LINDMARK.

STEAM TURBINE.

APPLICATION FILED DEC. 4, 1902.

NO MODEL. 2 SHEETS—SHEET 1.

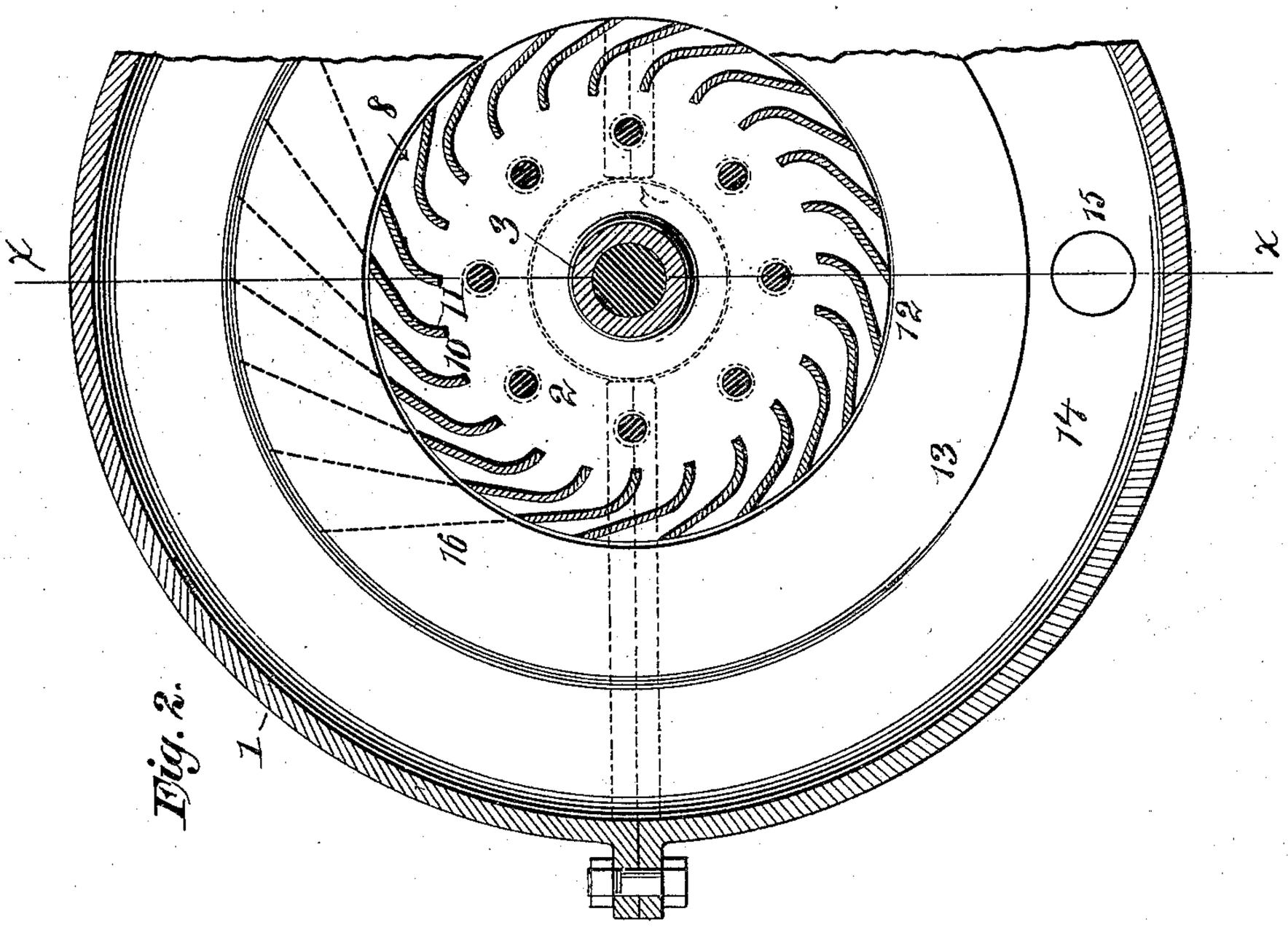

Fig. 2.

