June 6, 1944. J. SZYDLOWSKI 2,350,839

MACHINE FOR COMPRESSING GASES BY CENTRIFUGAL EFFECT

Filed March 8, 1941

Fig.7.

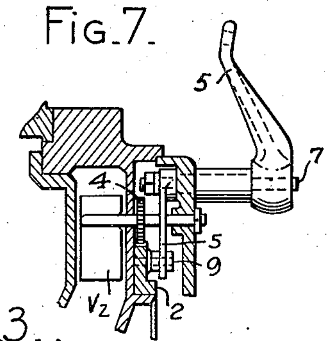


Fig.1.

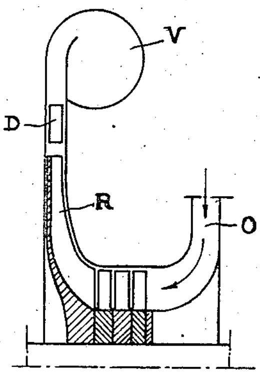


Fig.2.

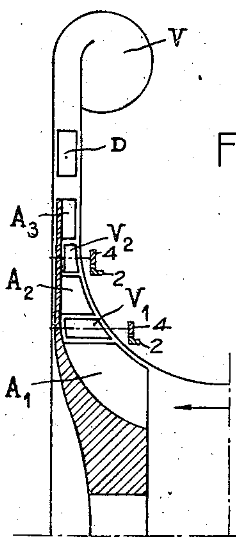


Fig.3.

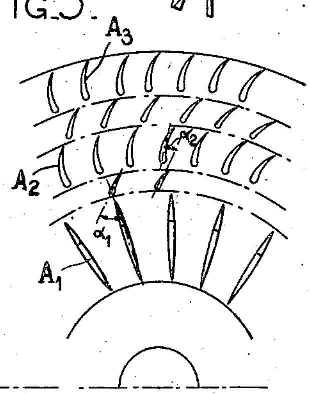


Fig.2a

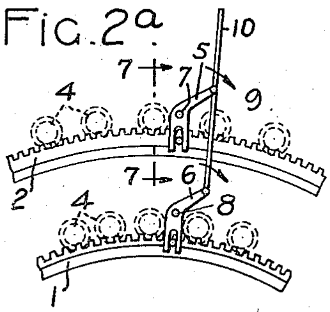
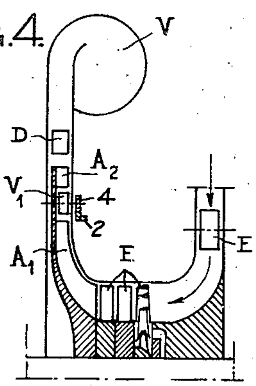
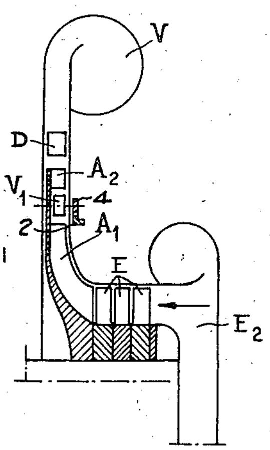


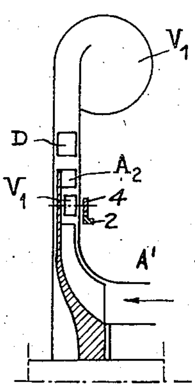
Fig.5

Fig.6.

Fig.4.







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2,350,839

MACHINE FOR COMPRESSING GASES BY CENTRIFUGAL EFFECT

Josef Szydlowski, Saint Pé de Bigorre, France; vested in the Alien Property Custodian

Application March 8, 1941, Serial No. 382,283
In France April 8, 1940

4 Claims. (Cl. 230—114)

The present invention concerns machines for compressing gases by centrifugal effect, such as turbo-compressors and in particular the turbo-compressors utilised for supercharging the internal combustion engines on board aircraft.

Machines of this kind impart to the gas sucked in, a vis viva which is converted into static energy or pressure at the outlet.

It has been attempted, in all the applications of these machines, to obtain a high compression ratio, for a minimum bulk and weight, with an output as high as possible.

The invention satisfies these conditions by including upon one and the same rotor in a single machine with concentric rings of blades having diameters increase from the inlet port to the outlet port, and between which rings are arranged rings of adjustable blades.

The accompanying drawing illustrates by way of example only, some forms of apparatus embodying the salient features of my invention.

Fig. 1 of the accompanying drawing is a diagram of a known type of machine shown in axial half-section.

Fig. 2 is an axial half section of a machine made according to this invention.

Fig. 2*a* is a partial end view showing certain ring detail.

Fig. 3 is another partial end view showing blade arrangement.

