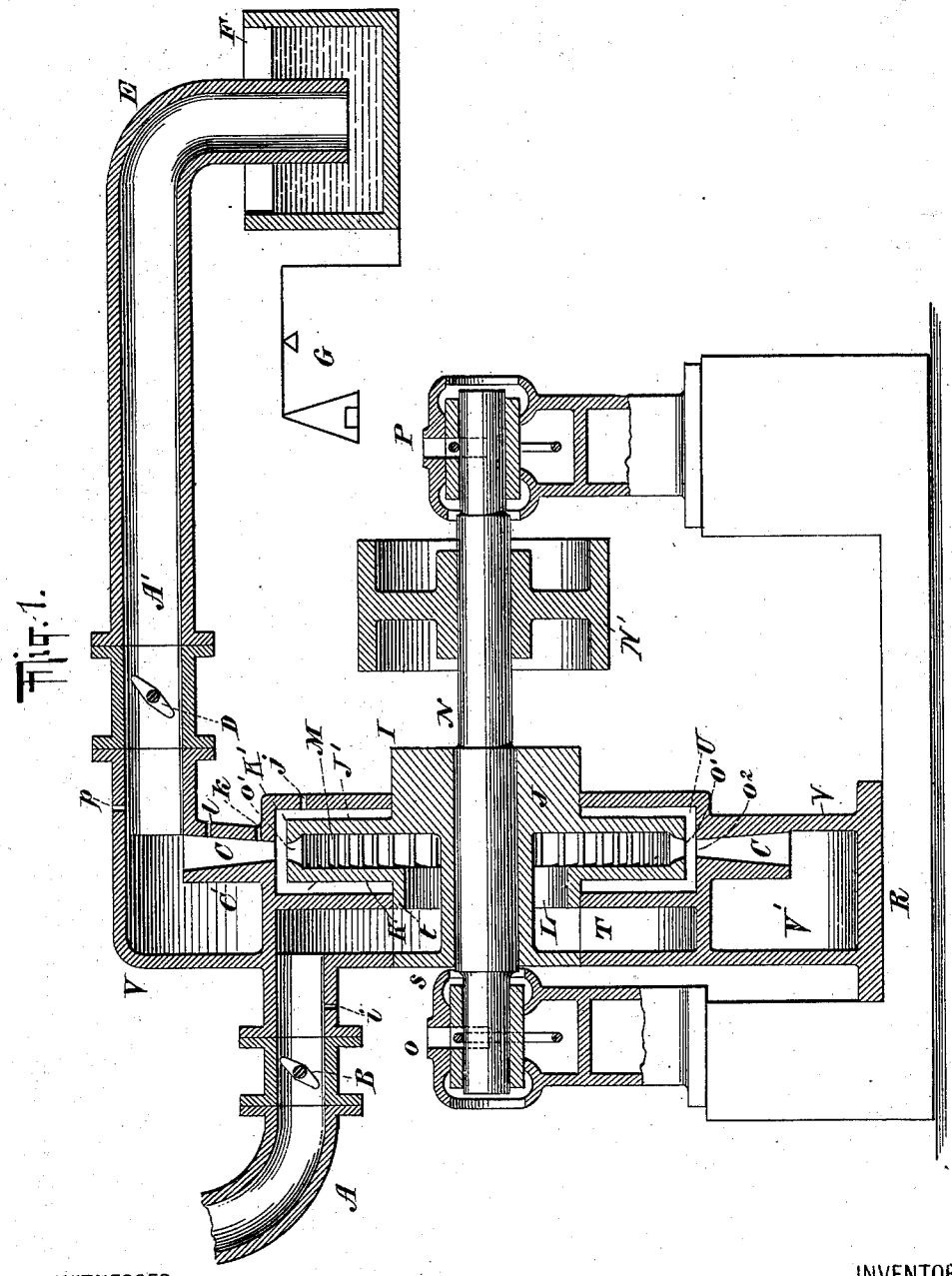
No. 717,875. PATENTED JAN. 6, 1903.

T. G. E. LINDMARK.

MULTIPLE ENGINE.

NO MODEL. APPLICATION FILED DEC. 13, 1901. 3 SHEETS—SHEET 1.

Fig. 1.



