

M. LEBLANC.
WHEEL WITH ELASTIC NAVE FOR STEAM OR GAS TURBINES AND TURBO COMPRESSORS.
APPLICATION FILED AUG. 18, 1911.

1,175,460.

Patented Mar. 14, 1916.
5 SHEETS—SHEET 1.

Fig. 1.

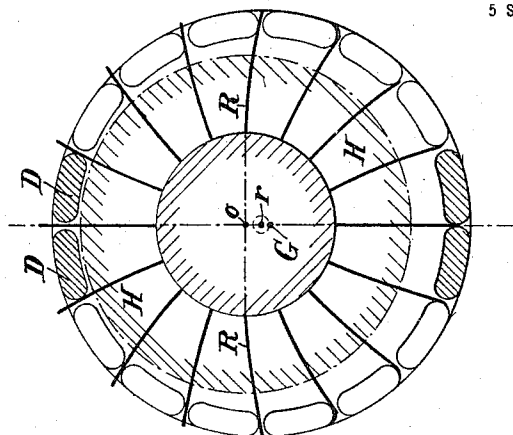
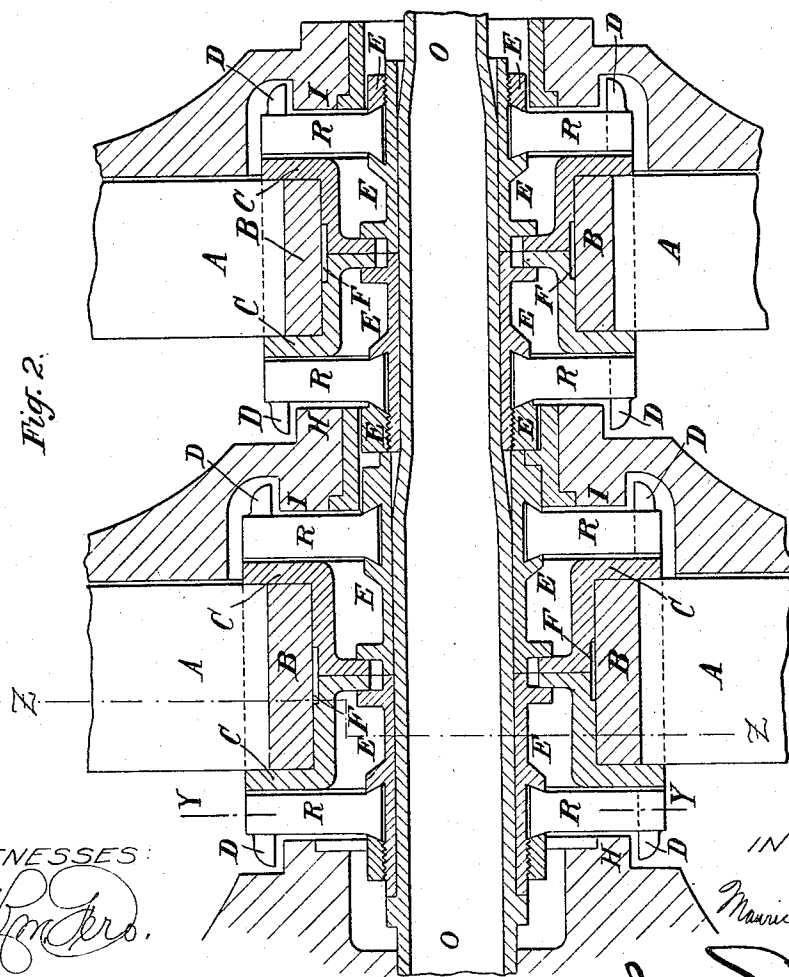


Fig. 2.



WITNESSES:

