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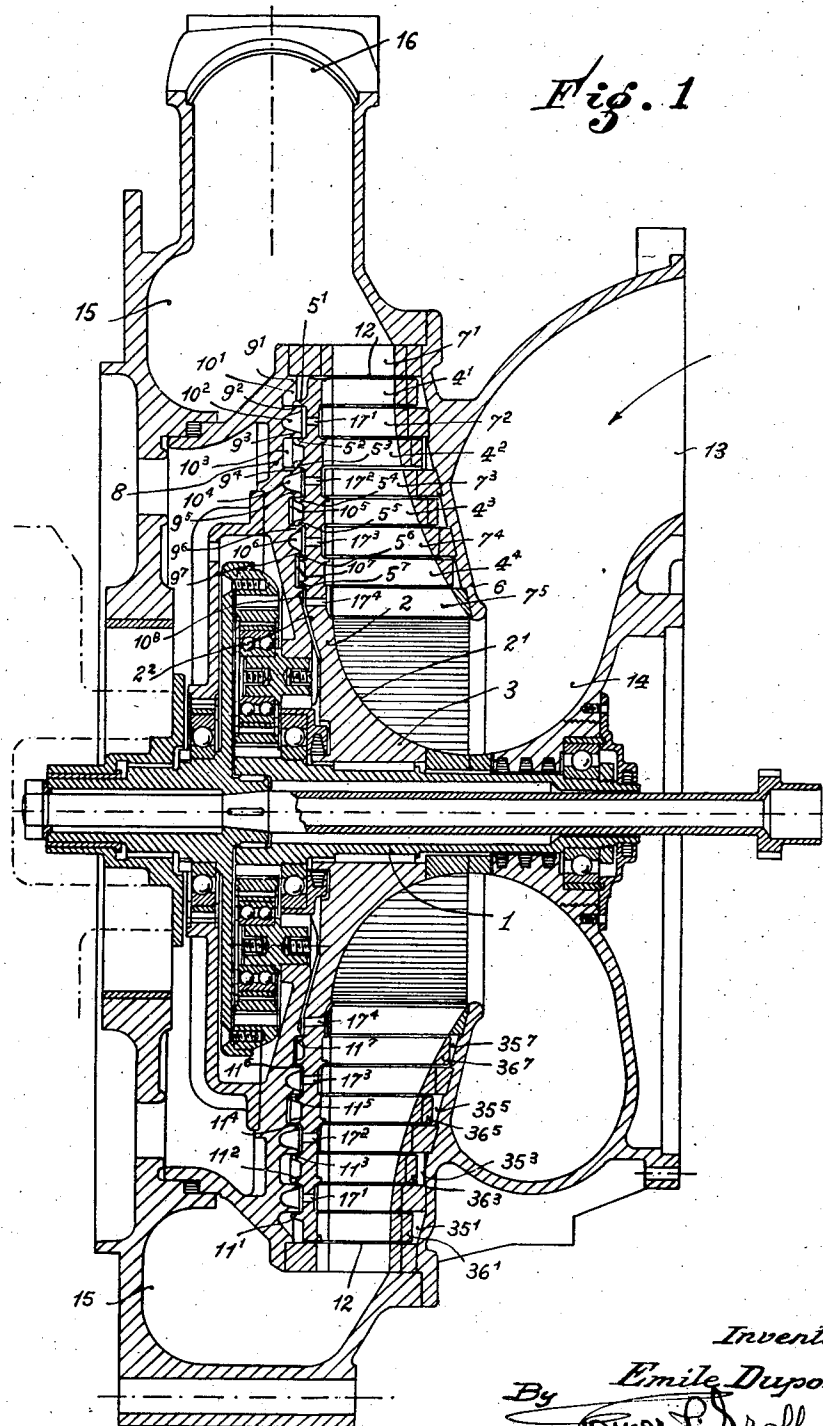
E. DUPONT

2,374,671

TURBINE

Filed Oct. 16, 1941

4 Sheets-Sheet 1



Inventor:
Emile Dupont,
By *Emile L. Dreff*
Attorney.

May 1, 1945.