Figs. 4, 5 and 6 are views similar in character to Fig. 2, showing modifications.

Fig. 7 is an enlarged vertical section on the line 7—7 of Fig. 2*a*, showing the details of the control means for one of the racks of Figs. 2 and 2*a*.

In the embodiment illustrated in Fig. 4, the gas, for instance air, sucked in through an inlet orifice O is drawn along in a rapid rotary movement by the blades of a rotor R and ejected at high speed into a manifold V or recovery volute chamber. Between the rotor and volute chamber of manifold V, is interposed a suitable fixed blade D or diffuser, the function of which is to increase the output of the conversion of the vis viva of the air into static pressure.

The compression ratio between the inlet and the outlet increases with the angular speed of the rotor. This speed has for upper limit, the value which corresponds to a linear speed of the air at the end of the blades equal to the local speed of sound. Beyond this speed, the output of the machine rapidly lowers.

For avoiding this obstacle, it has been proposed to couple in several stages, with several machines working one after the other. That of the second stage sucks in the air previously compressed by the machine at the stage immediately preceding.

A unit is thus obtained which is capable of ensuring a high compression ratio, while limiting in each machine, the compression energy and, consequently, the angular speed of the rotor.

It has also been proposed to provide on one and the same rotor of a single machine concentric rings of blades that is to say of diameters increasing from the inlet to the outlet, between which are arranged fixed rings of blades which are simply guiding blades. When a compressor of high compression ratio thus devised is coupled to the engine of an aircraft, serious inconveniences generally result therefrom. The delivery pressure of the compressor from the ground up to the altitude at which the engine must have its optimum power, is limited by the detonation of the engine. As the engine rotates at constant speed, it results therefrom that the pressure of the compressor is too high from the ground up to the altitude in question. It is then necessary, either to eliminate a portion of the pressure by means of valves, which corresponds to a costly destruction of the energy supplied by the engine, or to provide complicated and heavy change speed mechanisms, in order to cause the working speed of the compressor to vary according to the altitude, whereas the working speed of the engine remains constant.

The applicant has already disclosed in his United States Patent No. 2,210,155 a solution for remedying this inconvenience. This solution consists in providing, before the admission of air into the rotor, settable shutters as shown at E^1 in Fig. 4 of the drawing annexed to the present application. The air passes through said shutters towards the centre of the machine. In proportion as the shutters are inclined, the speed of rotation they impart to the air increases in proportion as said air approaches the centre of the machine. This increase is limited by the speed of sound which constitutes an upper limit. Said limit is rapidly reached and a considerable reduction in the output results therefrom.

The present invention allows of obtaining a high compression ratio and is adaptable to the most varied conditions of flight without giving rise to the above mentioned inconveniences.

A machine improved according to the invention causes the air to be subjected to an evolution comparable to that to which it is subjected in known compressors having several stages.

The air delivered by the first rotating ring, approaches the intermediate fixed blades which slow it down, the effect of which is to increase its static pressure.

The admission of the air into the second ring of rotating blades takes place at this static pressure and the kinetic energy imparted to the mass of air in said second rotating ring is again converted into pressure in the following fixed ring. The pressure thus increases from one to the other as in known multi-stage machines.

The rotor of the machine as shown in Fig. 2 comprises three rings or concentric sets of blades A^1, A^2, A^3. Two rings of blades V^1 and V^2 are arranged between the rings A^1 and A^2 and A^2 and A^3.

In Fig. 3 α^1 is the angle of the air streams relatively to the vector radius of the machine, at the outlet of the set of blades A^1; α^2 is the angle corresponding to the air streams after they have been deviated by the fixed set of blades V^1.

It will immediately be seen that if α^2 is smaller than α^1, the movement of the air is slowed down and a part of its kinetic energy is converted, by the set of blades V^1, into potential energy. On the other hand, it will be seen that the set of blades of the stage immediately following A^2, is fed with a lower circumferential speed (proportional, for an equal output, to tangent α^2). The application of the theorem of the impulse moments then shows that the increase of pressure produced by the set of blades A^2 is so much the greater as α^2 is smaller. The conclusion is the reverse if α^2 is greater than α^1.

If the blades of the fixed rings V^1 and V^2 are pivotally mounted on suitable spindles, by setting them accordingly, the rotating set of blades immediately following them can be charged or discharged at will.

When the invention is applied to the supercharging of an aeroplane engine, from the ground up to the so-called balance altitude, this circumstance is particularly advantageous. The required compression ratio is in fact very variable according to the altitude at which the aeroplane is flying. The blades V^1 and V^2 can be adjusted in such a manner that they slow down the air or accelerate it. The following set of blades (A^2 or A^3) might then be discharged, even until the apparatus operates as a turbine.

