PUBLISHED
JUNE 8, 1943.
BY A. P. C.

E. DUPONT

TURBINE

Filed Oct. 16, 1941

Serial No.
415,306

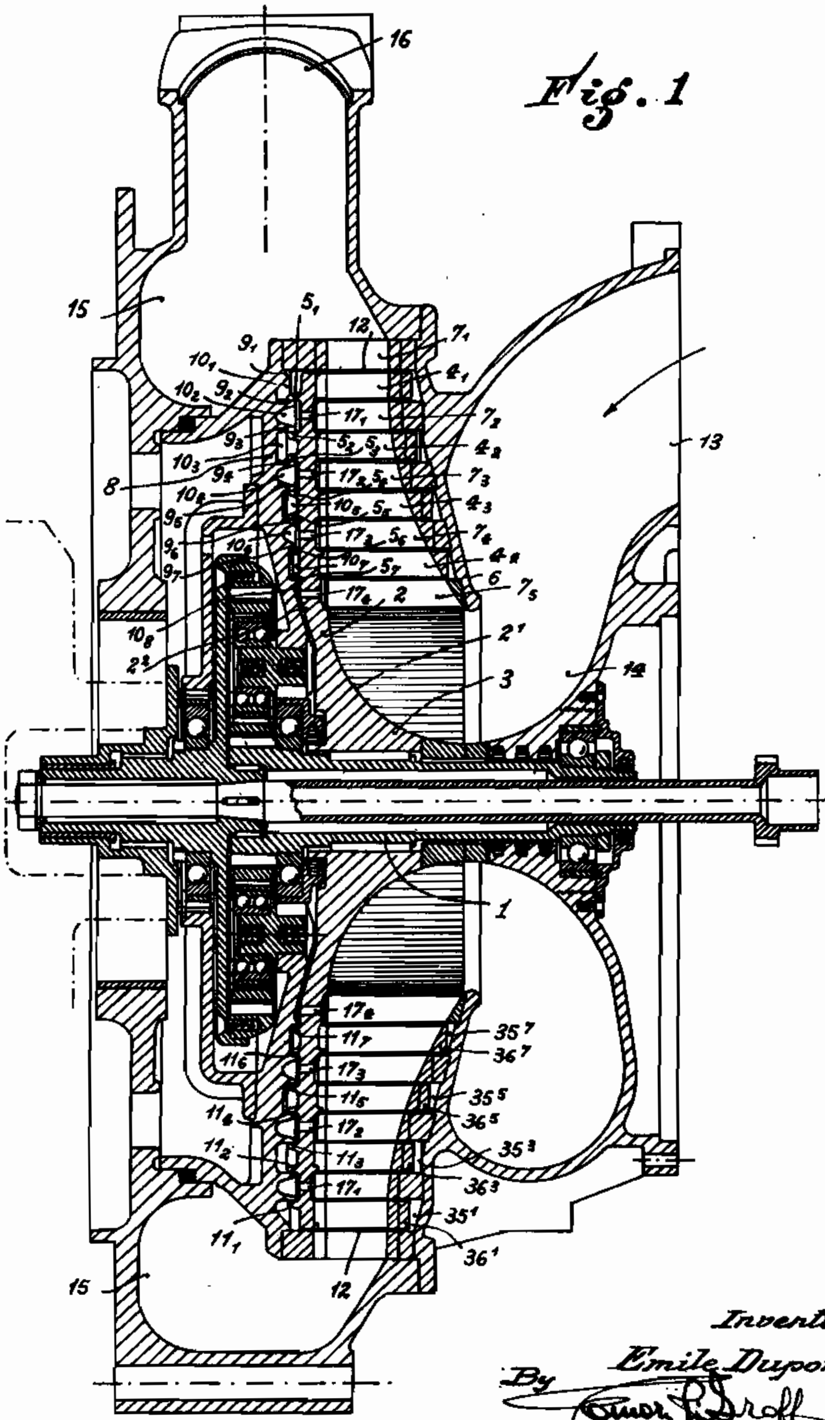

Fig. 1

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Fig. 2