E. DUPONT

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Fig. 2

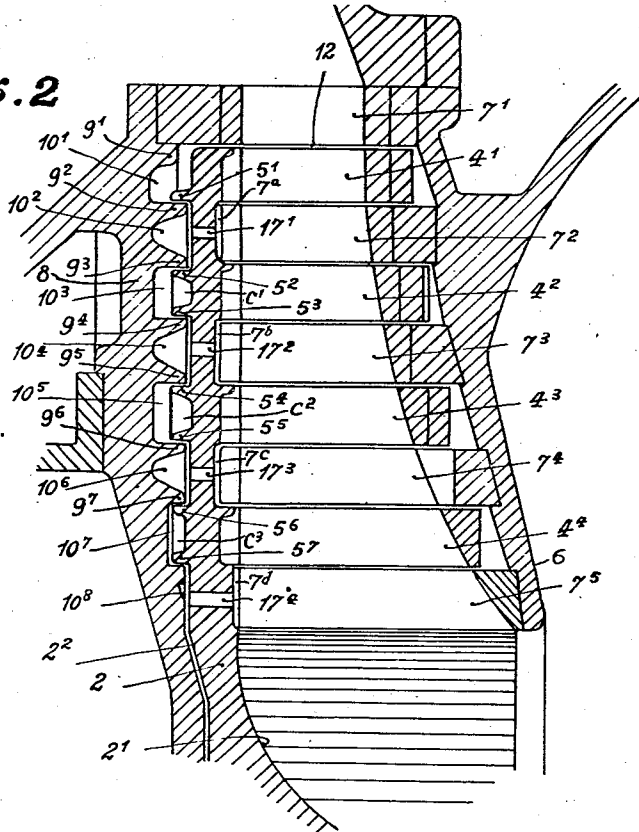


Fig. 3

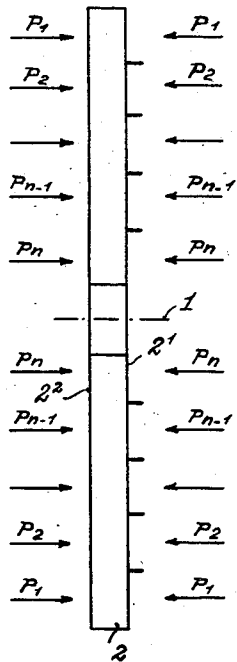
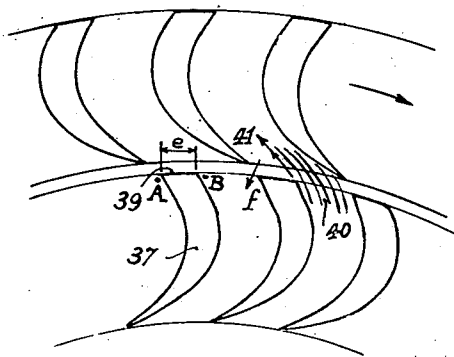


Fig. 6

Inventor:
Emile Dupont,
By *Emory R. Druff*
Attorney.

May 1, 1945.