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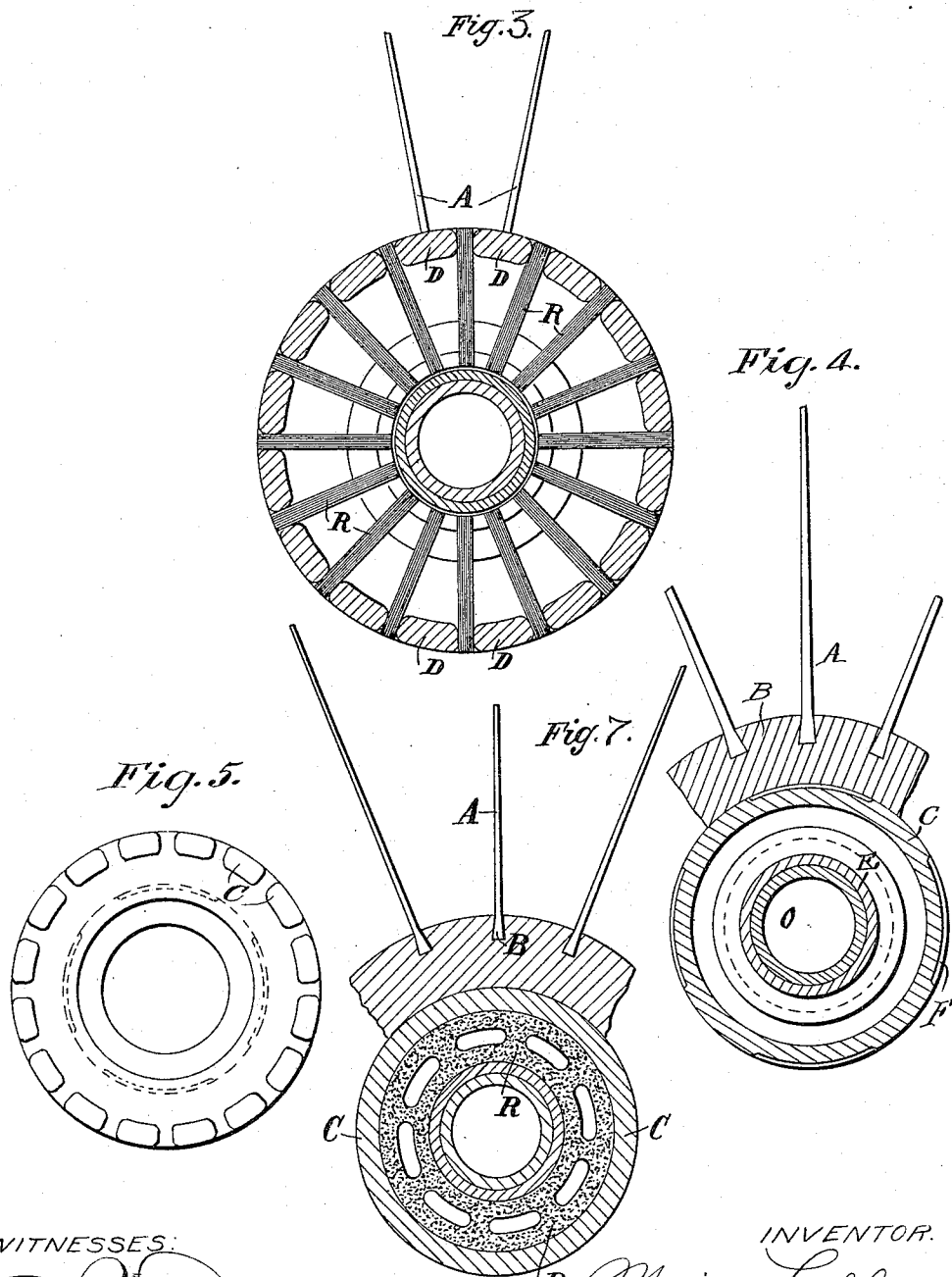
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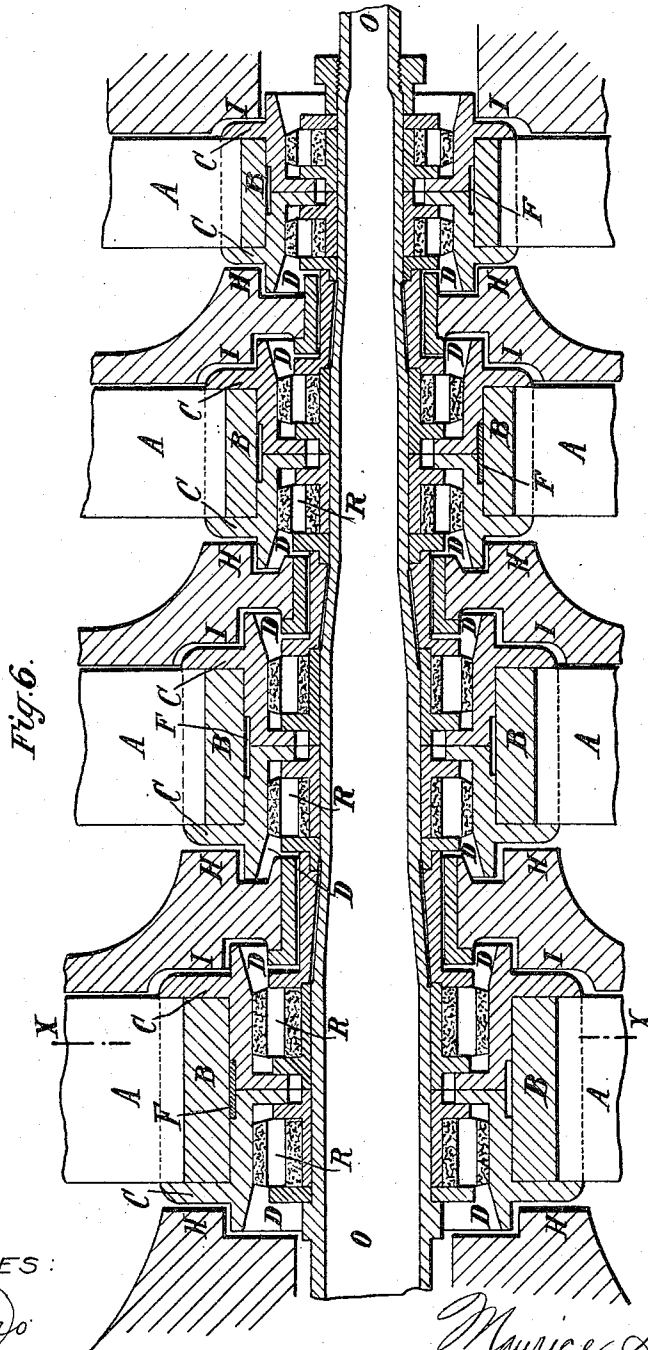
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5 SHEETS—SHEET 4.