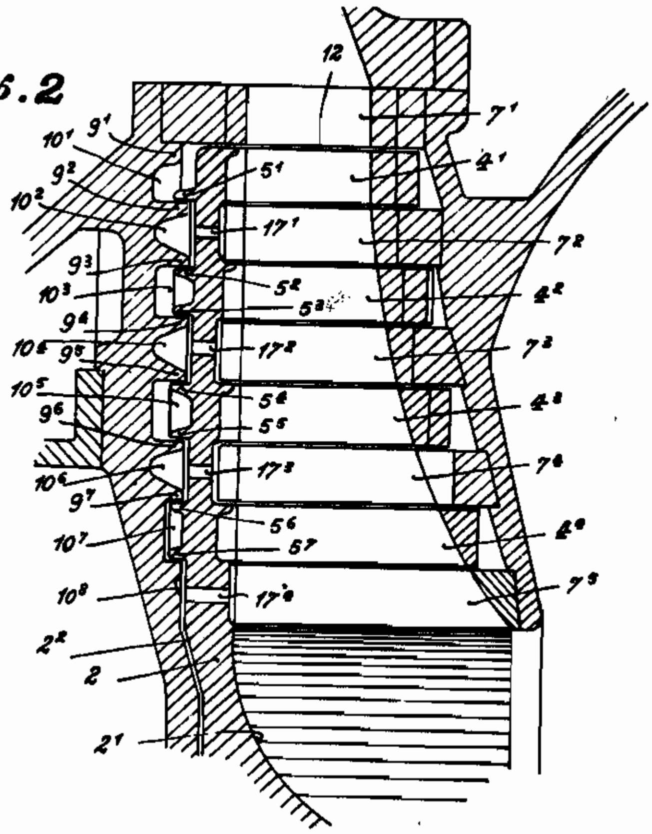

Fig. 3

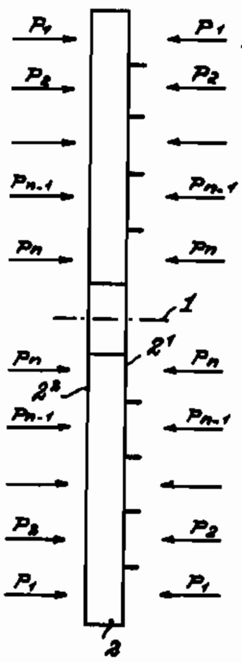

Fig. 6

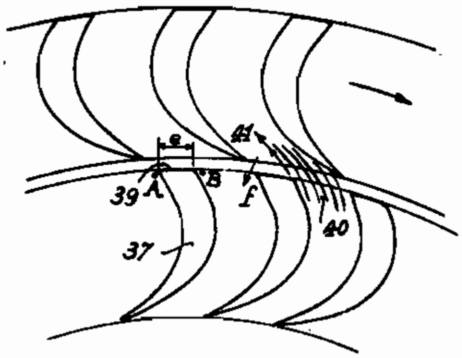

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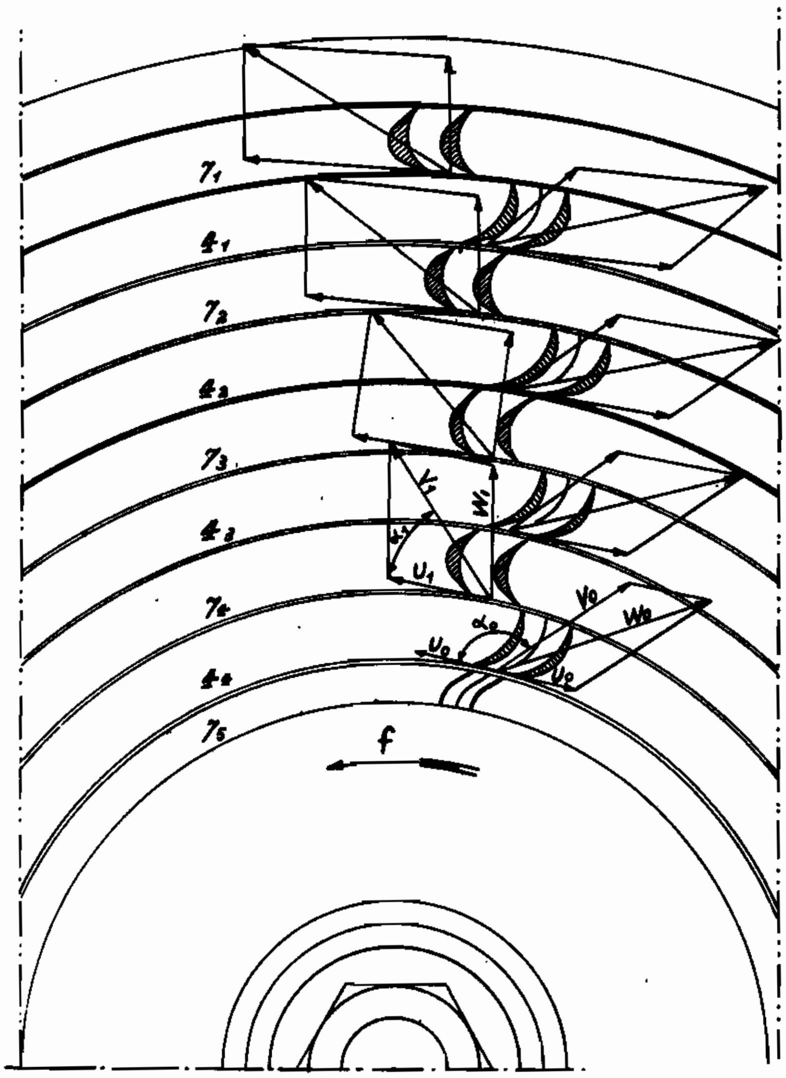
Fig. 4