E. DUPONT

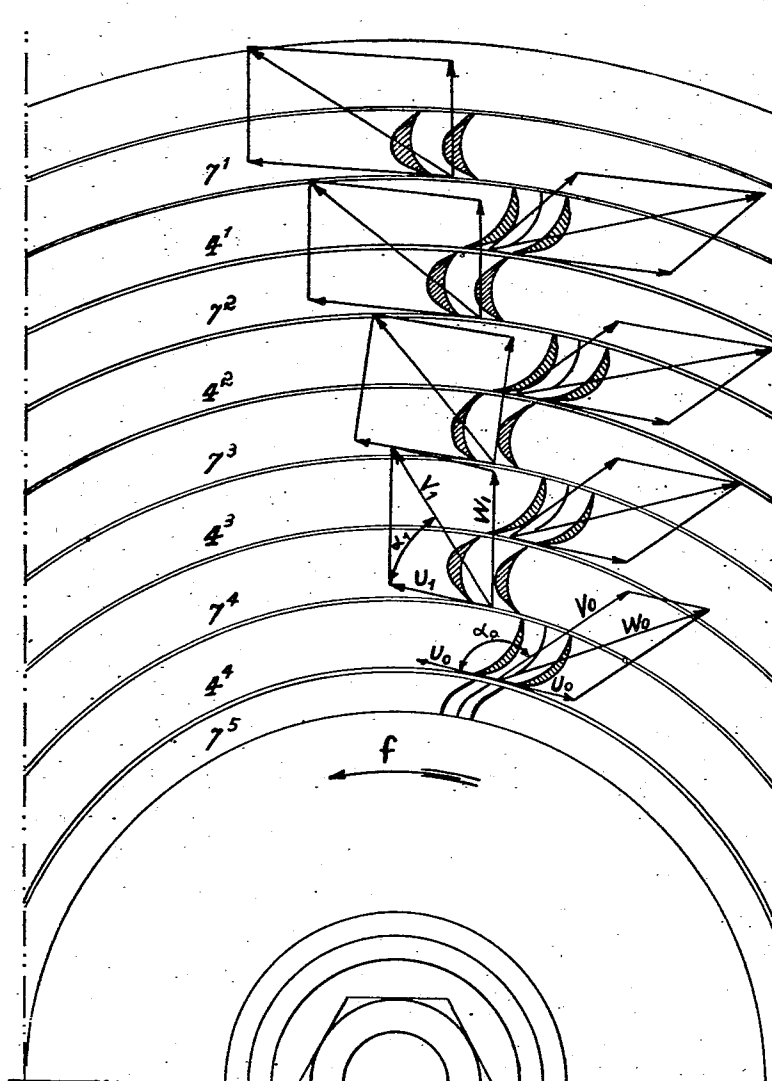
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Fig. 4



Inventor:

Emile Dupont,

By Emory D. Hoff
Attorney.

May 1, 1945.

