

March 20, 1945.

A. P. E. PLANIOL

2,371,706

AXIAL FLOW COMPRESSOR

Filed Oct. 16, 1941

2 Sheets-Sheet 1

Fig. 1.

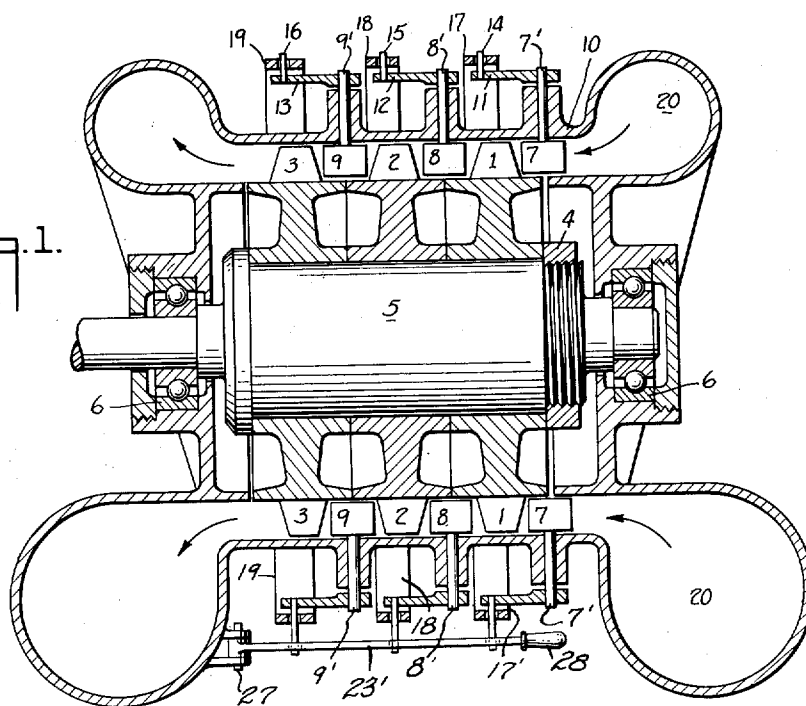


Fig. 2.

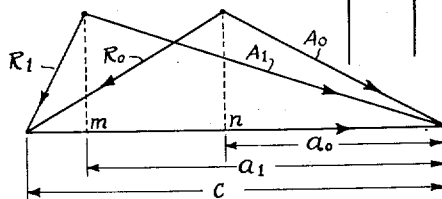
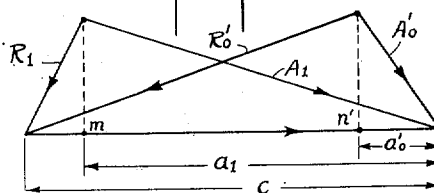


Fig. 3.



INVENTOR
ANDRÉ PAUL EUGÈNE PLANIOL
BY
Barlett, Eyre, Keel & Weymouth
ATTORNEYS

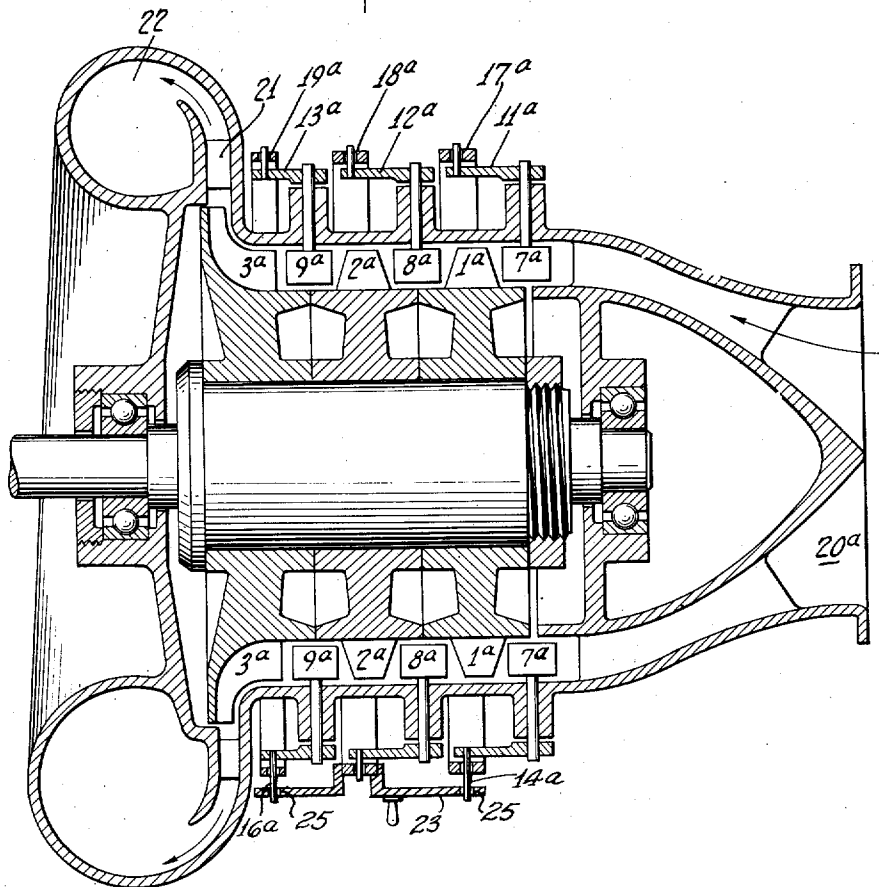
March 20, 1945.