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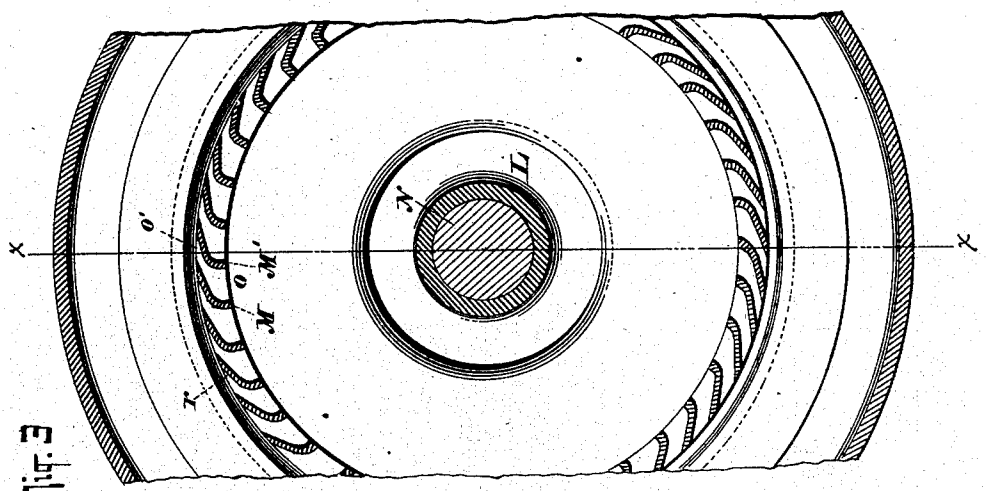


Fig. 3

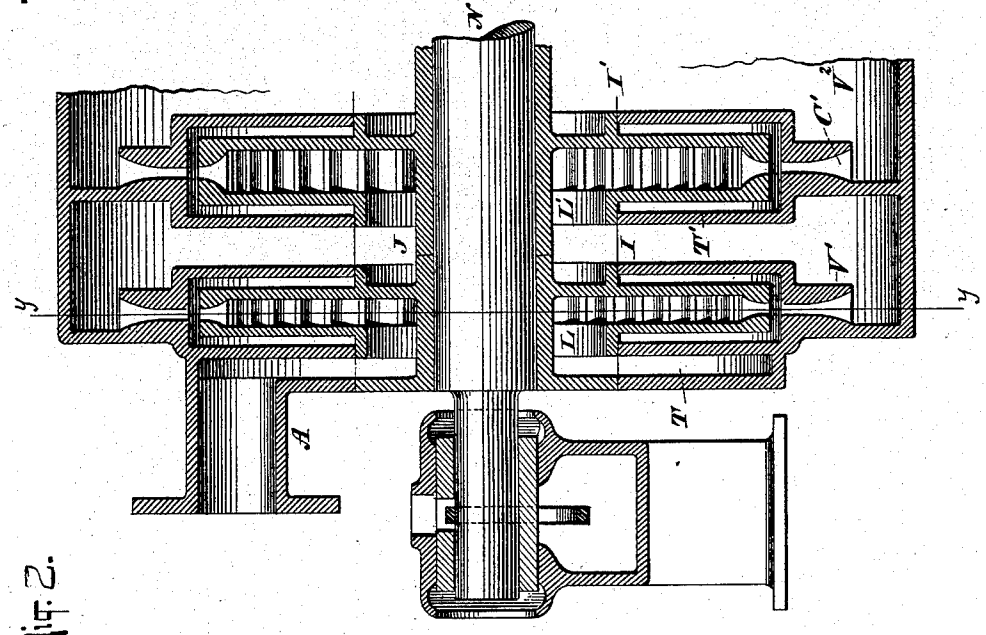


Fig. 2

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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 5.