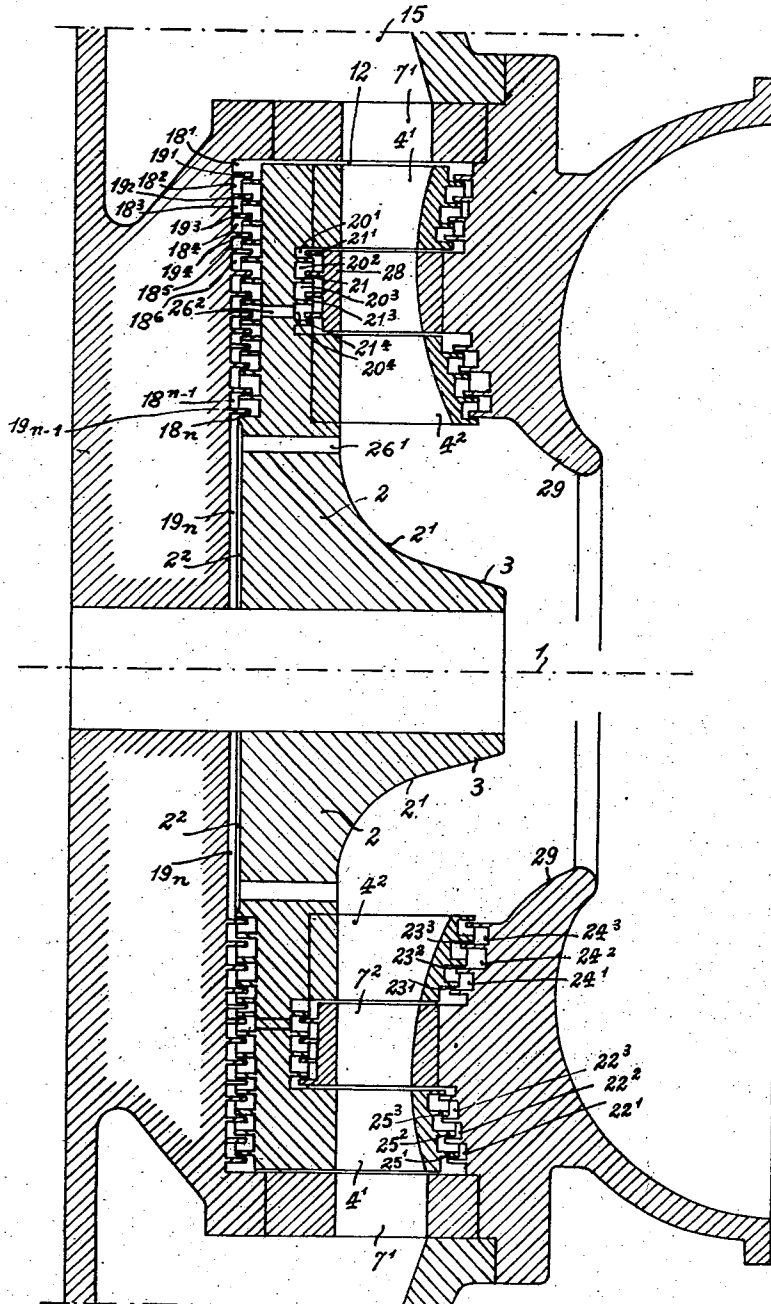
E. DUPONT

2,374,671

TURBINE

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Inventor:
Emile Dupont,
By Emory D. Hoff
Attorney.

UNITED STATES PATENT OFFICE

2,374,671

TURBINE

Emile Dupont, Antibes, France; vested in the
Alien Property Custodian

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In Switzerland June 24, 1941

2 Claims: (Cl. 253—87)

This invention relates to a machine used for converting mechanical force into a pressure or conversely, where the manometric height measuring the pressure used or produced by a single wheel is distributed over a plurality of concentric blade rims suitably spaced and arranged on one of the faces of the rotor, and over a plurality of concentric blade rims arranged on one face of the stator and inserted into the ring spaces between the blade rims of the rotor, the flow of the fluid being a centrifugal flow when the machine converts mechanical force into a pressure (compression and fluid pumps) and an inward radial flow when the machine converts pressure into mechanical force (gas turbine, steam and water turbines).

In the known machines of this kind the axial balancing is effected by means of a chamber between the face of the rotor without blades and a wall of the stator, and in which chamber the pressure is uniform and generally equal to the high pressure of the fluid. This is obtained by means of a passage provided in the rotor and insuring a communication between the said balancing chamber and the high pressure.

Thus, one of the faces of the rotor is submitted, for instance, to a uniform pressure, while the other face is submitted to decreasing pressures in front of each of the fixed and movable blade rims according to the working of the machine as a compressor.

Accordingly, in these known machines the resulting pressure, that is to say the difference between the pressures acting on the two faces of the rotor, varies according to the distance of the point under consideration with respect to the point where ambient atmospheric pressure exists.

The rotor is thus submitted in each of its points to resulting axial pressures the value of which varies and which for this reason do not produce a good balancing effect. In every case, the balancing effect is perfect only for a predetermined particular value of the highest fluid pressure and the least variation of this pressure produces an axial thrust.

The present invention has for an object to avoid these drawbacks and to obtain a good axial balancing of the rotor in all the points of its surface.

On the other hand, machines with concentric blade rims have generally blades with such a profile that two successive blades of one and the same blade rim form together a curvilinear nozzle, which in the case of a compressor is a divergent nozzle.

Now, this divergent nozzle must in this case act as a diffuser which owing to its small radius of curvature has a poor efficiency.

This drawback is due to the fact that the centrifugal force acting on the fluid jet tends to sep-

arate the said jet from the convex face of the blade, which causes eddies which are prejudicial to efficiency.

Another object of the present invention is to avoid this drawback and to improve the known machines so as to avoid any separation of the fluid jet from the convex face of the blade.

The improved machine which accomplishes the above mentioned objects possesses the features set forth in the following description and more particularly in the appended claims.

Machines made according to the invention are shown by way of example in the appended drawings in which:

Figure 1 is an axial sectional view of the machine.

Figure 2 is a partial axial sectional view of the said machine.

Figure 3 is a diagram showing the axial pressures in the machine according to the invention.

Figure 4 is on a larger scale a cross-sectional view through the blades with the parallelograms of velocities.

Figure 5 is a partial axial cross-sectional view of modified form of machine according to the invention.

Figure 6 shows the lay-out of the blades of a machine according to the invention.

The machine shown in Figures 1 to 4 has a driving shaft 1. A rotating wheel 2 is keyed on the driving shaft 1; the wheel 2 is profiled in its middle part according to a cone 3 the profile of which corresponds to that of the gaseous jet flow path on the intake side of the apparatus.