The torque received from the engine will thus be reduced to the strict minimum necessary for supplying the engine at its nominal admission pressure. This reduction of the torque is so much the more substantial as the aeroplane flies at a lower altitude.

By limiting the number of stages to two, the compressor of the present invention has a diametral cumbersomeness equal or scarcely greater than a single-stage compressor of the same category. The longitudinal cumbersomeness remains the same as that of a single-stage machine.

In the example of Fig. 4, the rotor comprises, in a manner known per se, blades E helically inclined with respect to the rotor axis and disposed on the upstream side of the set of blades A^1 and A^2 according to the invention. These sets of blades E are adapted to bring the air without shock to the inlet of the set of blades A^1. The air is admitted in the machine through shutters E^1 which can be set, also in a known manner and which, in the machine according to the invention, add an adjustment of the pressure ratio to that produced by the ring V^1.

The adjustment by means of the shutters E^1 can be done away with and the intermediate blades V^1 between both stages need only be maintained as regulating system. In this case the helical wheels E are preceded only by an axial or radial axial channel provided or not with a fixed guiding set of blades.

The control of the orientation or setting of the blades such as V^1V^2 can be obtained by any suitable means superfluous to illustrate in the various embodiments.

The admission of air can also be effected through a volute chamber E^2, opening into an axial or radial channel (Fig. 5). The inlet shutters E^1 are done away with and the angle of incidence of the first helical or inclined blade wheel E is constant. Its value results from the suitable adaptation of the main section of the volute chamber to that of the channel. This method of construction is more particularly suited to radial type engines.

A single-stage and simply radial compressor can also be devised (Fig. 6) obtained by doing away with all the driving members preceding the fixed intermediate sets of blades V^1, except the blades A. The admission of air takes place, in this case through the axial channel occupied by the helical or inclined blade wheels E in the preceding examples. This channel can open directly to the free air or be connected to an inlet volute chamber or to a radial channel.

Fig. 2a is a partial end view corresponding to Fig. 2 and shows two toothed rings 1 and 2 which can rotate on bearings of the casing of the compressor and mesh with pinions 4 respectively fast on each of the blades of the rings V^1 and V^2. The toothed rings or racks 1 and 2 are controlled by levers 5 and 6 pivoted at 7 and 8, respectively, and acting by their fork-shaped end on a finger 9 of each ring. Both levers can be controlled separately or in combination by a link-work 10 which is manually or automatically acted upon from a pressure-gauge, for instance.

Fig. 7 shows on an enlarged scale, as already indicated, the detail of the control of a ring 1 or 2 of the other views, such as Figs. 2 and 2a, for example.

What I claim as my invention and desire to secure by Letters Patent is:

1. In a centrifugal turbo-compressor, a casing having an inlet port and an outlet port for the fluid, and a plurality of radially spaced concentric sets of guide blades having substantial axial and radial extent, a rotor mounted in said casing concentric with said sets of guide blades, and having a plurality of radially spaced sets of impeller blades interposed between said radially spaced sets of guide blades, each of said guide blades being adjustable about an axis parallel to the rotor axis.

2. In a centrifugal turbo-compressor, a casing having an inlet port and an outlet port for the fluid, and a plurality of radially spaced concentric sets of guide blades having substantial axial and radial extent, a rotor mounted in said casing concentric with said sets of guide blades, and having a plurality of radially spaced sets of impeller blades interposed between said radially spaced sets of guide blades, each of said guide blades being adjustable about an axis parallel to the rotor axis, and means for adjusting said guide blades.

3. In a centrifugal turbo-compressor, a casing having an inlet port and an outlet port for the fluid, a plurality of settable guiding shutters adjacent the inlet port, a plurality of fixed diffusing

blades adjacent the outlet port, and a plurality of radially spaced concentric sets of guide blades having substantial axial and radial extent, between said shutters and said diffusing blades, a rotor mounted in said casing concentric with said sets of guide blades and having a plurality of axially spaced sets of radial blades having axial action upon the fluid, and a plurality of radially spaced sets of impeller blades interposed between said radially spaced sets of guide blades, each of said guide blades being adjustable about an axis parallel to the rotor axis.

4. In a centrifugal turbo-compressor, a casing having an inlet port and an outlet port for the fluid, a guiding volute chamber at said inlet port for imparting to the fluid a rotation component, a plurality of radially spaced concentric sets of guide blades having substantial axial and radial extent, adjustably mounted in said casing, a plurality of diffusing blades fixed in said casing adjacent the outlet port, a rotor mounted in said casing concentric with said sets of guide blades, a plurality of axially spaced sets of radially projecting blades on said rotor and inclined with respect to the rotor axis to cause axial flow of the fluid, and a plurality of radially spaced sets of impeller blades on said rotor interposed between said radially spaced sets of guide blades to cause centrifugal flow of the fluid.

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