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Filed Oct. 16, 1941

Serial No.
415,306
4 Sheets-Sheet 4

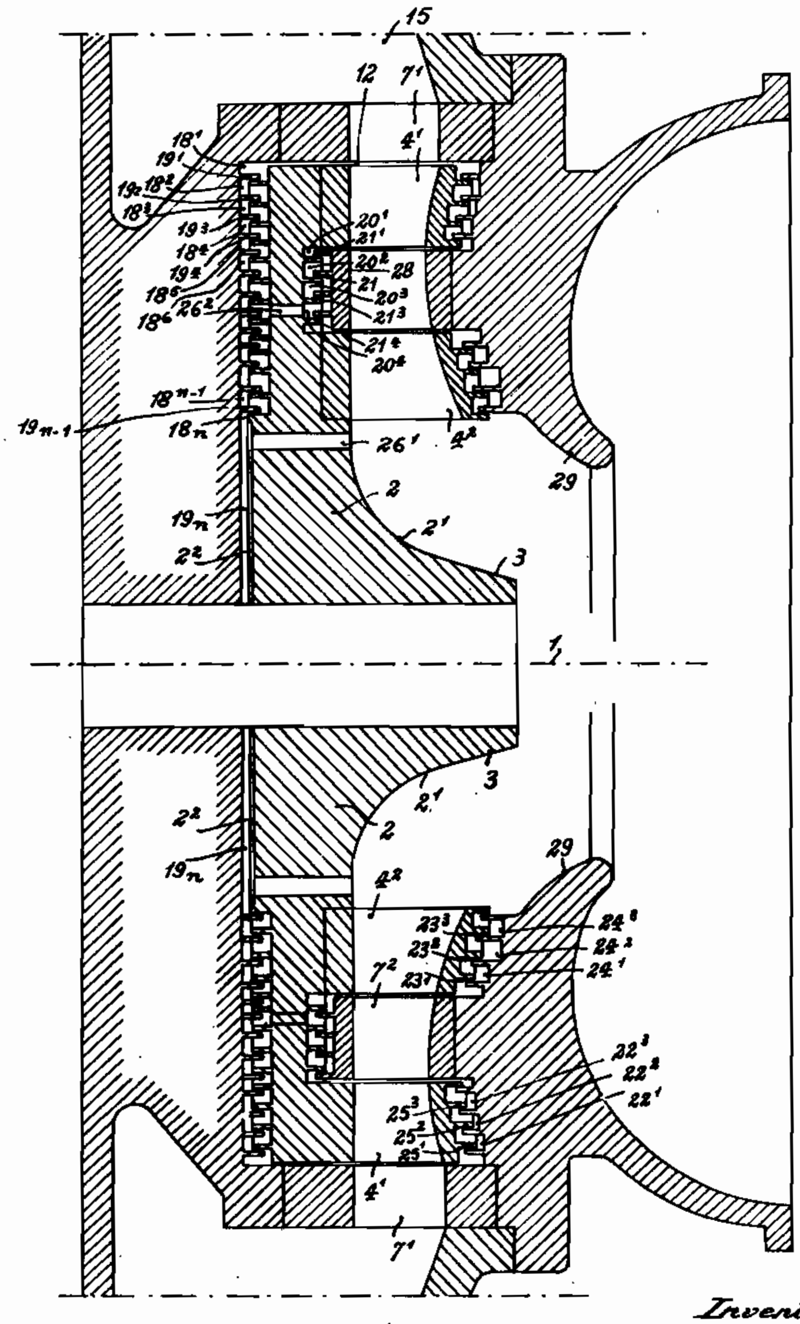

Fig. 5

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Published June 8, 1943 **Serial No. 415,306**

ALIEN PROPERTY CUSTODIAN

TURBINE

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

Application filed October 16, 1941

This invention relates to a turbine used for converting work into a pressure or conversely, where the manometric height 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 work into a pressure (compression and fluid pumps) and an inward radial flow when the machine converts pressure into work (gas turbine, steam and water turbines).

In the known turbines 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 turbine as a compressor.

Accordingly, in these known turbines the resulting pressure, that is to say the difference between the pressures acting on both faces of the rotor varies according to the distance of the point under consideration with respect to the air.

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

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

On the other hand. turbines 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 casc act as a diffusor which owing to its small radius of curvature has a bad efficiency.

This drawback is due to the fact that the centrifugal force acting on the fluid vein tends to separate the said vein from the convex face of the blade, which causes eddies which are prejudicial to the efficiency.

Another object of the invention is still to avoid this drawback and to improve the known turbines so as to avoid any separation of the fluid vein from the convex face of the blade.

The improved turbine which permits to attain the above mentioned objects possesses the features resulting from the following description and more particularly from the appended claims.

Turbines made according to the invention are shown by way of example in the appended drawing in which:

Figure 1 is an axial sectional view of the turbine.

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

Figure 3 is a diagram showing the axial pressures in the turbo-compressor 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 another turbine according to the invention.