The rotating wheel 2 carries on one face 2¹ blade rims 4¹, 4², 4³, 4⁴, the movable blades; the profile of the said blades 4¹, 4², 4³, 4⁴ (Figure 4) varies from one rim to the other and according to the characteristics of the apparatus (velocity, delivery), but they are always such that two successive blades of one and the same rim form a curvilinear nozzle.

The face 2² of the wheel which is not provided with blades carries circular ribs 5¹, 5², 5³, 5⁴, 5⁵, 5⁶, 5⁷ adapted for forming the annular chambers C¹, C², and C³.

The stator is provided with a slightly conical bracket 6; this bracket carries fixed blade rims 7¹, 7², 7³, 7⁴, 7⁵ which are inserted between the movable blade rims 4¹ to 4⁴, the fixed blade rim 7¹ being arranged externally with respect to the movable blade rim 4¹. Like the movable blades, the fixed blades are so formed that two successive blades of one and the same rim form a curvilinear nozzle.

The stator is also provided with a bracket 8 which carries on one of its faces circular ribs 9¹, 9², 9³, 9⁴, 9⁵, 9⁶, 9⁷ forming with the circular ribs 5¹ to 5⁷ of the rotating wheel 2, chambers 10¹, 10², 10³, 10⁴, 10⁵, 10⁶, 10⁷, 10⁸, which are connected

together by conduits of small section 11¹, 11², 11³, 11⁴, 11⁵, 11⁶, 11⁷. A conduit 12 is provided between the fixed blade rim 7¹ and the movable blade rim 4¹; the said conduit connects the chamber 10¹ with the face 2¹ of the wheel 2.

The conduits 11 and 12 are formed by the necessary clearances between the fixed and movable parts.

Counterpressure chambers 7^a, 7^b, 7^c and 7^d are provided between the fixed blade rims 7², 7³, 7⁴ and 7⁵ and the face 2¹ of the wheel 2.

Passages 17¹, 17², 17³, 17⁴ are provided in the wheel 2 and connect chambers 7^a, 7^b, 7^c, 7^d and chambers 10², 10⁴, 10⁶ and 10⁸.

Counter-pressure chambers 35¹, 35², 35³, 35⁷ are provided between the cover ring 36¹, 36², 36⁵, 36⁷ of each movable blade rim and the bracket 6 of the stator.

The fluid is admitted through a conduit 13 provided in the stator and opening into an admission manifold 14; the fluid leaving the blades is delivered into an outlet manifold 15 and flows out through openings 16 which are provided in this manifold 15.

The above described machine works as a compressor in the following manner:

The rotor rotates in the direction of the arrow *f* (Figure 4); a movable blade rim 4¹ and the fixed blade rims 7⁵ and 7⁴ which are directly on both sides of the former will now be considered. The fixed blades of the rim 7⁵ which are so inclined as to insure the correct inlet of the fluid into the movable blades form a distributor. The fixed blades of the rim 7⁴ act as a diffuser for the movable blade rim 4¹ and as a distributor for the movable blade rim 4³.

Thus, each movable blade rim 4¹ to 4⁴ produces an independent compression as well as each fixed blade rim 7¹ to 7⁵ so that successive compression stages are formed seriatim.

The gaseous fluid which is thus drawn in through the axial conduit is progressively compressed by the fixed and movable blade rims before it escapes into the manifold 15, then it passes through a fixed blade rim 7¹ where the whole of the peripheral velocity acquired in the movable blade rim 4¹ is converted into pressure while retaining a velocity which is just sufficient for the necessity of discharge. The so compressed fluid is collected in the manifold 15 and forced out through openings 16.

The power absorbed by each of the stages of the compressor is expressed by:

$$W = \frac{P}{g} (U_1 V_1 \cos \alpha_1 - U_0 V_0 \cos \alpha_0)$$

where

P is the weight of fluid treated per second,
g the acceleration of the gravity,

*U*₁ the driving velocity on the periphery of the movable blade rim,

*V*₁ the absolute velocity of the fluid leaving the movable blade rim,

α_1 the angle formed by both these velocities,

*U*₀ the driving velocity at the inlet to the movable blade rim,

*V*₀ the absolute velocity of the fluid at this inlet,

and

α_0 the angle formed by these two velocities.