Fig. 9.

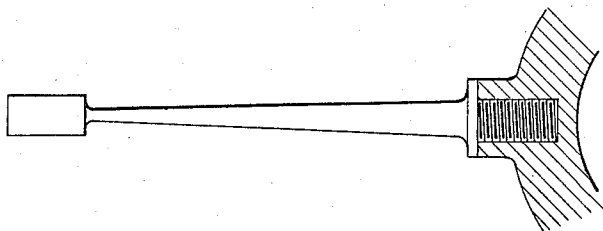


Fig. 8.

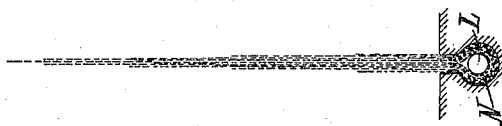


Fig. 12.

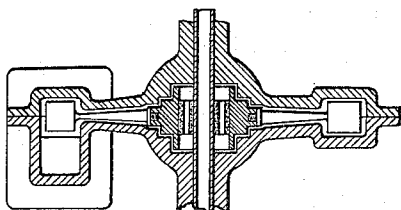


Fig. 11.

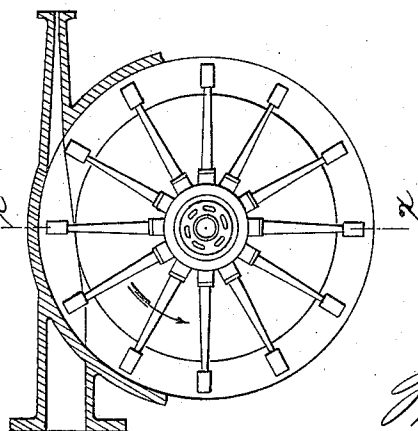


Fig. 10.