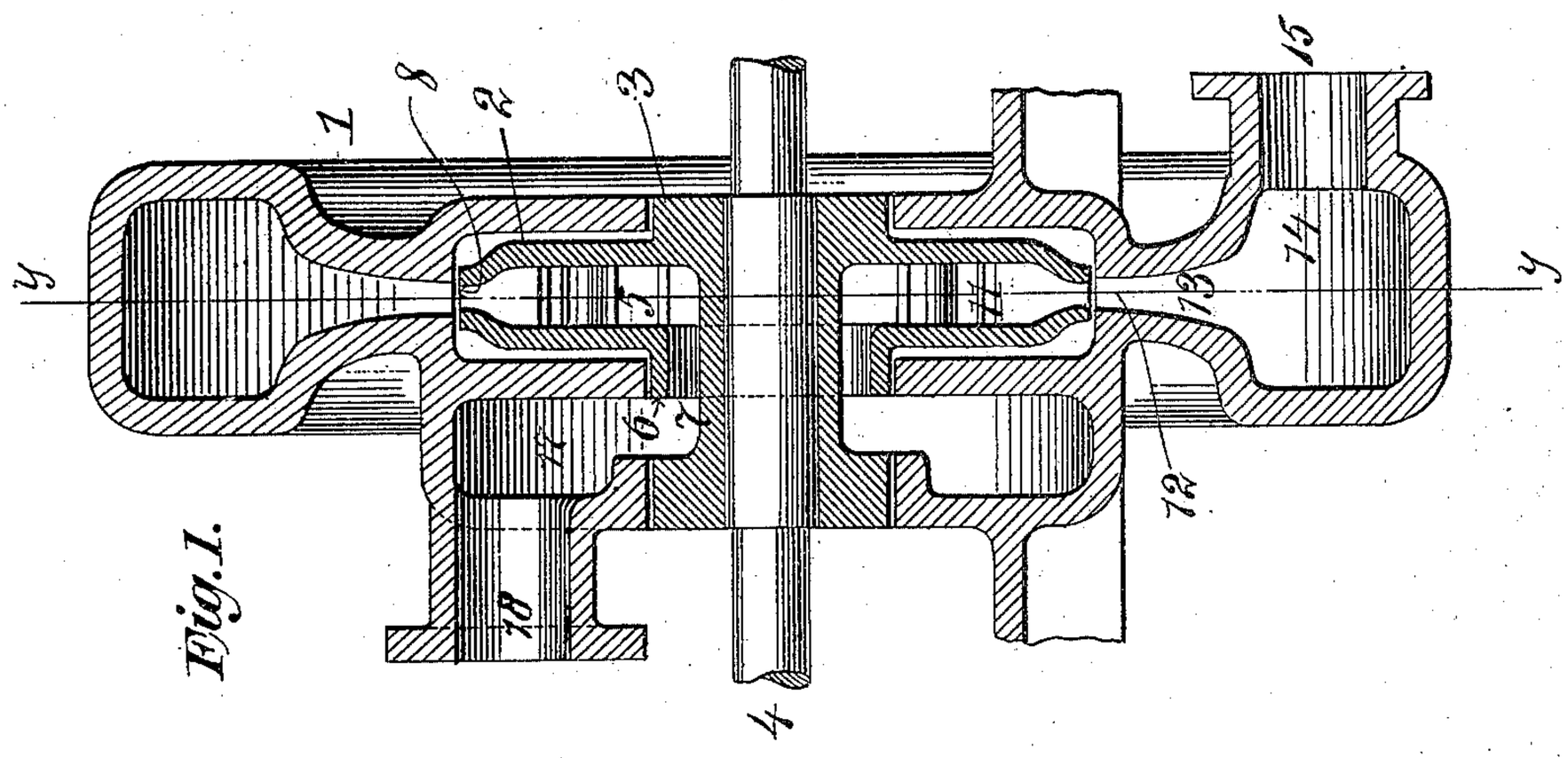

Fig. 1.

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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 3.