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

The turbine shown in Figures 1 to 4 is mounted on a driving shaft 1. A 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 vein on the suction side of the apparatus.

The wheel 2 carries on its face 2^1 blade rims 4^1 4^2 4^3 4^4, the so-called movable blades; the profile of the said blades 4^1 . . . 4^4 (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 2^2 of the wheel which is not provided with blades carries circular ribs 5^1 5^2 . . . 5^7 adapted for forming the axial balancing chambers.

The stator is provided with a slightly conical bracket 6; this bracket carries fixed blade rims 7^1 7^2 . . . 7^7 which are inserted between the movable blade rims 4^1 . . . 4^4, the fixed blade rim 7^1 being arranged externally with respect to the movable blade rim 4^1. 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 9^1 9^2 . . . 9^8 forming with the circular ribs 5^1 . . . 5^7 of the wheel 2 chambers 10^1 . . . 10^8 which are connected together by conduits of small section 11^1 . . . 11^7. A conduit 12 is provided between the fixed blade rim 7^1 and the movable blade rim 4^1; the said conduit connects the chamber 10^1 with the face 2^1 of the wheel 2.

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

Passages 17^1 . . . 17^4 are provided in the wheel 2 and connect both faces of the wheel together in the place of each fixed blade rim 7^2 7^3 7^4 and of the ring chambers 10^2 10^4 10^6 and 10^8.

Counter-pressure chambers 35^1 35^3 35^5 35^7 are provided between the cover ring 36^1 30^3 36^5 36^7 of each movable blade rim and the bracket 8 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 after compression is delivered into an outlet manifold 15 and flows out through openings 16 which are provided in this manifold 15.

The above described turbine works as compressor in the following manner:

The rotor rotates in the direction of the arrow *f* (Figure 4); a movable blade rim 4^4 and the fixed blade rims 7^5 and 7^4 which are directly on both sides of the former will now be considered. The fixed blades of the rim 7^5 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 7^4 act as a diffusor for the movable blade rim 4^4 and as a distributor for the movable blade rim 4^3.