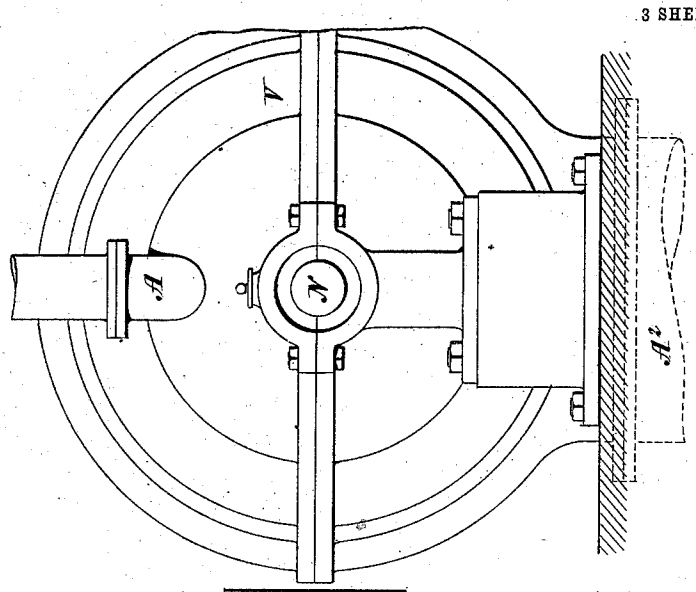
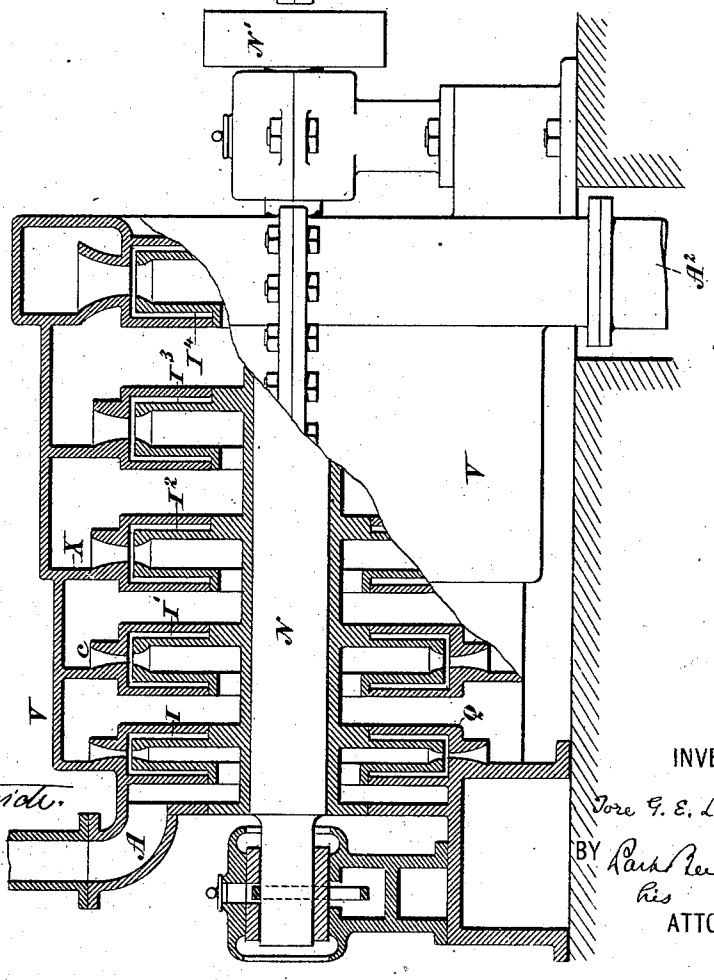


Fig. 4.



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UNITED STATES PATENT OFFICE.

TORE GUSTAF EMANUEL LINDMARK, OF STOCKHOLM, SWEDEN.

MULTIPLE ENGINE.

SPECIFICATION forming part of Letters Patent No. 717,875, dated January 6, 1903.

Application filed December 13, 1901. Serial No. 85,747. (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 Multiple Engines, of which the following is a specification.

The invention relates to elastic-fluid motors, and more particularly to compound or multiple motors wherein the working fluid passes successively through a number of units and in so doing undergoes progressive expansion.

My invention consists in means for transforming the kinetic energy of the exhaust into potential energy or pressure during its passage from one unit to the next. Therefore instead of the pressure of said fluid falling from the first unit of the series until final escape from the last, said fluid is expanded in the first working member of the series, then raised to a pressure lower than its pressure before expansion, but higher than its pressure after such expansion, then again expanded in the second working member of the series, then raised in pressure as before, and so on throughout all of the units.