The profile of the movable blades is selected so as to give to the angle α_0 a value of more than 90°; accordingly the term *U*₀*V*₀ cos α_0 has a positive value and is added to the term *U*₁*V*₁ cos α_1

in the above given formula, thus giving the power *W*.

The slight inclination of the movable blade rims 4 at the outlet in the front part of the movement has for its effect to cause the angle α_1 to approach zero the cosine of this angle α_1 tends to approach unity and the value of the term *U*₁*V*₁ cos α_1 increases while approaching *U*₁*V*₁ which is its maximum value.

Of course, the value of the angles α_0 and α_1 may vary while being limited by the production considerations in the manufacture of the blades.

The axial balancing is effected in the following manner: the passages 17¹, 17², 17³, 17⁴ connect the annular chambers 10², 10⁴, 10⁶, 10⁸ with the corresponding fixed blade rims 7², 7³, 7⁴ and 7⁵ of the face 2¹ of the rotor and thus produce in the said chambers pressures which are equal to the pressures existing in the said fixed blade rims and acting on the face 2¹ of the rotor. At these points of the rotor the pressure is thus the same on the face 2¹ and on the face 2², thus producing the axial balancing effect.

On the other hand, the passages 11 connect the chambers 10¹ to 10⁸ together so that in the chamber 10³, for instance, a pressure is established which is intermediate to the pressures existing in the chambers 10² and 10⁴ between which the said chamber is inserted. This intermediate pressure is the same as the pressure exerted by the chamber 35³ on the cover ring 36³ of the movable blade rim 4². This pressure is intermediate between the pressures existing in the fixed blade rims 7² and 7³ between which the movable blade rims 4² are inserted; in a like manner the pressure in the chambers 35¹, 35⁵, 35⁷ corresponding to the movable blade ribs 4¹, 4³ and 4⁴ corresponds to an equivalent pressure in the chambers 10¹, 10⁵, 10⁷ opposite to the said movable blade rims.

Thus the pressures are equal in all points on each face of the rotor so that the axial balancing is attained in a perfect manner.

This regular distribution of the balancing effect is clearly shown by the diagram of Figure 3; to each pressure *P*₁ . . . *P*_{*n*} acting on the face 2¹ of the rotor which is provided with movable blades corresponds an equal counter-pressure of contrary direction *P*₁ . . . *P*_{*n*} acting on the opposite face 2² of the said rotor; thus an axial balancing effect is obtained in each point of the surface of the rotor.

Numerous changes can be made in the machine shown in Figures 1 to 3 without departing from the spirit and scope of the invention.

Figure 5 more particularly shows a machine according to another modification of the invention. The rotor 2 of this machine is provided on its face 2² with annular chambers 18¹, 18² . . . 18_{*n*} acting as balancing chambers. These annular balancing chambers are connected together by passages 19¹ . . . 19_{*n*}, the whole of the chambers 18 and of the passages 19 forming a labyrinth in which the fluid velocity acquired in one passage 19 is reduced to zero in the following chamber 18.

On the other hand, in the cover rings 27¹, 27² of the movable blade rims, hollows are provided which form annular balancing chambers 22¹, 22², 22³ and 24¹, 24², 24³ with the wall 25 of the stator, the chambers 24 being connected together by the passages 23¹, 23², 23³ and the chambers 22 being connected together by the passages 25¹, 25², 25³.

The cover rings 28 of the fixed blade rims are also provided with cavities forming with the wall

2' of the rotor annular balancing chambers 20¹, 20², 20³ connected together by passages 21¹, 21², 21³.

Passages 26¹, 26², . . . in any number are provided in the wheel 2 and connect both faces of the wheel together in the place of the balancing chambers 20² and 18⁵, 20³ and 18⁶. Certain of these passages 26¹ are always arranged between the centre of the rotor and the first movable blade rim in order to connect the centre of the rotor with the intake side of the machine, and must have a sufficient cross-sectional area for leading the fluid leakage from the face 2² towards the face 2¹.

