Dec. 8, 1936. P. M. F. M. ROY 2,063,194

ROTARY PUMP AND COMPRESSOR

Filed March 11, 1935

Fig. 1 Fig. 2 Fig. 3

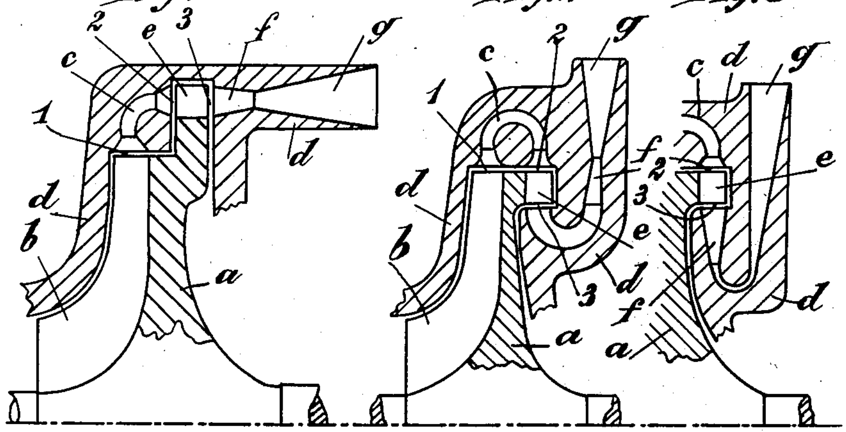


Fig. 4

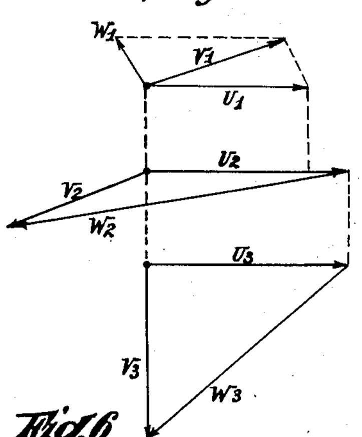


Fig. 5

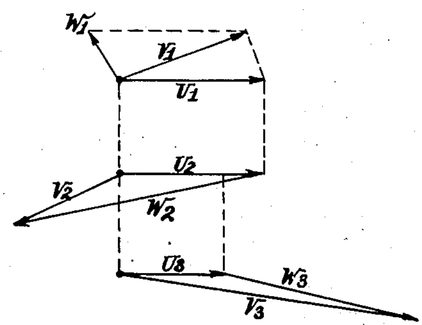


Fig. 6

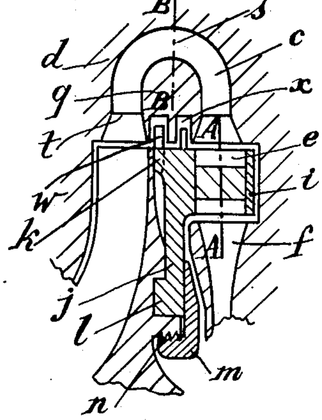


Fig. 7

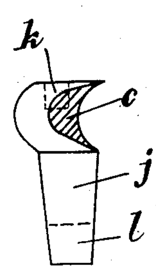
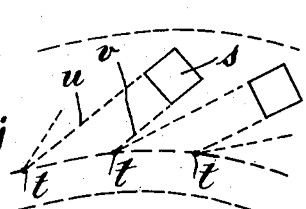


Fig. 8



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Patented Dec. 8, 1936

2,063,194

UNITED STATES PATENT OFFICE

2,063,194

ROTARY PUMP AND COMPRESSOR

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Application March 11, 1935, Serial No. 10,550
In France March 15, 1934

7 Claims. (Cl. 103—95)

The present invention concerns an arrangement of blade rings for centrifugal pumps and compressors or, in a more general way, pumps and compressors of a rotary type adapted to give a continuous flow of fluid and to permit of imparting a very high final absolute velocity to said fluid with a view to obtaining high rate compression.

It is known that, with the ordinary arrangement of wheels provided with blades either radial or more or less convex in the direction of their rotation, the absolute velocity of exit of the fluid is of the same order of magnitude as the peripheral velocity of the wheel, which velocity is itself limited by the mechanical resistance of the rotor.

