

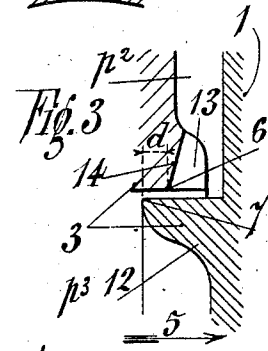
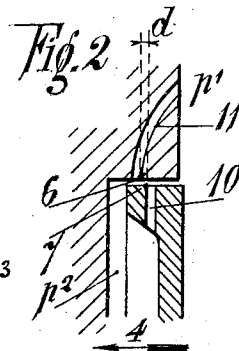
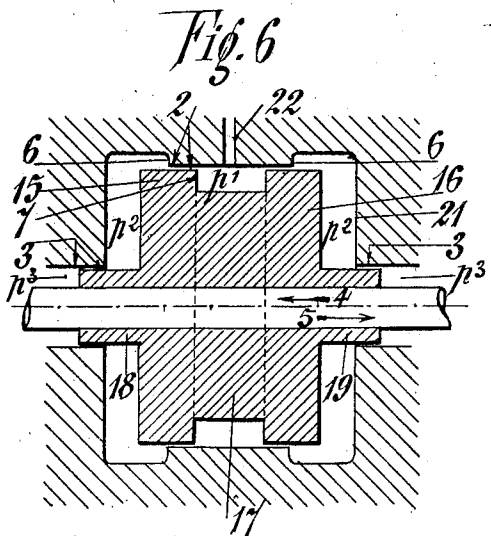
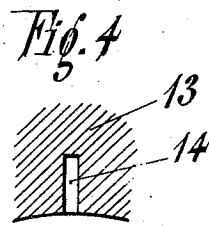
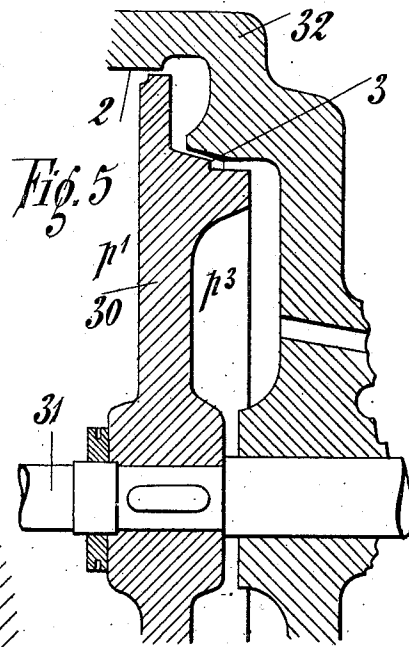
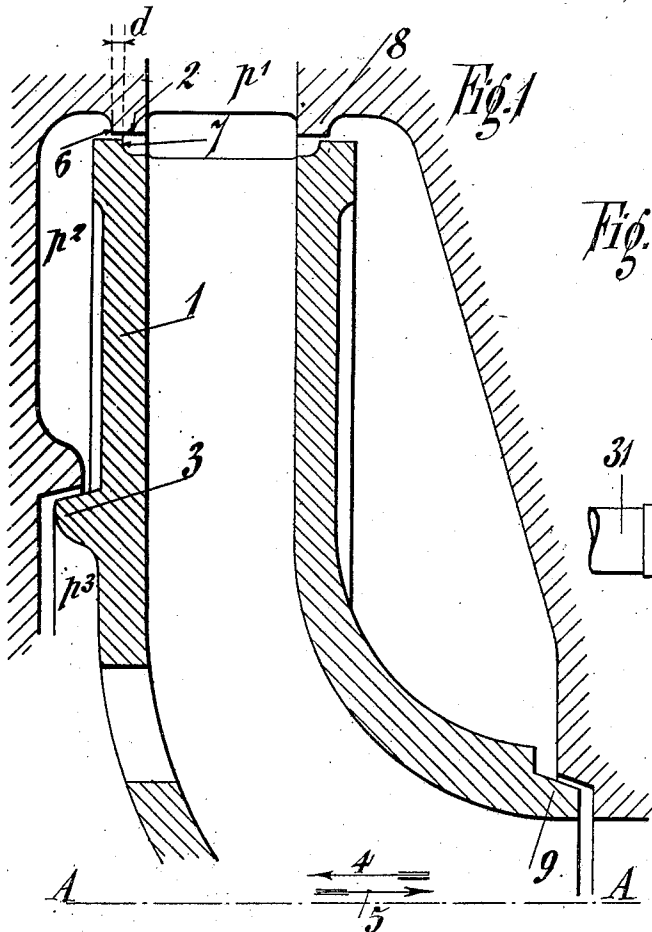
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P. J. C. MARÉCHAL