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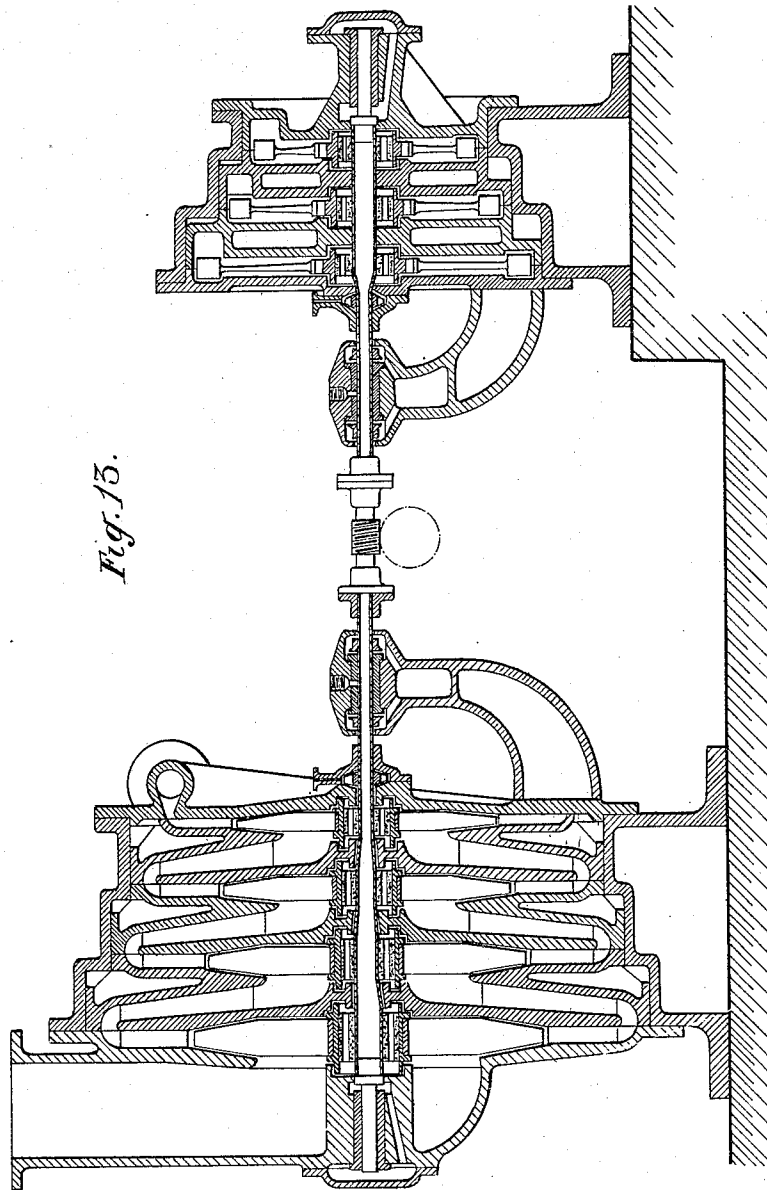
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5 SHEETS—SHEET 5.



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UNITED STATES PATENT OFFICE.

MAURICE LEBLANC, OF PARIS, FRANCE, ASSIGNOR TO STÉ. ANONYME POUR L'EXPLOITATION DES PROCÉDÉS WESTINGHOUSE-LEBLANC, OF PARIS, FRANCE.

WHEEL WITH ELASTIC NAVE FOR STEAM OR GAS TURBINES AND TURBO-COMPRESSORS.

1,175,460.

Specification of Letters Patent.

Patented Mar. 14, 1916.

Application filed August 18, 1911. Serial No. 644,780.

To all whom it may concern:

Be it known that I, MAURICE LEBLANC, a citizen or subject of the Republic of France, of 45 Rue de l'Arcade, Paris, France, have made a new and useful Invention in Wheels with Elastic Nave for Steam or Gas Turbines and Turbo-Compressors, of which the following is a specification.

The elastic nave construction, the object of this invention, allows of a rigid shaft being used for turbines and turbo-compressors having a multiplicity of wheels.

The present invention will be described with reference to the accompanying drawings, in which—

Figure 1 is a diagrammatic figure indicating theoretically the relative positions of the center of gravity G of the wheel, of the center of the figure or nave r and of the center of rotation O , Fig. 2 is a longitudinal section of the whole apparatus, Fig. 3 is a cross section on line $Y-Y$ in Fig. 2, Fig. 4 is a cross section on line $Z-Z$ in Fig. 2, Fig. 5 is a sectional view of the casing C , Fig. 6 is a longitudinal section, showing a modified apparatus wherein the springs in Fig. 1 are replaced by caoutchouc rings, Fig. 7 is a cross section on line $X-X$ in Fig. 6, Fig. 8 is a sectional view representing the mounting of a rubbered fabric band, constituting a turbo-compressor blade, in the nave of the wheel, Fig. 9 is a part section representing the mounting of a turbine arm on the nave, Fig. 10 is a section representing a turbine bucket, Fig. 11 is an elevation, sectional in part, showing the disposition of the turbine arms, Fig. 12 is a section on the line $x-x$ in Fig. 11; and Fig. 13 is a section representing a turbo-compressor, having four wheels constructed according to this invention, coupled directly to a turbine with three wheels of the same kind.