In the annular chambers, for instance 20¹, 20², 20³, a flow of fluid will establish itself through the passages 21¹, 21², 21³ so that the pressure existing in these chambers will be the same as the pressure existing in the blade rim 7². In short, this device establishes a pressure in the space between the cover ring of the blades and the stator in the case of a movable blade rim, or between the blade cover ring and the rotor in the case of a fixed blade rim, which pressure is equal, on the one hand, to the pressure existing in the blade rim under consideration and, on the other hand, to the pressure existing in the corresponding chambers of the face 2² of the rotor, thus producing an axial balancing effect in all the points of the rotor.

This machine offers various advantages and more particularly the following ones:

(a) A perfect balancing effect is obtained if the member of the chambers and the dimensions of the latter are the same for each face of the wheel;

(b) The tightness between two successive blade rims is increased, so that leakage is reduced and the efficiency increased.

For working as a compressor the machine of the invention avoids the drawbacks of the known blade rims by providing a particular form of blade rims (Figure 6).

The blades of these fixed and movable blade rims have an increased thickness 37 from the region of their bend up to their extremities; accordingly, the fluid jet remains always in contact with the convex surface 38 of the blade and thus the above mentioned separating effect due to the centrifugal force is avoided.

The blades are also provided on their outlet faces with a cylindrical surface 39 which is so formed that the fluid jet 40 leaving the front blade rim leaves a partial vacuum zone 41 in the following blade rim.

The said blade rims offer the following advantages:

(a) The efficiency of the curvilinear nozzle formed of two successive blades of one and the same blade rim is increased since the fluid jet flow path is not separated from the convex surface 38, which avoids the formation of eddies in the said jet;

(b) The action of the centrifugal force in a curvilinear blade rim has for its effect that at A (Figure 6) the pressure is considerably higher than at B.

Thus as the hollow face of a movable blade is moving in the direction of the arrow and receives fluid of a higher pressure, then the edge of this movable blade is at a given instant positioned in

front of the rear edge of the fixed blade (position shown in Figure 6). Then, during the time which the movable blade requires for travelling along the segment e, its hollow face receives no fluid. Thus, the pressure drops along this hollow face due to the inertia of the fluid which it contained and which possessed a certain velocity, as well as due to the friction of the jet flow which flows along the convex face of the preceding blade.

When the hollow face of the movable blade comes in front of the point B (front edge of the fixed blade) the pressure existing along this hollow face is nearer to that which exists in B.

The tendency of the fluid jet to flow back which periodically occurs in blade rims made according to the methods heretofore employed, each time when a movable blade passes in front of a fixed blade, is reduced to a low value or even to zero in the case of my invention. Eddies are thus less violent and the internal efficiency is therefore improved.

My invention covers this particular form of structure of the blades irrespective of the kind of turbine or compressor in which the said blades are used.

I claim:

1. In a machine for converting the pressure of a fluid into mechanical force or conversely: a rotor formed of a disc carrying on one of its faces concentric suitably spaced blade rims, a stator also carrying concentric blade rims inserted into the annular spaces between the blade rims of the said rotor, cover rings for the fixed and movable blade rims, means for radially conducting the fluid into the concentric blade rims of the said stator and rotor, annular chambers provided on the face of the rotor which is not provided with blade rims, each annular chamber being arranged in front of a blade rim, annular balancing chambers provided between the cover rings of the fixed blade rims and the rotor, on the one hand, and the movable blade rims and the stator on the other hand, the said annular balancing chambers simultaneously insuring tightness between the successive blade rims and the balancing of the rotor and of the cover rings of the fixed and movable blade rims and passages for conducting the fluid to the annular chambers.

2. In a machine for converting the pressure of a fluid into mechanical force or conversely: a rotor formed of a disc carrying on one of its faces concentric suitably spaced blade rims, a stator also carrying concentric blade rims inserted into the annular spaces between the blade rims of the said rotor, the successive fixed or movable blades leaving between themselves spaces in form of nozzles, the profile of the movable blades being such that the direction of movement of the fluid at the inlet is reversed with respect to the direction of the movement of the blades, means for radially leading the fluid into the concentric blade rims of the said stator and rotor, annular chambers provided on the face of the rotor which is not provided with blade rims, each annular chamber being arranged in front of a blade rim in order to insure an axial balancing effect in every point of the surface of the rotor and passages for conducting the fluid to the annular chambers.

EMILE DUPONT.