1,488,931

TURBO ENGINE

Filed Oct. 26, 1921



Inventor:
Paul Joseph Charles Maréchal.
By *Alfred...*
Att'y.

UNITED STATES PATENT OFFICE.

PAUL JOSEPH CHARLES MARÉCHAL, OF PARIS, FRANCE.

TURBO ENGINE.

Application filed October 26, 1921. Serial No. 510,565.

To all whom it may concern:

Be it known that I, PAUL JOSEPH CHARLES MARÉCHAL, citizen of the Republic of France, residing at 41 Rue des Ecoles, Paris, France, have invented certain new and useful Improvements in or Relating to Turbo Engines, of which the following is a specification.

My invention relates, and has for its object, a means for maintaining in turbo engines a stable equilibrium of the rotor of such engines as to its movement along the axis.

This result is attained, both for turbo engines provided with multiple elements (such as centrifugal and multicellular pumps, air compressors, and steam turbines) and engines provided with a single element.

For this purpose I may: either balance the whole of the rotor by well known methods taking into account all axial thrusts, including those due to coupled engines, and then provide all or a portion of the elements of the rotor with the device which constitutes the subject matter of this invention, or I may key upon the shaft of the turbo engine a balancing disc and provide this disc with the device which constitutes the subject matter of this invention.

This device has a certain number of stabilizing chambers provided between a certain number of elements integral with the rotor and the adjacent parts of the stator, the pressure of the fluid in these chambers varying according to the movements of the rotor parallel with its axis and tending by these variations to oppose themselves to the said movements.

In the accompanying drawing and by way of example:

Figure 1 shows the application of the present invention to a turbo engine, the stabilization being ensured by the simultaneous working of two joints.

Figures 2 and 3 each shows a modification of the construction of the two joints according to my invention.

Figure 4 is a front view of the joint shown in Figure 3.

Figure 5 shows the application of the device to a balancing disc.

Figure 6 is a longitudinal section of a device with a balancing disc according to this invention.

The rotor of the turbo-engine consists in

an element 1 (Fig. 1) adapted to rotate about the axis A—A of the turbo-engine. The various axial thrusts exerted on this element 1 are balanced in a well-known manner. In accordance with my invention, I create on one or both sides of this element a zone 2—3 of revolution about the axis A—A against which the pressure of the fluid is variable according to the movements of the turbine in the direction of the axis. These variations of pressure are such that they oppose themselves to the movement which, when started, has given rise to them.

This result is obtained in the following manner:

The zone 2—3 in which the variable pressure P_2 exists, is located between two zones in which the pressures are P_1 and P_3 respectively, determined by the law of the turbo engine with

$$P_1 > P_2 > P_3$$

At 2 is placed a joint constituted in the following manner:

During normal operation the movable part and the fixed part present opposite each other two cylindrical surfaces. These two cylindrical surfaces, therefore, overlap each other for a certain length which, when counted parallel to the axis A—A of the rotor is represented by the distance d , which separates the stop 6 from the stop 7.

When movement of the movable part takes place in the direction of the arrow 4, the stop 7 comes opposite the stop 6 and then moves past it. After this, by reason of recesses which are judiciously made on the one hand in the movable part on the right hand side of 7 and on the other hand in the fixed part to the left of 6, the joint 2 offers to the passage from the region of pressure P_1 to the region 2—3 a section which is sensibly greater than the section originally provided.

In like manner there is placed at 3 a joint of such a nature that the fixed part and the movable part present opposite each other two conical surfaces slightly inclined to the axis of the turbo engine. Movement in the direction of the arrow 4 has the effect of sensibly reducing the section of the passage offered to the fluid in order to allow it to pass from the region 2—3 to the region of pressure P_3 .