A. P. E. PLANIOL
AXIAL FLOW COMPRESSOR
Filed Oct. 16, 1941

2,371,706

2 Sheets-Sheet 2

Fig. 4.



INVENTOR
ANDRÉ PAUL EUGÈNE PLANIOL
BY
Barthett, Eyer, Neal & Macgregor
ATTORNEYS

UNITED STATES PATENT OFFICE

2,371,706

AXIAL FLOW COMPRESSOR

André Paul Eugène Planiol, Huntington, N. Y.

Application October 16, 1941, Serial No. 415,190
In France February 10, 1941

3 Claims. (Cl. 230-114)

The present invention relates to machines such as blowers, compressors or the like wherein power is utilized to increase the pressure of a fluid. The invention is particularly concerned with the helical or helico-centrifugal type of such machine, that is, one wherein the fluid flow is purely helical or helico-centrifugal, and comprises an improved machine which has a high efficiency and which includes means for regulating the generated pressure differential while maintaining constant the rotational speed. In accordance with the invention, the new machine may deliver either a variable or a constant weight of fluid per unit of time as desired.

The new machine is characterized by the provision of grids of vanes which are orientable around axes disposed normally to the rotational axis of the machine and in the radial direction therefrom in combination with helicoid fans of the classic type, the number of fans and the number of vanes and their particular shape depending upon the particular use to which the machine is to be put. There may be the same number of grids of radial orientable vanes as there are helicoid fans constituting the rotatable blades of the machine, or the number of grids may be more or less than the number of fans, according to the amount of power to be transmitted to the fluid and the pressure differential to be created.

The principle of the invention may be applied to a wide variety of helical or helico-centrifugal machines. As a particular example, the invention will be described as embodied in compressors suitable for supercharging aircraft engines.

For a better understanding of the invention reference may be had to the accompanying drawings, of which

Fig. 1 is a sectional view through an axial flow compressor constructed according to the invention;

Figs. 2 and 3 are vector diagrams explanatory of the theory of the invention; and

Fig. 4 is a sectional view through a helico-centrifugal flow compressor illustrating another embodiment of the invention.

In Fig. 1 is shown a compressor having three helicoid fans 1, 2 and 3. The particular number of fans is immaterial as a greater or fewer number could be employed. In this particular embodiment of the invention the fans are mounted on a shaft 5 and secured thereon by a nut 4; the shaft being mounted in bearings 6. In accordance with the invention a plurality of grids of orientable vanes 7, 8, 9 are carried by shafts 7', 8' and 9' which are rotatably mounted in the casing

10 of the compressor. The number of these grids of vanes can be varied, depending upon the desired difference between the minimum and maximum pressure to be created. Any suitable means may be provided for orienting the vanes about their axes. As an example, in Fig. 1 the ends of the shafts 7', 8' and 9' beyond the casing 10 are shown as secured to levers 11, 12 and 13 respectively, the levers carrying pins 14, 15 and 16 which pass through apertures in rings 17, 18 and 19 respectively. Thus, rotational movement of ring 17 about the axis of the compressor effects rotation of vanes 7 by turning levers 11, and similarly rotation of rings 18 and 19 rotate vanes 8 and 9 respectively. The rings 17, 18 and 19 may be rotated separately or together, as desired; suitable linkage being provided to connect the rings together for their appropriate movement and according to the relationship to be established between the angular displacement of the vanes 7, 8 and 9 around their respective axes of oscillation. For example, if it is desired to obtain equal angular movements of the three vanes, the rings 17, 18 and 19 could be made of a single piece, movement of which would give an equal rotation to the levers 11, 12 and 13. If, on the contrary, it is desired to have unequal angular displacement of the vanes, rigid linkage could still be provided between the rings, the levers being made with unequal lengths and different orientation, or, as shown, a bar 23' having longitudinal slots for reception of the pins 14, 15 and 16 could be pivotally mounted on the casing 10 for simultaneous unequal rotation of the vanes upon pivotal movement of the bar by a handle 28. The rings could of course be kept independent of each other and any suitable means provided for establishing an appropriate mutual relationship between the grids of vanes. Instead of the particular mounting of the vanes illustrated, suitable gears, racks, cams or the like could be employed.