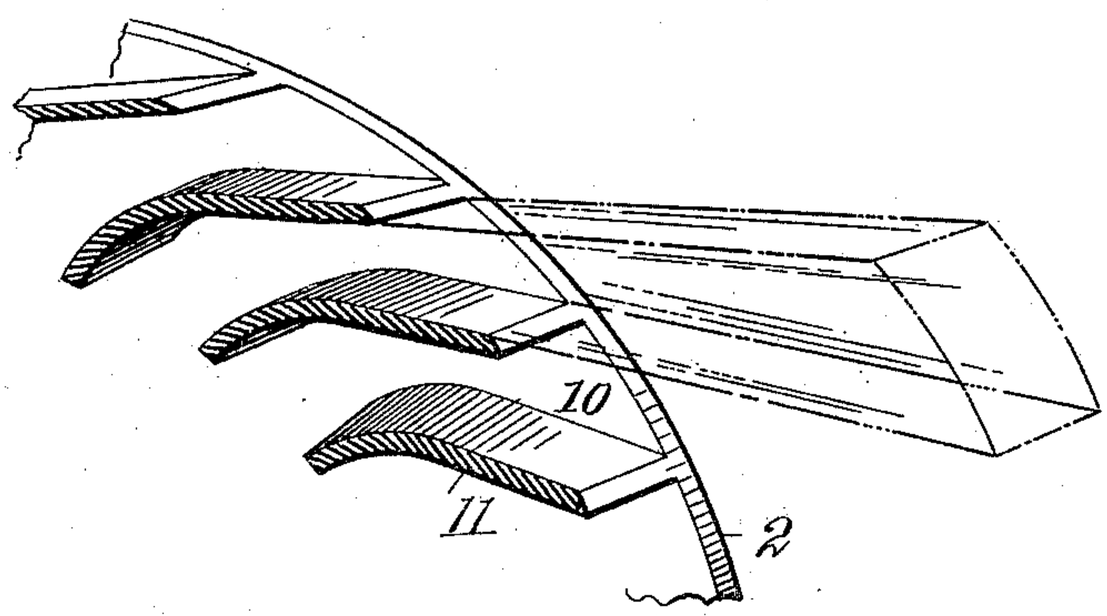
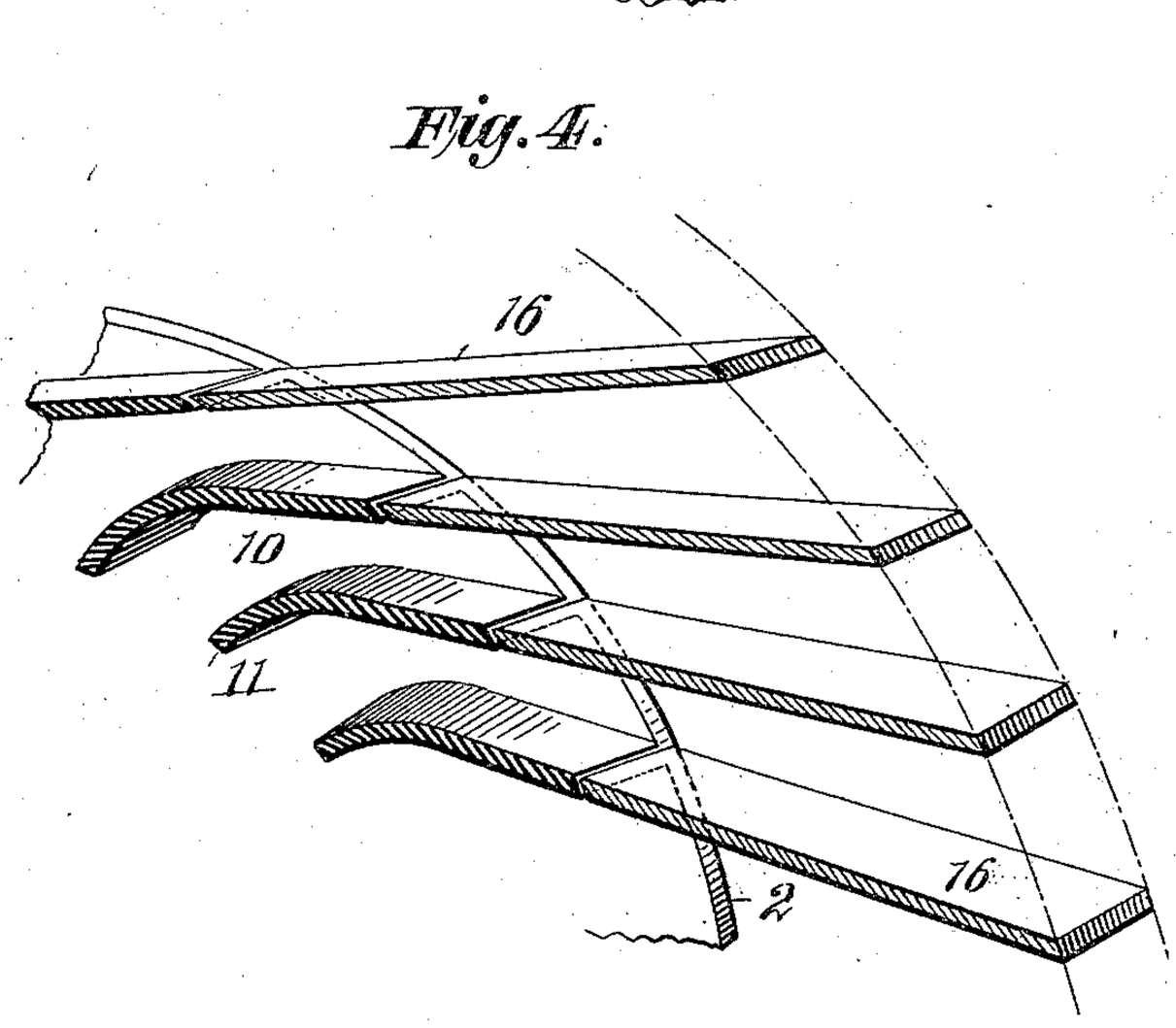