In the present embodiment of my invention I accomplish the foregoing by means of a passage receiving the exhaust and having increased cross-sections from the inlet to the outlet of said passage, said cross-sections being measured at right angles to the direction of the fluid-jet conjointly with means for throttling the fluid before its next expansion, all as hereinafter more particularly explained.

My invention further consists in the construction set forth, whereby my said invention is applied to steam or gas turbines.

One object of the invention is to permit the construction of such turbines of high power without making them of large diameter or driving them at excessive speeds.

In the accompanying drawings, Figure 1 is a longitudinal section of an elastic-fluid turbine embodying my invention, the said invention, however, being here illustrated in simplified form for the purpose of exhibiting more clearly the principle. Fig. 2 is a section on the line x x of Fig. 3, showing two units, such as Fig. 1, in a compound engine, the additional units being broken away. Fig. 3 is a partial transverse section on the line y y of Fig. 2. Fig. 4 is a partial vertical longitudinal section of a multiple engine of five units, the wheel-buckets being omitted for the sake of clearness. Fig. 5 is an end elevation of said engine.

Similar letters of reference indicate like parts.

Referring first to Fig. 1, I is a turbine-wheel of the type in which the steam enters the wheel-body around the center and escapes at the circumferential openings. Said wheel consists of a body portion J, having a projecting wheel-head J′, the opposite wheel-head being the annular plate K. The wheel-heads J′ K are connected by the peripheral wall K′. Between the hub J and the flange t on the head K is an annular opening L, through which the steam passes to the interior of the wheel. The wheel-buckets M (best shown in Fig. 3) are located in the peripheral wall K′. Their outer portions r are inclined in one direction. Between adjacent buckets as M M′, passages are formed for the escape of the steam from the wheel. The inlet-orifice o to each passage is larger than the outlet-passage o' thereof. The hub J of the wheel is fast upon a shaft N, which is supported in suitable bearings O and P upon a bed-plate R. Surrounding the wheel is a cylindrical casing V, also supported upon the bed-plate. This casing fits steam-tight against the flange S at one end of the hub J and against the solid body portion of said hub at the other end thereof and also against the flange t of the wheel-plate K. In said casing is an annular chamber T, in which steam from pipe A enters and thence passes through an annular opening L into the body of the wheel, finally escaping through the bucket-outlets o' and into the chamber U in the casing V, which completely incloses the wheel. Through the wall of chamber U is made a circular opening o^2, which corresponds in position to and surrounds the outlets o' in the wheel-periphery, and this opening is the inlet to an annular passage C, one side of which is formed by a flange C′ and the other by a wall of the external casing V. This passage is formed with increased cross-sections from inlet to outlet, said cross-sections being taken at right an-

gles to the direction of the fluid-jet. It conducts the steam from the chamber U into the chamber V′, formed by the casing V, which chamber communicates with the pipe A′. The steam enters the wheel through the pipe A, which is provided with a throttle-valve B. It will pass first into the chamber T through opening L into the body of the wheel I and thence between the buckets M and out of the orifice o', setting the wheel in rotation by the reaction. The exhaust will escape through the annular flaring passage C to the chamber V′. It is to be noted that the width of the passage C at its narrowest portion—namely, o^2, Fig. 1—is about equal to the width of the escape-orifice o' in the wheel and is placed directly in front thereof, so that as the steam escapes from all of the openings around the wheel circumference it passes at once into the continuous inlet to passage C, which everywhere surrounds it, and thence into the chamber V′, which everywhere surrounds said passage.