For the better understanding of the invention, some matters of a technical character will be first considered which relate to the critical speed of a turbine shaft and to the position of the center of gravity of a wheel with respect to the center of the figure or nave and the center of rotation of the wheel.

When a turbine shaft supports several wheels it should be flexible, but then there is the difficulty that the shaft acquires as many critical speeds as wheels, these critical speeds increasing with the number of

wheels. It is necessary to give the shaft such a flexibility that under the weights of the several wheels it will acquire an inadmissible deflection. To obviate this drawback, a rigid shaft can be used and each wheel be provided with springs, the springs of one wheel acting independently from those of another; the wheel naves are then secured to the rigid shaft by an elastic connection.

It is known, moreover, that if the center of gravity G of a wheel be at a certain distance from the geometric center of the nave, as long as the speed of rotation w is less than the critical speed w_c , the geometrical center of the nave r is nearer the axis of rotation than the center of gravity G ; on the contrary, if w be greater than w_c , the center of gravity G is between the axis of rotation and the geometrical center r (Fig. 1).

If the distance between the center of gravity G and the geometrical center r be termed the eccentricity then when center r is at a distance from the axis of rotation O greater than the eccentricity the center of gravity G can be brought between the axis and the center r by turning the wheel through 180° around its geometrical center and so G will be altered to G^1 . The nave, the object of this invention, is constituted to permit this rotation around the center of the figure, and that in an automatic manner, by means of guard plates contacting with two wheels $D D$, constituted by peripheral projections on the casing C which cause the turbine wheel A to slide with respect to the casing C which carries it. In fact, as the speed increases, so the pressure at the point of contact also increases, and it will not be long in overcoming the friction against the nave; the wheel A will slacken in its movement and will slide on casing C by turning around the geometrical center r (Fig. 1); it will cause the center of gravity G to turn about point r and will tend to bring it between points r and O ; a moment arrives when the retarding forces due to the springs $R R$ surpass the centrifugal force and the contact of the nave and guide rings will cease, but free to recur if the critical speed be not again exceeded at this moment. The drive on the shaft will be effected simply by friction, which increases with the speed.

The turbine wheel is mounted on a rigid shaft turning around axis O O; the nave B is hollow and rests on a cylindrical casing C around which it can turn. This casing has two series of peripheral projections constituting two drums or wheels D D provided with sockets for the reception of the extremities of the springs R, so that they can be independently displaced. The other extremities of the springs are invariably connected with the shaft. These springs are straight and are radially directed so that centrifugal force may not deform them. Each of them consists of a bundle of very thin strips or blades, retained in position by the recesses or sockets E E. On the exterior face of the casing C are arranged diametrically opposed recesses F F in which are fixed with some little play metal tongues or feathers. These are retained against the interior face of the nave by centrifugal force, the pressure being proportional to the square of the speed of rotation. The friction at starting can be increased by bending these tongues like a spring.

The nave is moved only by friction. At the moment of starting, this friction is due only to the weight of the wheel A, then as the speed increases the pressure exerted by the metal tongues increases.

The overhanging projections of the wheels D surround two fixed guard rings H and I which limit the displacements of the wheels with respect to the axis of rotation. These guide rings allow an amplitude of deformation greater than the eccentricity of the center of gravity of the wheel with respect to the center of the figure.

In a state of rest, the springs are flexed merely under the weight of the wheel. They should be disposed in sufficient number for the flexure to be independent of the angle through which the shaft is turned. The direction of these springs should be such that one can, by acting on the nave, describe about the geometrical center around the axis of rotation O O, a circle of radius at least equal to the flexure + the eccentricity (the distance between the geometrical center and the center of gravity). The play allowed between the overhanging extensions of the wheels D D and the guard rings should be equal to $f+e$, (f being the flexure, e the eccentricity). The result is exactly as if the wheel were carried merely by a flexible shaft capable of momentarily twisting and bending, whereas it is on a rigid axis incapable of twisting and turning, and this is attained by the elastic connection afforded by the springs, and the capability that the wheel has of sliding on the casing C at the moment of attaining the critical speed, the sliding being effected by the contact existing between the guard plates and the wheels D D.