The conical surfaces above mentioned in connection with Figure 1 constituting the

joint 3 may be replaced by cylindrical surfaces similar to those which constitute the joint 2. Experience has shown that this arrangement is particularly advantageous.

On the whole therefore a movement of the movable part in the direction of the arrow 4 has the effect of producing an increase of pressure in the zone 2-3 which opposes the movement of the element in the direction of the arrow 4.

Moreover, if the rotor is displaced parallel to the axis A-A in the direction of the arrow 5, the length of the inlet joint 2 will either be increased without a variation of its cross-section, if the stops 6 and 7 occupy the position indicated in Fig. 1, or the cross-section of the inlet joint 2 will be decreased, if the stop 7, at the beginning of the said displacement, is on the left of the stop 6, while at the joint 3 the section of the passage offered to the fluid which tends to flow from the region p^2 to the region of pressure p^1 , will sensibly increase.

Thus, the resistance of the inlet joint 2 increases, while the resistance of the outlet joint 3 decreases, the two effects thus obtained contribute, therefore, to produce a decrease in the pressure p^2 of this chamber. Consequently, when the rotor is displaced parallel to its axis in the direction of the arrow 5, i. e. when the whole of the forces which act on the rotor in this direction becomes preponderant, the one of these forces, namely the force due to the pressure p^2 , automatically decreases, which re-establishes the equilibrium of the rotor and allows it to return to its initial position under the action of the various forces acting on the rotor in the opposite direction of the arrow 5.

The required stability will therefore be obtained whatever be the direction of movement of the rotor.

The sensitiveness of this stabilization can be increased by the creation on the other face of the element under consideration of a similar zone 8-9 which will act in a similar manner.

It may be noted that when the rotor is displaced parallel to its axis in the direction of the arrows 4 or 5, the cross-section of the inlet joint 2, if the stop 7 is at the right of stop 6, remains constant, but the length of said joint, i. e. the distance separating the stops 6 and 7 varies. One can bring the two cylindrical surfaces constituting the joint 2 very close to each other (1/10 to 2/10 of a millimeter) for centrifugal pumps such as illustrated in Fig. 1. As a result thereof the variations in the length of the joint 2 involve corresponding variations in the resistance which the said joint opposes to the passage therethrough of the fluid. These variations in the resistance which are already noticeable, when

a liquid of small viscosity, e. g. water, is admitted into the stabilizing chamber, become important, when one feeds these stabilizing chambers with a very viscous liquid, such as glycerine or castor oil, such as will be hereafter explained with the aid of Fig. 6.

The distance d separating the stops 6 and 7 in the normal position of equilibrium of the rotor (Fig. 1) is selected in such a way that it is less than the maximum displacements of the rotor parallel to its axis A-A. Therefore, when the rotor is displaced in the direction of the arrow 4 in leaving the normal position of equilibrium, the length and consequently the resistance of the joint 2 first slowly decrease and result in a slow and progressive increase of the pressure p^2 of the stabilizing chamber.

When the lack of equilibrium of the forces which has caused the displacement of the rotor parallel to its axis in the direction of the arrow 4 is equalized, the said displacement stops without any oscillation of the rotor about its position of equilibrium being produced, which is due to the slowness of the progressive variations of the forces of pressure p^2 in the stabilizing chamber.

On the other hand, if the lack of equilibrium of the forces which involved the displacement of the rotor in the direction of the arrow 4 increases and if the rotor continues to become displaced in that direction in spite of the progressive increase of the pressure p^2 in the stabilizing chamber, the stop 7 of the rotor glides past the stop 6 of the stator so that the inlet joint 2 is wide open. The pressure p^2 of the stabilizing chamber thus reaches a maximum value in practice very close to the pressure p^1 . This gliding past each other of the stops thus enables the stabilizing chamber to exert its maximum effect to counteract the exaggerated displacement of the rotor in the direction of the arrow 4.

Thus, the fact of constituting a joint 2 by two cylindrical surfaces, the distance d separating the stops 6 and 7 being smaller than the maximum displacements of the rotor parallel to its axis, carries the advantage of insuring, on the one hand, a slow and progressive equilibration of the rotor without producing oscillation around the balanced position in case of slight axial displacements of the rotor, and, on the other hand, a prompt and efficient action of the stabilizing chamber when the rotor undergoes exaggerated axial displacements.