In operation of the machine of Fig. 1, the gas to be compressed reaches the compressor from the collector 20 and passes at first through the grid comprising the orientable vanes 7. The passage through the vanes communicates a kinetic momentum to the gas depending upon the orientation of the vanes. The gas is then acted upon by the fan 1 which modifies the kinetic momentum of the gas and increases the pressure of the gas. The gas in passing through the vanes 8 and the fan 2 and thereafter through the vanes 9 and the fan 3 is similarly operated upon by the respective vanes and fans.

Euler's relation connecting the power W fur-

nished by the fan to the fluid, the flow of weight of the gas per unit of time being I , may be written—

$$W = \frac{I}{g}(c_1 a_1 - c_0 a_0)$$

in which c denotes the tangential speeds of the fan and a the projections of the absolute speed of the fluid on the tangential speeds, the index 0 corresponding to the inlet and the index 1 to the outlet of the fan.

In a purely axial machine such as is represented by the structure of Fig. 1, the movement of the different stream-tubes is parallel to the axis and consequently, as the inlet radii are same and the angular velocity is constant, the tangential speed at each considered radius will be constant, hence—

$$c_0 = c_1 = c$$

and therefore—

$$W = \frac{I}{g}c(a_1 - a_0)$$

If we consider the phenomenon occurring at the first couple formed by the orientable vanes 7 and fan 1 when traversed by a fluid, and if we assume that the angular velocity and the flow of mass per unit of time I , are kept constant as indicated hereabove, then according to the orientation given by the levers 11 to the blades constituting the vanes 7, the absolute speed of the fluid leaving the vanes and entering the first fan 1 will be more or less inclined with respect to the plane normal to the rotating axis of the compressor; it may be directed in the direction of rotation or in the opposite sense. For simplicity, let us neglect the case when the absolute speed A_0 is directed in an opposite sense to the rotation of the machine but both theoretically and practically this case can not be excluded and may be used in certain special conditions. We thus suppose A_0 is directed so that its projection a_0 on the tangential speed c of the fan is in the same sense as c as shown in the vector diagrams Figs. 2 and 3. In Fig. 2 the projection of the vector A_0 on the vector c is indicated as a_0 . R_0 represents the relative speed of the fluid at the inlet of the fan. A_1 , projected as a_1 on the tangential speed c , and R_1 are the absolute and relative speeds of the fluid at the outlet of the fan. We see that the difference $a_1 - a_0$ of the projection on c at the inlet and outlet of the fan is equal to mn . The power transmitted to the fluid is thus proportional to the product of mn and the speed c . If we change the orientation of the vanes 7, for example if we turn them nearer to the normal of the plane of the speed c so that we increase the angle of the new absolute speed A'_0 with c , we obtain the diagram of Fig. 3 where the component of A'_0 normal to c , which represents the axial speed of the fluid, keeps the same value as in Fig. 2 in accordance with the assumption that the mass of fluid per unit of time is constant. The new projection a'_0 is much less than the value a_0 , thus mn' is much greater than mn and the power transmitted to the fluid which is proportional to $c \times mn'$, will be greatly increased as will also be the generated pressure.

If we denote by H_1 the theoretical increase of pressure of the fluid, we have

$$I. \quad H_1 = W = \frac{I}{g} \times c \times mn$$

or

$$H_1 = \frac{c}{g} \times mn$$

Thus variation of orientation of the vanes 7 simultaneously varies in the same direction the power transmitted to the fluid and the theoretical elevation of pressure. This is true within extended limits, depending only on the aerodynamical properties of the grids of vanes formed by the vanes 7 and fan 1 which are chosen according to the properties to be achieved. The succeeding couples comprising the grid of vanes 8 and fan 2 and the grid of vanes 9 and fan 3 function in an analogous manner to that above described in connection with vanes 7 and fan 1 and generate respectively pressures of H_2 and H_3 . The total theoretical increase in pressure H , created by the machine is thus—

$$H = H_1 + H_2 + H_3$$

and varies in the same way as the total power

$$W = W_1 + W_2 + W_3$$

transmitted by the fans to the fluid.

It is obvious from the foregoing that we may, without departing from the spirit of the invention, design a machine having any number of fans and orientable vanes. Instead of all of the vanes being orientable some could be fixed according to the known techniques of the axial polycellular compressors if the difference between the minimum and maximum pressure generated does not require all the grids of vanes to take part in the regulation of the pressure. In this way the machine may be simplified but at the cost of a lowering of the efficiency of the machine for when fixed vanes are substituted for orientable vanes it is necessary to increase the change in the inclination of the other vanes to obtain the same variation in the total generated pressure differential.