The type of spring may be varied pro-

vided the centrifugal force does not tend to break them. In Figs. 6 and 7, the springs R R are replaced by caoutchouc rings pierced with holes, lying parallel with the axis of rotation, for increasing their flexibility. These rings are arranged between the shaft and the casing C which is disposed as described above. The cylindrical extensions of the casing C, constituting the wheels D D, turn in the interior of the fixed guard rings H and I.

When wheels are carried by an indeformable axis, they can be increased in number without their reacting the one on another, that is to say the springs of one, in bending, cannot transmit any strain to the springs of another. The use of these wheels having flexible naves allows of steam or gas turbines or turbo-compressors with multiple wheels, being run at speeds of several hundred turns per second, which has not up to the present time been possible with single wheel turbines. By way of example there is shown in Fig. 13 a turbo-compressor of the new system with four wheels coupled directly with a turbine of the new system having three wheels.

The present invention allows, besides the elastic nave, a particular system of blades for turbo-compressors, which, by reason of their lightness, render the reactions of the springs of each wheel on the shaft very feeble.

The blades of the turbo-compressor wheels are constituted by radially arranged metal blades connected to the nave in any suitable way. In Fig. 4, by way of example, they are attached by dovetail joints. The thickness of these blades is at first constant, then it increases from periphery toward the center; the strain per unit of surface, thus remains constant.

The density of a gas being always low and the tangential force exerted on the blades small, they can be very slight at their extremities and therefore very light and flexible, which allows the centrifugal force to maintain them radially directed.

Blades of wood or rubbered bands of fabric can be used; the very light organic fibers withstand better the effects of centrifugal force.

Fig. 8 shows how the bands are assembled. Strips of material of successively decreasing length, but of the same width, are superposed one over the other, so that the two extremities of each strip are at equal distances from the ends of the longest strip, and the strips are then glued or united together. They are wrapped around a cylindrical rod L. The rod and strips are placed in a metal sheath N and then vulcanized. On the periphery of the nave slots are made corresponding to the sheaths N into which the latter are slid.

As a second application of the present invention, an arrangement of turbine arms will be described.

To resist the action of the centrifugal force, instead of fixing the different buckets on one and the same disk, each bucket is connected to the nave by a separate rod. Each rod is made solid and of uniform strength, the diameter of any section of the rods being equal to the thickness of the disk, that thickness being taken parallel to the axis and at the same distance from the axis as the section of the rod. As the section of a rod varies as the square of its diameter, then with equality of stress a tangential speed can be transmitted $\sqrt{2}$ times greater to the rod than to the disk. But if each bucket is connected separately to the disk, it is advantageous to reduce as much as possible the number of buckets, and to use buckets of the kind represented in Fig. 10, arranged as shown in Figs. 11 and 12.

Having thus described the nature of my said invention and the best means I know of carrying the same into practical effect, I claim:

1. An elastic nave construction for wheels of machines of the character described employing a plurality of wheels mounted on one and the same rigid shaft and comprising a seating fixed to the rigid shaft, a circular casing supporting the nave of the wheel, adapted to be operated by the friction of parts interposed between the casing and the nave and to move eccentrically with respect to the rigid shaft, an elastic connection connecting the seating to the casing and a pair of wheels constituted by peripheral projections on the casing adapted to abut against two guard plates and thereby cause the automatic sliding of the wheel with respect to the casing.

2. An elastic nave construction for wheels of machines of the character described employing a plurality of wheels mounted on one and the same rigid shaft and comprising a seating fixed to the rigid shaft, a circular casing supporting the nave of the wheel adapted to be operated by the friction of parts interposed between the casing and the nave and to move eccentrically with respect to the rigid shaft, two wheels constituted by peripheral projections on the casing and provided with sockets, springs connecting the seating to the casing having each one end fixed to the seating and the other end adapted to slide in said sockets so that the wheels may abut against guard plates and thereby cause the automatic sliding of the wheel with respect to the casing.