The object of the arrangement of blade rings according to the present invention is to give the fluid a very high final absolute velocity, which may eventually exceed the order of magnitude of the peripheral velocity of the rotor and average twice or thrice this order of magnitude, and to transform the kinetic energy into pressure by means of a diffuser which receives the stream of fluid fed thereto with a high velocity, in which diffuser the compression of this fluid takes place with a high efficiency, especially owing to the advantageous utilization, in the case of compressible or gasiform fluids, of the phenomenon called "shock wave".

The arrangement according to the present invention consists essentially in adding to the usual blade ring, located on one face of the rotor, a second blade ring, located on the periphery or on the other face of the wheel and forming a velocity stage, and in providing, on the stator, between these blade rings, a row of stationary blades of the impulse kind, that is to say devised in such manner as to produce no substantial variation of pressure.

Other features of the present invention will result from the following detailed description of some embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described, with reference to the accompanying drawing, given merely by way of example, and in which:

Fig. 1 is a diagrammatical axial sectional view of a rotary compressor according to the present invention in which the second path of travel of the fluid in the wheel is of the helicoid type;

Fig. 2 is a view, similar to Fig. 1, of another embodiment in which the second path of travel of the fluid is first centripetal and then rendered centrifugal by means of a suitable row of guide blades;

Fig. 3 is a view, similar to Fig. 2, of a modification;

Fig. 4 is a diagram showing the triangles of velocities at different points of the path of travel of the fluid through the apparatus of Fig. 1;

Fig. 5 is a diagram similar to that of Fig. 4, corresponding to the embodiments of Figs. 2 and 3;

Fig. 6 is an axial sectional view of a practical embodiment of the wheel according to the present invention;

Fig. 7 is a sectional view on the line A—A of Fig. 6; and

Fig. 8 is a sectional view on the line B—B of Fig. 6.

The simple compressor, embodiments of which are diagrammatically shown in Figs. 1, 2 and 3 of the drawing, is fitted with the arrangement of rows of blades which is the essential feature of the present invention. The wheel or rotor *a* is provided on one face with blades *b* and both the intake and the wheel itself may be devised in any conventional or other way and preferably as shown in my French Patent No. 752,623, of June 21, 1932. The fluid issuing from the wheel at the periphery thereof, at **1**, passes through a row of stationary guide blades *c*, called reversing blades, which work according to the impulse principle, that is to say at a substantially constant pressure and which reverse through an arc of about 180° the absolute velocity of the fluid in the plane of flow, that is to say in the plane of the absolute and relative velocities, without modifying to any considerable extent the magnitude of this velocity. This row of blades, which is carried by the envelope or stator, thus directs the fluid onto a row of blades *e* disposed either on the periphery of the wheel (Fig. 1) or preferably on the other face of said wheel (Figs. 2 and 3).

This row of blades *e*, through which takes place the second portion of the flow of the fluid through the wheel, either with a helicoid motion (Fig. 1) or preferably with a centrifugal motion (Figs. 2 and 3) also works on the impulse principle and deviates the fluid as quickly as possible in order that its relative velocity may be brought toward a direction parallel with the meridian plane of the apparatus, or even beyond this direction, so as to come close to the direction of the peripheral velocity.

When leaving this second row of blades *e* carried by rotary wheel *a*, the fluid enters the stationary diffuser.

In the embodiment of Fig. 1, the second portion of the path of travel of the fluid is helicoid-shaped and the diffuser is provided, in its inlet or close to its inlet, and before the free portion *g* thereof, with a system of stationary guide blades *f* intended to bring back the direction of the absolute velocity of the fluid into a meridian plane, that is to say to cause the streamlines of the fluid to flow along the generatrices of a body of revolution coaxial with the wheel, the sections of flow between the blades of this system *f* being such that, along this portion of the path of travel of the fluid through the diffuser, the pressure of the fluid cannot increase and preferably decreases slightly.

This row of blades *f* of the diffuser extends as far as the point where the streamlines of the fluid move along the generatrices of a body of revolution coaxial with the wheel, and the second portion *g* of said diffuser, located behind said blades, consists merely of its two walls which constitute a conduit in the form of a body of revolution, of gradually increasing cross section. This portion *g* of the diffuser is free from obstacles over the portion thereof in which the velocity of the fluid remains important, or at least the obstacles are reduced to the minimum necessary for ensuring, if need be, the connection between said walls, and they are streamlined and disposed in meridian planes.