In practice the chamber V′ communicates with the inlet of a second wheel arranged on the same shaft N, as shown in Fig. 2, but before describing this I prefer to explain the operation of my principle in connection with the wheel exhibited in Fig. 1. To this end I have shown in said figure a pipe A′, communicating with the chamber V′ and having in it a throttle-valve D. This pipe is bent at E and terminates in a water-tank F, which is supported upon a scale-beam, (diagrammatically indicated at G.) This arrangement of tank and scale-beam is a well-known appliance for weighing the amount of steam passing through the engine. If the valve D be left completely open and the valve B be suitably regulated a certain amount of pressure—say, for illustration, one hundred and thirty pounds—can be measured at the point i in the inlet-pipe A. If now the wheel be held from rotation and steam-pressure measurements be made at certain other points—as, for example, at j', at k, at l and p—it will be found that while the pressure in the steam-pipe at i is, as stated, one hundred and thirty pounds the pressure in the wheel-chamber taken at j will be seventy-five pounds and pressure at the narrowest part of the flaring passage C, taken at k, will be but sixty-five pounds. The pressure at the wider part of said flaring passage—namely, at l—will be but fifteen pounds, and the pressure at p within the chamber V′ will be also fifteen pounds. At the same time by means of the tank and scales it will be possible to determine the weight of the steam condensed per hour, which, for illustration, I will call nineteen hundred and eighty pounds. If now the valve D be closed as much as possible without changing the pressure of seventy-five pounds at the point j, or, in other words, in the wheel-chamber, it will be observed that although the steam-pressures at the points i and j will remain the same the pressure at the point k will have increased to ninety pounds and at l and p to one hundred and ten pounds. If the wheel now be permitted to revolve, the power which it develops can of course be easily measured by a brake applied to its shaft. Let this pressure be, say, ten-horse power and let the valve D be closed as much as possible without changing the steam-pressure within the wheel-chamber, or, in other words, at the point j, which remains at seventy-five pounds, as before. Owing to the peripheral speed of the wheel, which of course diminishes the efflux speed of the steam, a somewhat lower pressure will be obtained in the chamber V′; but it will be found that although the inlet-pressure of one hundred and thirty pounds will descend to seventy-five pounds at j, nevertheless at k it will reach eighty-five pounds and at l and p ninety-seven pounds, although the brake horse-power developed will remain the same.

To sum up, the construction shown in Fig. 1 exhibits a rotating wheel having a circumferential discharge, which discharge is delivered into the wheel-chamber. From that wheel-chamber the discharge passes through the annular flaring passage C. From the passage C it goes to the chamber V′, which is provided with a throttling-valve D. By the conjoint action of the flaring passage C and the throttling-valve D the velocity component of the energy of the steam escaping from the wheel becomes changed into pressure in that chamber, and, referring to the instances already given, instead of the steam-pressure falling from one hundred and thirty pounds, for example, in the steam-inlet pipe A to the atmosphere in the chamber V′ it descends to seventy-five pounds in the wheel-chamber U, but afterward rises to ninety-seven pounds in the chamber V′, the brake horse-power developed by the wheel remaining the same.

As I have already stated, in the application of my invention to the compound turbine the actual throttle-valve D and the means for weighing the steam illustrated in Fig. 1 are not used; but, as shown in Fig. 2, steam from the chamber V′ goes into chamber T′, similar to chamber T, and from chamber T′ through an opening L′ into the next turbine-wheel I′, which is constructed in like manner to turbine I and has its hub fast on shaft N.

It will be observed that in the wheel I′ the transverse width of the buckets is greater than in the wheel I, and the cubic contents of the passage T′ between chamber V′ and inlet L′ is greater than that of the passage T. The reason for this construction is the same as obtains in all compound engines and requires the increase of effective area of surface upon which the steam acts in order to produce the same motive effect as the pressure falls off. The width of the escape-outlet of the wheel I′ determines the compression of the steam in the chamber V′ and becomes the equivalent of the valve D of Fig. 1 when said valve is set in some definite position to pro-

duce the desired result. Therefore, by reason of the flaring passage C, interposed between the wheels and by reason of the retardation or throttling of the steam through the proportioning of the steam-passages in the second wheel, the pressure in the chamber V′ is raised above that of the exhaust from the first wheel, and at this increased pressure said steam will enter the admission-opening L′ of the wheel I′ and act upon the buckets of that wheel and escape as before, passing through passage C′ into the chamber V^2, and so on from wheel to wheel, as many as may be employed in succession, until it finally becomes reduced to atmospheric pressure or any other desired degree. Thus in Figs. 4 and 5 a complete engine containing five wheels is shown, the steam-passages increasing in size in each wheel successively to the last. The steam then proceeds from wheel I to wheel I′, to wheel I^2, to wheel I^3, to wheel I^4, and so to the final exhaust, which is represented at A^2. The casing V is preferably made in two parts bolted together, as shown, and the successive chambers V′ V^2 therein are divided by partitions X. The shaft N carries a driving-pulley N′.