3. An elastic nave construction for wheels of machines of the character described employing a plurality of wheels mounted on one and the same rigid shaft and comprising a seating fixed to the rigid shaft, a cir-

cular casing supporting the nave of the wheel, adapted to be operated by the friction of parts interposed between the casing and the nave and to move eccentrically with respect to the rigid shaft, caoutchouc rings pierced with holes parallel to the axis of rotation connecting the seating to the casing, peripheral projections on the casing constituting two wheels, adapted to cause the automatic sliding of the wheel with respect to the casing on abutting against two guard plates.

4. An elastic nave construction for wheels of machines of the character described employing a plurality of wheels mounted on one and the same rigid shaft and comprising a seating fixed to the rigid shaft, a circular casing supporting the nave of the wheel, adapted to be operated by the friction of parts interposed between the casing and the nave and to move eccentrically with respect to the rigid shaft, an elastic connection connecting the seating to the casing, two wheels constituted by the cylindrical projections on the casing adapted to cause the automatic sliding of the turbine wheel with respect to the casing on abutting against two guard plates, and a system of blades, for the wheel constituted by flexible members radially disposed and fixed to the nave of the wheel.

5. An elastic nave construction for wheels of machines of the character described employing a plurality of wheels mounted on one and the same rigid shaft and comprising a seating fixed to the shaft, a cylindrical casing supporting the nave of the wheel and adapted to be operated by the friction of parts interposed between the casing and the nave, and to move eccentrically with respect to the rigid shaft, an elastic connection connecting the seating to the casing, two wheels constituted by cylindrical projections on the casing adapted to cause the automatic sliding of the wheel with respect to the casing, on abutting against two guard plates, and flexible blades constituted by rubbered strips of fabric fixed in slots formed in the nave.

6. An elastic nave construction for wheels of machines of the character described employing a plurality of wheels mounted on one and the same rigid shaft and comprising a seating fixed to the shaft, a cylindrical casing supporting the nave of the wheel and adapted to be operated by the friction of parts interposed between the casing and the nave, and to move eccentrically with respect to the rigid shaft, an elastic connection connecting the seating to the casing, two wheels constituted by cylindrical projections on the casing adapted to cause the automatic sliding of the wheel with respect to the casing, on abutting against two guard plates, and blades for the wheel formed of straps or several bands of fabric folded one over the

other with the short bands on the outside, and a rod around which the bands are folded for securing each blade so formed to the nave.

5 7. An elastic nave construction for wheels of machines of the character described, employing a plurality of wheels mounted on one and the same rigid shaft and comprising a seating rigidly mounted on the rigid
10 shaft, a circular casing for supporting the nave of the wheel yieldingly supported on said seating, and a nave surrounding said casing and operatively connected thereto by means of friction only.

15 8. An elastic nave construction for wheels of machines of the character described, comprising a seating rigidly mounted on a rigid shaft, a nave support surrounding the seating and movable eccentrically with relation
20 thereto, means for yieldingly connecting the seating to the support, a nave loosely mounted on the support, and means between the nave and the support for frictionally connecting the nave to the support.

25 9. An elastic nave construction for wheels of machines of the character described, comprising a seating mounted on a rigid shaft, a nave support surrounding the seating and movable eccentrically with relation to the
30 shaft, a nave loosely mounted on the nave support, and means responsive to centrifugal force for increasing the frictional engagement between the nave and the support proportionally to the increased speed of
35 the wheel.

10. An elastic nave construction for

wheels of machines of the character described, comprising a seating adapted to be rigidly mounted on a rigid shaft, a nave surrounding the seating and movable eccentrically with relation to the mounting shaft, and metallic plates disposed radially between the seating and the nave for yieldingly supporting the nave, the inner ends
40 of said plates being secured to the seating by means of a dovetail construction. 45

11. A wheel of the character described, comprising a hub, blades of extreme lightness so located on the hub, that the plane of each blade passes through the axis of
50 the wheel, each blade being formed of leather bands which extend axially with relation to the laminated blade thus formed, and means for securing the blades to the hub. 55

12. A wheel of the character described, consisting of a nave, blades, and a separate rod for mounting each blade on the nave, each of said blades being formed by straps or several bands of flexible material of increasing length, said bands being folded
60 about the mounting rod so that the shortest bands are located farthest away from the rod.

In witness whereof I have hereunto
signed my name in the presence of two subscribing witnesses. 65

MAURICE LEBLANC.

Witnesses:

ALBERT DELAS,
H. C. COXE.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."