Under these conditions, if the fluid is fed to the diffuser with a velocity higher than the velocity of sound, the shock wave that must be produced in the diffuser is localized therein at the outlet end of the guide blades or beyond; it is orthogonal to the direction of flow and produces a sudden rise of pressure with a very good adiabatic efficiency.

When the row of blades corresponding to the second portion of the flow of fluid through the rotary wheel is devised in such manner as to impart a truly radial velocity to the fluid issuing therefrom, the sections of these blades are disposed in such manner that the outflow of fluid takes place with a slight expansion and in this case the diffuser is not provided with guide blades. If a shock wave is produced in the diffuser, it is still orthogonal and it is then localized in the inlet of the diffuser or beyond.

In the embodiment of Figs. 2 and 3, the second portion of the flow of fluid through the wheel, which takes place through the row of blades *e*, is centripetal and the outflow into the diffuser takes place in a centrifugal direction. In the case of Fig. 2, the centripetal stream issuing from the row of blades *e* is first rendered centrifugal owing to the provision of a curved passage *h*, of revolution about the axis of the wheel, then the stream of fluid passes through guide blades *f*, located at a distance from the axis substantially equal to that of blades *e* and finally the fluid flows out through free passage *g*.

On the contrary, in the case of Fig. 3, the guide blades *f* for causing the fluid to move in axial planes are located in the centripetal portion, immediately after blades *e*. The fluid is then caused to move in a centrifugal direction by passing through curved passage *h*.

Figs. 4 and 5 diagrammatically show, transferred into the same plane, the triangles formed by the blade velocity U, the relative velocity of the fluid W and the absolute velocity V of the fluid at points marked 1, 2 and 3 in Figs. 1 to 3, at which points the fluid leaves blades *b*, enters blades *e*, and leaves said blades *e*, respectively. In these figures, the reference characters U, W and V are completed by digit 1, 2 or 3, according to the point of the wheel to which it corresponds.

Fig. 4 corresponds to the case of a centrifugal-helicoid arrangement, since the blade velocity U_3 is equal to U_2 and greater than U_1, this arrangement being analogous to that of Fig. 1, but with the difference that the fluid leaves blades *e*, at point 3, in a direction parallel to the axis of the wheel, since V_3 is at right angles to U_3. In this case, the guide blades *f* of the embodiment of Fig. 1 are unnecessary.

Fig. 5 corresponds to the case of a centrifugal-centripetal arrangement of the rotary wheel analogous to what is shown in Figs. 2 and 3, since U_2 is equal to U_1 and greater than U_3. Furthermore, in this case, the fluid then issues at point 3 in a direction close to the tangent to the wheel at this point and the diffuser then necessarily includes a set of guide blades *f*, as shown by Figs. 2 and 3.

The disposition of the absolute velocities V_1 and V_2 in the diagrams of Figs. 4 and 5 shows how the absolute velocity of the fluid is obtained by means of blades *c*.

On the other hand, the theory of turbo-engines makes it possible to easily ascertain that if points 1, 2 and 3 are at distances from the axis of the wheel relatively little different from one another and if the flow takes place from point 1 to point 3 substantially at constant pressure and without any substantial interchange or loss of energy, and if, finally, the relative velocity W_1 at point 1 is relatively low, the absolute velocity V_3 at the exit is of the order of magnitude of the peripheral velocity multiplied by

$$\sqrt{3}$$

or by 3 in the case of Figs. 4 and 5 respectively, that is to say of an order of magnitude which indicates the advantages obtained according to the invention.

Fig. 6 diagrammatically shows in axial section, an embodiment of the upper part of wheel *a* and of the stationary guide conduits limited by blades *c*, Figs. 7 and 8 being detail views.

In this embodiment, a blade *e* consists of a piece which is obtained by cutting or by moulding under pressure and which may be made hollow so as to reduce its weight. Said piece is guided, at its upper part, by a tooth engaged in a corresponding and radial groove of the wheel, and it is fixed in position in the wheel by a projection *l*, the whole being held with respect to the wheel by a circular nut *m* (Fig. 6) screwed on a threaded portion *n* of said wheel. On the side of said piece *e* that is not applied against the wheel, said piece is provided with a thin element *i* and the whole of these elements *i*, when all the blades *e* are juxtaposed, forms a continuous external ring which closes, laterally, the passage between two consecutive blades.

The conduit between two consecutive blades of the row of blades *e* consists, from the edge *t* of said blades, of a conduit of rectangular section *s* of constant height and the width of which varies very little, extending between planes *u* and *v*, both parallel to the axis of the wheel and to the direction of the absolute velocity of the fluid when impinging upon edge *t*.