Thus, each movable blade rim 4^1 . . . produces an independent compression as well as each fixed blade rim 7^1 . . . 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 7^1 where the whole of the peripherical velocity acquired in the movable blade rim 4^1 is converted into pressure while retaining a velocity which is just sufficient for the necessity of the delivery. 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:

$$W=\frac{P}{g}(U_1V_1 \cos \alpha_1 - U_0V_0 \cos \alpha_0)$$

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 $U_0V_0 \cos \alpha_0$ has a positive value and is added to the term $U_1V_1 \cos \alpha_1$ 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 tend to nil; the cosine of this angle α_1 tends to 1 and the value of the term $U_1V_1 \cos \alpha_1$ increases while tending towards U_1V_1 which is its maximum value.

Of course, the value of the angles $\alpha_0\alpha_1$ may vary while being limited by the considerations of working in the manufacture of the blades.

The axial balancing is effected in the following manner: the passages 17^1 . . . 17^4 connect the annular chambers 10^2 10^4 10^6 10^8 with the corresponding fixed blade rims 7^2 7^3 7^4 and 7^5 of the face 2 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 1 of the rotor. In these places of the rotor the pressure is thus the same on the face 2^1 and on the face 2^2, thus producing the axial balancing effect.

On the other hand, the passages 11 connect the chambers 10^1 . . . 10^8 together so that in the chamber 10^3, for instance, a pressure is established which is intermediary to the pressures existing in the chambers 10^2 and 10^4 between which the said chamber is inserted. This intermediary pressure is the same as the pressure exerted by the chamber 35^3 on the cover ring 30^3 of the movable blade rim 4^2. This pressure is intermediary between the pressures existing in the fixed blade rims 7^2 and 7^3 between which the movable blade rims 4^2 are inserted; in a like manner the pressure in the chambers 35^1 35^5 35^7 corresponding to the movable blade rims 4^1 4^3 and 4^4 corresponds to an equivalent pressure in the chambers 10^1 10^5 10^7 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 2^1 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 2^2 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 turbine shown in Figures 1 to 3 without departing from the spirit and scope of the invention.

Figure 5 more particularly shows a turbine according to another form of execution of the invention. The rotor 2 of this turbine is provided on its face 2^2 with annular chambers 18^1 18^2 . . . 18_n acting as balancing chambers. These annular balancing chambers are connected together by passages 19^1 . . . 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 annihilated in the following chamber 18.

On the other hand, in the cover rings 27^1 27^2 of the movable blade rims, hollows are provided which form annular balancing chambers 22^1 22^2 22^3 and 24^1 24^2 24^3 with the wall 25 of the stator, the chambers 22 being connected together by the passages 23^1 23^2 23^3 and the chambers 24 being connected together by the passages 25^1 25^2 25^3.

The cover rings 28 of the fixed blade rims are also provided with cavities forming with the wall 21 of the rotor annular balancing chambers 20^1 20^2 20^3 connected together by passages 21^1 21^2 21^3.

Passages 26^1 26^2 in any number are provided in the wheel 2 and connect both faces of the wheel together in the place of the balancing chambers 20^2 and 18^5, 20^3 and 18^6. Certain of these passages 26^1 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 suction side of the compressor and must have a sufficient section for leading the fluid leakage from the face 2^2 towards the face 2^1.

In the annular chambers, for instance 20^1 20^2 20^3 a flow of fluid will establish itself through the passages 21^1 21^2 21^3 so that the pressure existing in these chambers will be the same as the pressure existing in the blade rim 7^2. 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 2^2 of the rotor, thus producing an axial balancing effect in all the points of the rotor.

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

(*a*) A perfect balancing effect is obtained if the number 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 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 vein 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.

Blades show also on their outlet faces a cylindrical surface 39 which is so formed that the fluid vein 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 vein is not separated from the convex surface 38, which avoids the formation of eddies in the said vein;

(*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 the hollow face of a movable blade moving in the direction of the arrow receives fluid of a higher pressure, then the edge of this movable blade is suddenly 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 to the friction of the vein 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 vein of flowing back which periodically occurs in blade rims made according to the usual technical methods, each time when a movable blade passes in front of a fixed blade, is reduced or even annihilated in the case of the invention. Eddies are thus less violent and the internal efficiency is therefore meliorated.

The invention covers this particular form of execution of the blades irrespectively of the kind of turbine or compressor in which the said blades are used.

EMILE DUPONT.