Figure 2 shows a modification of the joint 2, in which 10 is a continuous circular passage acting opposite passages 11 formed in the fixed part.

The passages 10 and 11 are provided in the rotor and stator respectively in such a manner, that in the mean position of equilibrium of the rotor such as is shown

in Fig. 2, the distance d separating the stops 6 and 7 of the two passages 10, 11 is smaller than the maximum displacements of the rotor parallel to its axis. Thus, as in the embodiment of Fig. 1, the stops 6 and 7 will glide past each other for a greater length than d , as soon as the rotor becomes displaced, in the direction of the arrow 4, parallel to its axis.

Figure 3 shows a modification of the joint 3 in which the cylindrical surface of a rib 12 formed on the movable part 1 acts opposite a corresponding rib 13 on the fixed part. This latter is intersected by slots 14 which, when the engine is working normally are not uncovered by the rib 12 on the movable part.

The joint 3 thus formed constitutes the outlet joint of the stabilizing chamber of the pressure p^2 ; the stop 6 which limits the passage 13 of the stator and the stop 7 of the rotor 1 are arranged at a distance d from each other, which distance is less than the maximum axial displacements of the rotor. Consequently, when the rotor 1 is displaced parallel to its axis, in the direction of the arrow 5, for a greater length than d , the two stops 6 and 7 will glide past each other causing an instantaneous variation of the pressure p^2 , which drops to a value practically equal to the outlet pressure p^3 .

The device shown in Figure 5 has a balancing disc 30 fixed on the shaft 31 of the rotor of the turbine and forms by its combination with the fixed casing 32 two joints 2, 3 which play the same part as in the preceding examples.

In the device shown in Figure 6, the balancing disc has two cylindrical annular surfaces 15 and 16, separated by a cylindrical surface 17 of smaller diameter, and two cylindrical extensions 18 and 19.

The movable whole of 15 to 19, integral with the shaft of the rotor, is surrounded by a fixed casing 21 in which is formed an inlet passage 22 for fluid under pressure. The profile of this casing allows it to form a cylindrical joint 2 with each annular surface 15 and 16 and a cylindrical joint 3 with each extension 18, 19.

The balancing device hereinbefore described works in a similar manner. The fluid is admitted through 22 under a pressure p^1 in the space comprised between the annular surfaces 15 and 16. It passes through the joint 2 and is there subjected to a certain loss of pressure which lowers its pressure to p^2 and finally it passes through the joint 3 and there undergoes a fresh loss of pressure which lowers the pressure to p^3 , there being also the inequalities:

$$p^1 > p^2 > p^3$$

If the rotor of the turbine, and consequently the balancing disc which is integral

therewith, moves in the direction indicated by the arrow 4, the joint 2 of the annular surface 15, the length of which decreases, opposes to the passage of the fluid a resistance which becomes less and less, while the joint 3 of the extension 18 opposes to this passage a resistance which becomes greater and greater. Consequently the pressure p^2 of the fluid in the stabilizing chamber provided between inlet joint 2 and the outlet joint 3 adjacent to the annular surface 15 tends to increase, moving near to p^1 and away from p^3 . This pressure p^2 finally becomes practically equal to p^1 , when the movable stop 7 has moved past the fixed stop 6. This increase of pressure p^2 tends to bring back in the reverse direction to that indicated by the arrow 4 the balancing disc and consequently the rotor which is integral therewith.

The phenomena which are produced on the annular surface 16 when the rotor moves in the direction of the arrow 4, are exactly the reverse of the preceding ones, the pressure p^2 acting on the annular surface 16 decreasing and tending to move nearer to p^3 .

The two variations of pressure produced on the one hand on 15 and on the other hand on 16 therefore agree in order to oppose the movement of the rotor in the direction of the arrow 4. The stability of the balancing of this rotor is thus produced.

A movement in the direction of the arrow 5 would produce similar phenomena.

The preceding balancing device can be installed on the shaft of rotors of very varied types. In the case in which it is of advantage to reduce the amplitude of the longitudinal movements of the shaft to which the balancing device is applied for example in the case of a steam turbine where the clearance between the fixed blades and the movable blades has a fixed value, it is of advantage to be able to regulate the fixed casing relatively to the balancing discs. This casing is rendered movable relatively to its base by the aid of suitable devices, such as screws.