I do not limit myself to the precise form of the passage C which is herein set forth, because the shape of that passage may be varied considerably without departing from my invention. As I have already pointed out, it is to have increased cross-sections from the inlet to the outlet, said cross-sections being measured at right angles to the direction of the fluid-jet. I have obtained good results with such a passage having a trumpet-shaped cross-section or flaring outward, substantially as herein shown. The circumferential inlet O^2 of the passage C being practically in continuation of the circumferential outlets *o′* of the wheel, the widths therefore should be the same. The length of the passage C, measured in a direction radially the wheel from circumferential inlet to circumferential outlet, should be no greater than that which would cause the desired pressure in the chamber to which the steam goes before passing to the next wheel. If the passage is too short, that pressure will not be reached. If it is too long, the part of the passage in excess will become virtually a part of the chamber and have the same pressure as the chamber, so that such increased length is needless.

With regard to the divergence of the inner faces of passage C, this may be varied; but it will be found that under any given circumstances too much divergence on the one hand or too little divergence on the other will not give as good results as some definite divergence which is readily ascertained by trial under the special conditions which may be prescribed.

I claim—

1. The combination of an elastic-fluid motor, a second motor actuated by the exhaust therefrom, and means for transforming the velocity component of energy of said exhaust into pressure, substantially as described.

2. The combination of two elastic-fluid motors, a passage connecting the exhaust-opening of one with the inlet-opening of the other and means for increasing the pressure of the working fluid within said passage, substantially as described.

3. The combination of two elastic-fluid motors, a passage connecting the exhaust-opening of one with the inlet-opening of the other, and means for transforming the velocity component of energy of said exhaust into pressure within said passage, substantially as described.

4. The combination of two elastic-fluid motors, and a passage connecting the exhaust-opening of one with the inlet-opening of the other; the said passage having increased cross-sections in the direction of the fluid-jet so as to permit an increase in the pressure of the exhaust fluid traversing it, substantially as described.

5. An elastic-fluid motor, an exhaust-conduit therefor having increasing cross-sections in the direction of the fluid-jet, a chamber receiving the discharge from said conduit, and means for throttling the fluid escaping from said chamber; whereby the pressure of said fluid within said chamber is increased, substantially as described.

6. In a multiple turbine wherein the working fluid undergoes progressive expansions in successive wheels, means for converting the velocity component of the energy of said working fluid into pressure between successive expansions thereof substantially as described.

7. In a multiple turbine wherein the working fluid undergoes progressive expansions in successive wheels, means for compressing the working fluid between successive expansions thereof, substantially as described.

8. In a multiple elastic-fluid turbine, a member wherein the fluid is first expanded to a certain degree to perform work, means for compressing the exhaust fluid to a pressure lower than its pressure prior to said expansion but higher than the pressure after said expansion and a second member receiving said fluid in which member said fluid is again expanded to a certain degree to perform work substantially as described.

9. In a multiple elastic-fluid turbine, a wheel, a passage external to said wheel having increased cross-sections from inlet to outlet in the direction of the fluid-jet, and receiving the exhaust from said wheel; and a second wheel actuated by said exhaust; the area of the outlet of said second wheel being less than the area of the outlet of said passage, substantially as described.

10. In a multiple elastic-fluid turbine a series of wheels having progressively larger fluid-passages and exhaust-openings, means for conducting the exhaust successively from wheel to wheel, and means for converting the velocity energy of said exhaust into pressure

between successive expansions of the fluid, substantially as described.

11. In a multiple elastic-fluid turbine, a series of hollow wheels each having a central inlet and circumferential outlet, and each after the first of the series actuated by the exhaust from the wheel next preceding and circumferentially surrounding each wheel-outlet, an annular exhaust-passage C having increased cross-sections in the direction of the fluid-jet, substantially as described.

12. In combination with a plurality of elastic-fluid turbines of the type herein described, a cylindrical casing inclosing each of said wheels and provided with a continuous passage through its wall, the said passage extending circumferentially around said wheel and having increased cross-sections from inlet to outlet in the direction of the fluid-jet, and conduits interposed between said casings communicating with said passages and each conducting the exhaust traversing the passage in one casing to the inlet-opening of the wheel in the next casing, 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.

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I. A. VAN WART.