Fig. 4.



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TORE GUSTAF EMANUEL LINDMARK, OF STOCKHOLM, SWEDEN.

STEAM-TURBINE.

SPECIFICATION forming part of Letters Patent No. 726,315, dated April 28, 1903.

Application filed December 4, 1902. Serial No. 133,821. (No model.)

To all whom it may concern:

Be it known that I, TORE GUSTAF EMANUEL LINDMARK, a subject of the King of Sweden and Norway, residing at Stockholm, Sweden, have invented a new and useful Improvement in Steam-Turbines, of which the following is a specification.

The object of the invention is to increase the efficiency of the steam-turbine wheel.

The invention consists in the combination, with a steam-turbine of the type wherein the steam from the interior of the wheel is emitted in a compact jet, of a chamber constructed and arranged to receive said jet, the said chamber increasing in cross-sectional area in a direction at right angles to the direction of said jet; also, in combination with said turbine, an annular chamber, as set forth; also, in combination with said turbine emitting a multiplicity of jets, a multiplicity of chambers receiving said jets and constructed as set forth.

In the accompanying drawings, Figure 1 is a section of wheel and casing on the line *x x* of Fig. 2. Fig. 2 is a section on the line *y y* of Fig. 1. Fig. 3 is a diagram illustrating the shape of the solid steam-jet emitted by a wheel of the type hereinafter referred to. Fig. 4 is a diagram illustrating the division of the annular passage receiving the jets from the wheel into a multiplicity of passages corresponding in number to the number of escape-outlets between the wheel-buckets.

Similar numbers of reference indicate like parts.

1 is the wheel-casing, and 2 the wheel, which is supported on the hub 3, fast on shaft 4. The wheel-body is hollow. The wheel-head 5 is flanged at 6, so that an annular inlet 7 is formed around the hub. In the circumferential periphery of the wheel is the annular steam-outlet 8, which is divided into a number of smaller outlets 10 by the wheel-buckets 11. The outlet 8 corresponds to and registers with an annular inlet 12, formed in the casing and communicating with the passage or chamber 13, which passage, as shown in Fig. 1, has diverging walls. Passage 13 communicates with the surrounding chamber 14, which opens into the exhaust 15. Steam entering the inlet 16 in the casing passes to the chamber 17 and thence by the inlet 7 to the interior of the wheel 2. It then escapes through the openings 10 between the buckets 11 to the diverging chamber 13, whence it passes to the chamber 14, and so to exhaust 15.