The reversing conduits may be made by means of a cylindrical milling cutter, which is given a movement parallel to planes *u* and *v* and which cuts in a suitable manner envelope *d*, the inner recess of which may be fitted with a core *q* made of parts cut externally in a corresponding manner and which may be assembled or not on a central and common portion of core *q*. The spacing of the conduits and the distance of edges *t* from the axis of the machine are so chosen that the height of rectangular section *s* is but little different from its width.

Of course, any known means such as a ring *w* or an annular packing element *x* may be employed for ensuring fluid tightness and preventing leakage, especially from one face to the other of the wheel.

The wheel, especially when it is desired to use high peripheral speeds, may be cut as a whole in a mass of high resistance metal, such as special steel or light alloys or aluminium or magnesium.

Furthermore, for all the blades, the respective radii of curvature of the opposite faces of each blade, at the edge where they are joined together, are very little different and for the movable blades the mean value is, with an approximation of at most 25%, equal to the external radius of the wheel multiplied by the ratio of the relative velocity of the wheel and of the double of the peripheral velocity of the wheel. For all conditions of working in which the relative velocities vary nearly proportionally with the peripheral velocity, the adaptation of the blade to the flow is thus ensured without correction.

The arrangements above described may be applied, either separately or in combination, to centrifugal pumps and compressors of any kind whatever and especially to those including either one intake or two opposed intakes, a distributor before the wheel, one or several wheels associated in series or in parallel, etc.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. A rotary machine of the type including pumps and compressors giving a continuous flow of fluid which comprises, in combination, a casing, a fluid driving wheel journalled in said casing, an intake in said casing, a system of blades carried by the face of said wheel located opposite said intake, for driving the fluid admitted through said intake outwardly, a second row of blades carried by said wheel, and stationary guide means carried by said casing for bringing back the fluid driven by the first system of blades onto the second row of blades, said stationary guide means being shaped to reverse through an angle of about 180°, the absolute velocity of the fluid, considered with reference to the plane determined by the absolute velocity and the blade velocity, without substantially modifying the magnitude of this absolute velocity and having a continuous gradual curvature from one end to the other, said blades and guide means being so shaped that the flow takes place with a substantially uniform pressure from the outlet of the first mentioned system of blades to the outlet of the second mentioned system of blades.

2. A machine according to claim 1, in which the second row of blades is carried by the periphery of the wheel.

3. A machine according to claim 1, in which the second row of blades is carried by the opposite face of the wheel.

4. A machine according to claim 1 in which the blades of the second row of blades are so devised as to bring the absolute velocity of the fluid back into a meridian plane of the machine.

5. A rotary machine of the type including pumps and compressors giving a continuous flow of fluid which comprises, in combination, a casing, a fluid driving wheel journalled in said casing, an intake in said casing, a system of blades carried by the face of said wheel that is located opposite said intake for driving the fluid admitted through said intake outwardly, a second row of blades carried by said wheel, stationary guide means carried by said casing for directing the fluid driven by the first system of blades onto the second row of blades, said stationary guide means being shaped to reverse, through an angle of 180° approximately, in the plane of flow, the absolute velocity of the fluid, without substantially modifying the magnitude of this velocity and having a continuous gradual curvature from one end to the other, a diffuser adapted to receive the fluid having passed through said second row of blades, and stationary guide blades at the inlet of said diffuser for causing the fluid in the diffuser to flow parallel to the axis of said wheel, said stationary guide blades extending just as far as the point where this direction of flow is obtained, said blades and guide members being so shaped that the flow takes place with a substantially uniform pressure from the outlet of the first mentioned system of blades to the outlet of the second mentioned system of blades, and with a slight expansion in the stationary guide blades of the diffuser.

6. A machine according to claim 1 in which said wheel is provided with grooves and the blades of the second mentioned row of blades consist of elements adapted to be juxtaposed, each including projections adapted to engage in said grooves respectively, further including means for rigidly securing all of said elements on said wheel.

7. A machine according to claim 1 in which said guide means consist of stationary blades carried by said casing so as to leave between any two consecutive stationary blades a conduit of rectangular cross section limited at the upper and lower part by two planes parallel to the direction of the absolute velocity of the fluid when flowing past the edge of the blade separating two consecutive conduits.

PAUL MARY FERDINAND MAURICE ROY.