The various devices hereinbefore described may be supplied with any kind of fluid (e. g. water, steam, etc.). However, it is advantageous to feed these devices with liquids having a co-efficient of great viscosity.

This application ensures the following principal advantages. Firstly this viscous body traverses the joints 2 and 3 very slowly and with great losses of pressure. The quantities of liquid under pressure traversing the joints per unit of time are therefore small. High pressures may consequently be maintained in the apparatus and the balancing disc and the whole device may be made of reduced dimensions, which reduces the amount of space occupied and the cost price of the installation.

Finally the application of viscous bodies to a device such as that shown in Figure 6 in the accompanying drawings, ensures great sensitiveness of this device. In actual fact the differences of pressure between two points of a joint 2, for example, are greater the more viscous the liquid is.

It is obviously possible to select a viscous body of any kind in order to put the invention into practice. It is however convenient to choose preferably liquids with a high coefficient of viscosity such as glycerine and castor oil.

I claim as my invention:—

1. In a device for maintaining the balance of the rotor of a turbo-engine, the combination with the piping of the engine, of an element integral with the said rotor, a fixed casing called the stator surrounding the said element, a stabilizing pressure chamber provided between the said element and the said casing so that for each displacement of the said rotor parallel to its axis, the variations of pressure resulting therefrom in the said chamber oppose such a displacement, a joint connecting the said chamber with the said piping, the said joint being formed by two surfaces of revolution around the axis of the said rotor, one provided on the said casing and the other on the said element, the said two surfaces partially overlapping each other in the normal balanced position of the said rotor in a direction parallel to the axis of the said rotor for a distance smaller than the maximum displacements of the rotor parallel to its axis.

2. In a device for maintaining the balance of the rotor of a turbo-engine, the combination with the piping of the engine, of an element integral with the rotor, a fixed casing called the stator, surrounding the said element, a stabilizing pressure chamber provided between the said element and the said casing so that for each displacement of the said rotor parallel to its axis, the variations of pressure resulting therefrom in the said chamber oppose such a displacement, a joint connecting the said chamber with the said piping, the said joint being formed by two surfaces of revolution around the axis of the said rotor, one provided on the said casing and the other on the said element, the said two surfaces partially overlapping each other in the normal balanced position of the said rotor, a recess provided in the said casing forming a hollow in the surface of revolution provided on the said casing, the distance between the edge (stop) of the surface of revolution of the said ele-

ment and the edge (stop) of the said recess in the normal balanced position of the said rotor being smaller than the maximum displacement of the said rotor parallel to its axis.

3. In a device for maintaining the balance of the rotor of a turbo-engine, the combination with the piping of the engine, of an element integral with the said rotor, a fixed casing called the stator surrounding the said element, a stabilizing pressure chamber provided between the said element and the said casing so that for each displacement of the rotor parallel to its axis the variations of pressure therefrom resulting in the said chamber oppose such a displacement, a joint connecting the said chamber with the said piping, the said joint being formed by two surfaces of revolution around the axis of the said rotor, one provided on the said casing and the other on the said rotor, the said two surfaces partially overlapping each other in the normal balanced position of the said rotor, a recess provided in the said casing and forming a hollow in the surface of revolution provided on the said casing, a recess provided in the said element and forming a hollow in the surface of revolution provided on the said element, the distance separating the edges (stops) of the said two recesses in the normal balanced position of the said rotor being smaller than the maximum displacement of the said rotor parallel to its axis.

4. In a device for maintaining the balance of the rotor of a turbo-engine, the combination with the shaft of the said rotor, of a disk secured to the said shaft, a fixed casing called the stator surrounding the said disk, two stabilizing chambers symmetrical relative to each other provided between each of two faces of the said disk and the said casing, each chamber communicating with the high and the low pressure region by two joints, the resistance of which varies in the reverse direction relative to each other for the same displacement of the said rotor parallel to its axis so that the pressure variations therefrom resulting in the said two chambers oppose such a displacement, each joint being formed by two adjacent cylindrical surfaces co-axial with the said rotor, the one of the said surfaces being provided on the said disk and the other on the said casing, and a conduit opening between the said two chambers and feeding the device with a pressure fluid.

In testimony whereof I have affixed my signature.

PAUL JOSEPH CHARLES MARÉCHAL.