There are two types of steam-turbines: first, so-called "impact-wheels," in which the steam in the form of a jet from a nozzle disposed exterior to the wheel strikes a bucket, usually of U shape and disposed at and transversely to the circumferential periphery of the wheel; second, reaction-wheels, in which the steam entering the wheel-body escapes at the periphery through the intervals between inclined buckets there disposed.

In the first-named class of wheels the steam-jet meets the inner side of one leg of the U-shaped bucket, sweeps around the interior of the bucket, and finally escapes in a direction nearly the opposite to that at which it entered. In the second class the steam escapes in the form of directly-emitted jet. By long experimenting with both classes of wheels I have discovered that the jet passing from the bucket of an impact-wheel is in the form of a very thin skin or sheet, so that the entire exhaust is made up of a number of these thin sheets with empty intervals or spaces between them. On the other hand, the jet from a reaction-wheel is compact and fills the interstitial spaces between the buckets, so that all around the wheel there is not a succession of thin sheets, but a uniform compact outflow of steam. The compact jet of steam escaping between successive buckets is illustrated by the dotted lines, Fig. 3. It is well known in the art that by means of a chamber receiving the waste steam escaping from the buckets of a steam-turbine and increasing in cross-sectional area the expansion of the steam admitted to the wheel can be extended to a certain degree, whereby the greatest possible effect from the steam which passes through the turbine is obtained. Also if the turbine is running non-condensing a certain vacuum may be maintained around the wheel, whereby the resistance offered to the rotation of the wheel by the medium in which it works is diminished. This is fully disclosed in British Patent No. 20,603, November 26, 1891, to Carl G. P. De Laval; but in said De Laval device the type of wheel employed is of the impact class, from which,

as I have explained, the steam is emitted in thin sheets. Now experiments have shown that the efficiency of said exhaust-chamber is greatly reduced if the steam enters the chamber in many thin sheets compared with the efficiency obtained when the steam enters in a compact jet. To meet the difficulty which would follow the entrance of these sheets directly into the diverging chamber, De Laval makes the sides of said chamber convergent for a short distance from the place of entrance of the steam. The effect of this is to collect the sheets, and so bring them into a more compact jet before their entrance into the diverging part of the chamber. It is apparent, therefore, that the De Laval device discloses an impact-turbine provided with a diverging exhaust-nozzle and that the "thin-sheet" difficulty incident to this type of turbine is met by the expedient of the initial convergence in the exhaust-chamber.

In United States Patent to Terry, No. 636,867, November 14, 1899, exactly the same device is represented as in the De Laval British patent, with the omission of the De Laval initial convergence in the exhaust-chamber, and therefore with no means at all for meeting the disadvantages of the thin sheets.

Now my invention consists in this, that with a nozzle or chamber on the exhaust side which increases in cross-sectional area in the direction at right angles to that of the compact jet of steam admitted into it I combine a turbine of the reaction type constructed to produce such compact jets, and thus I get the conditions of maximum efficiency. The said nozzle may be in the form of a continuous ring surrounding the escape-outlet 8, or it may be divided into enlarging chambers by means of partitions 16, as shown in Fig. 4 and in dotted lines, Fig. 2.

I claim—

1. In combination with a steam-turbine of the type wherein steam from the interior of the wheel is emitted in a compact jet, an elongated chamber directly receiving said jet; the said chamber increasing in cross-sectional area from inlet to outlet and being disposed tangentially the wheel circumference in the line of said jet, substantially as described.

2. In combination with a steam-turbine of the type wherein steam from the interior of the wheel is emitted at the periphery thereof in a compact annular jet, an annular chamber receiving said jet directly from said wheel and increasing in cross-sectional area in a direction at right angles to the direction of said jet in passing from said chamber, substantially as described.

3. In combination with a steam-turbine of the type wherein steam from the interior of the wheel is emitted at the periphery thereof in a plurality of compact jets, a casing having an annular passage surrounding said wheel and directly receiving said jets; and in said passage partitions dividing the same into chambers disposed tangentially the wheel circumference and in the line of direction of the received jets and increasing in cross-sectional area from inlet to outlet, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

TORE GUSTAF EMANUEL LINDMARK.

Witnesses:

WALDEMAR BOMAN,

T. EKEBOHN.