If it is desired to permit a variation in the mass of fluid passing through the machine per unit of time and also permit variation in the pressure while the rotational speed is constant, the present invention permits this to be achieved by disposing at the outlet of the last fan a supplemental grid of orientable vanes the influence of which on the mass of fluid being the more important as the number of vanes is decreased.

In Fig. 4 the invention is illustrated as embodied in a helico-centrifugal compressor having two axial fans 1a and 2a and a centrifugal impeller 3a discharging through diffuser vanes 21 into the scroll 22. Instead of the inlet scroll 20 of the embodiment of Fig. 1, I have shown an axially arranged air intake 20a which is a more efficient form for the intake of large air flows. The vanes 7a, 8a and 9a are mounted like vanes 7, 8 and 9 of Fig. 1 for oscillation about their respective axes, except that levers 13a coupling ring 18a with vanes 9a are shown as relatively shorter than levers 11a and 12a, whereby for equal rotation of the rings 17a, 18a and 19a, as by the bar 23 secured to the ring 18a, and having slots 25 for reception of the pins 14a and 16a, vanes 9a will be given greater angular rotation than vanes 7a and 8a. The arrangement of Fig. 4 of axial fans 1a and 2a with the radial impeller 3a gives increased pressure ratio for a given speed and the multiple sets of orientable vanes in between the different fans permit large variations in the generated pressures and may permit, in some cases, a reduction in the number of fans employed. The machine of Fig. 4 constitutes a compressor of the helico-centrifugal type with an adjustable pressure regulated by a set of vanes situated solely in the axial part of the machine.

The present invention applies to any type of machine of compression, displacement or elevation of fluid such as ventilators, blowers, compressors, pumps, etc.

I claim:

1. A machine for increasing the pressure of a fluid, comprising in combination a casing, a shaft rotatable therein, a plurality of helicoid fans mounted on said shaft, grids of vanes carried by the casing and each positioned upstream of one of said fans, and means accessible from without said casing for simultaneously oscillating the vanes of each of said grids through unequal angles about axes radially disposed with respect to the axis of the shaft.

2. A compressor or the like comprising in combination a casing, a plurality of helicoid fans and a helico-centrifugal fan mounted for rotation in

the casing about a common axis with the helico-centrifugal fan comprising the last stage of the compressor, grids of vanes cooperating with said fans in the passage of fluid through the compressor, each grid being positioned upstream of one of said fans, and means accessible from without said casing for oscillating the vanes of each of said grids about axes radially disposed with respect to the common axis of rotation of the fans.

3. The combination according to claim 2 wherein said last mentioned means are operable to simultaneously oscillate the vanes of the grids upstream of the helicoid fans through equal angles and the vanes of the grid upstream of the helico-centrifugal grid through relatively greater angles.

ANDRÉ PAUL EUGÈNE PLANIOL.

CERTIFICATE OF CORRECTION.

Patent No. 2,371,706.

March 20, 1945.

ANDRÉ PAUL EUGÈNE PLANIOL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 14, before "radii" insert --and outlet--; same line before "same" insert --the--; line 28, for "orinetation" read --orientation--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of June, A. D. 1945.

Leslie Frazer

Acting Commissioner of Patents.

(Seal)

The present invention applies to any type of machine of compression, displacement or elevation of fluid such as ventilators, blowers, compressors, pumps, etc.

I claim:

1. A machine for increasing the pressure of a fluid, comprising in combination a casing, a shaft rotatable therein, a plurality of helicoid fans mounted on said shaft, grids of vanes carried by the casing and each positioned upstream of one of said fans, and means accessible from without said casing for simultaneously oscillating the vanes of each of said grids through unequal angles about axes radially disposed with respect to the axis of the shaft.

2. A compressor or the like comprising in combination a casing, a plurality of helicoid fans and a helico-centrifugal fan mounted for rotation in

the casing about a common axis with the helico-centrifugal fan comprising the last stage of the compressor, grids of vanes cooperating with said fans in the passage of fluid through the compressor, each grid being positioned upstream of one of said fans, and means accessible from without said casing for oscillating the vanes of each of said grids about axes radially disposed with respect to the common axis of rotation of the fans.

3. The combination according to claim 2 wherein said last mentioned means are operable to simultaneously oscillate the vanes of the grids upstream of the helicoid fans through equal angles and the vanes of the grid upstream of the helico-centrifugal grid through relatively greater angles.

ANDRÉ PAUL EUGÈNE PLANIOL.

CERTIFICATE OF CORRECTION.

Patent No. 2,371,706.

March 20, 1945.

ANDRÉ PAUL EUGÈNE PLANIOL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 14, before "radii" insert --and outlet--; same line before "same" insert --the--; line 28, for "orinetation" read --orientation--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of June, A. D. 1945.

Leslie Frazer

(Seal)

Acting Commissioner of Patents.