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AXIAL FLOW COMPRESSOR

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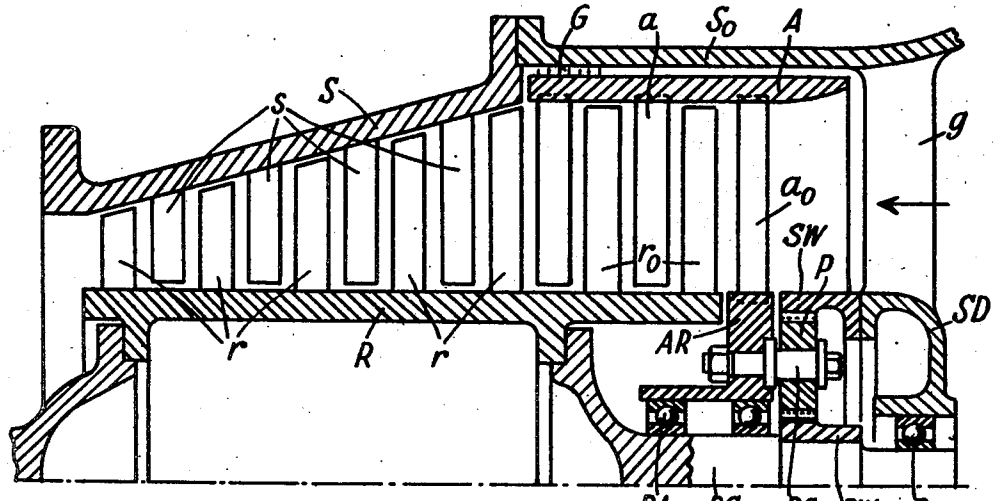


FIG. 1.

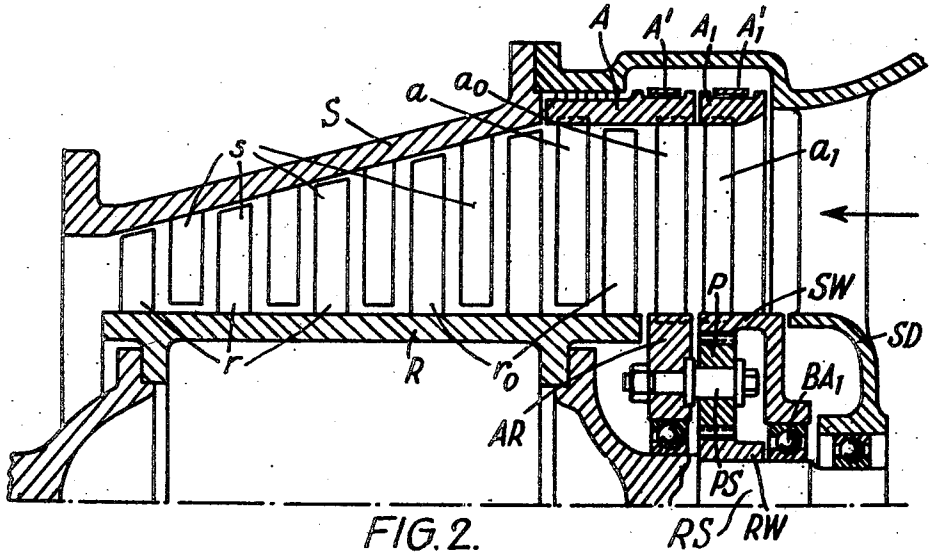


FIG. 2.

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AXIAL FLOW COMPRESSOR

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8 Claims. (Cl. 230—114)

1

This invention relates to axial flow air (or gas) compressors, more particularly but not exclusively for use for propulsion such as of aircraft.

In axial flow compressors of the uni-rotational type, that is to say having moving and stationary blade rows, the rotational speed (revolutions per minute) which is permissible for a given mass flow is limited by the "compressibility effects" obtained, especially in the initial compressor stages. Moreover, the difficulties arising from compressibility effects decrease towards the high pressure end by reason of the increased velocity of sound resulting from the increase of the temperature of the air at the high pressure end of the compressor.

According to the present invention which enables the rotational speed (revolutions per minute) of the compressor to be increased for a given rate of flow of air or gas mass, and consequently the weight to be reduced not only of the compressor but also of the turbine or other prime mover driving it, the blade rows in the early or inlet stages of the compressor, which in a normal compressor would be stationary ones, are made to rotate in the same direction as that of the rotor but at a rotational speed less than that of the rotor. The relative velocities of the successive early stage blades being thus reduced, so will also be reduced the velocities of the air or gas relative to the blades, with the result that the Mach number is reduced.

In carrying out the invention some of the otherwise normally fixed initial blading rows are carried from an auxiliary rotor housed within the normally stationary outer casing, the latter being suitably modified as to its shape, and this auxiliary rotor is connected through any convenient form of speed reduction gearing with the full speed main rotor of the compressor or with a part rotating therewith. In a convenient arrangement, the aforesaid auxiliary rotor is mechanically and rigidly connected, preferably through an added row of blades preceding the first rotating row attached to the main rotor, to an inner ring journalled on the main rotor shaft; this ring carries a planetary shaft or axle, or preferably several thereof distributed circularly around the axis of the compressor, for one or respective planet wheels as the case may be, peripherally engaging at a lesser radius a toothed wheel attached to the main rotor shaft, whilst at a greater radius the planet wheel(s) engage(s) with an internally toothed stationary ring, the outer periphery of which may conveniently form part of the inner wall of the air or gas passage at the inlet end of the compressor. With this arrangement, although power is transmitted through the planet gearing from the low speed rotor (auxiliary rotor) to the main rotor, the amount of this

2

power is relatively small and the dimensions of the gears can be kept within reasonable limits.

An important subsidiary feature of the invention is based upon the consideration that when the compressor forms part of an internal combustion plant for propulsion of aircraft the compressibility effects are particularly difficult to deal with at high altitudes where, owing to the low air temperature, the velocity of sound is reduced. However, for aircraft taking off and flying at low altitudes the thrust may be increased for a given rotational speed by the provision of means whereby certain of the initial blade rows concerned in the present invention as above set forth may temporarily be held stationary. Thus, if the rotational speed (revolutions per minute) of the plant is limited by factors other than compressibility effects under these low altitude conditions the speed reduction gear arrangement may be such that these initial stages are only permitted to rotate at high altitudes where otherwise reasonable efficiency at full speed revolutions per minute could not be reached as a result of compressibility effects.

In carrying out this subsidiary feature of the invention, the arrangement may be generally similar to that set forth above in some detail, with the exception that on the one hand the auxiliary rotor is provided with braking means, such as a band-brake around its periphery, whilst on the other hand the internally toothed ring engaged by the outer diameters of the planet wheels is no longer fixed but mounted for free rotation on the main rotor shaft. Moreover, this internally toothed ring carries one or more rows of blading which will be the initial blade row or rows for the compressor, said row(s) being solidly connected at the outer periphery, with an outer ring with which is associated further, and independently operable, braking means, such as a band-brake. With this arrangement in the case where the compressor is employed in conjunction with internal combustion plant for propulsion of an aircraft, for take-off and low altitude flying performance the first-mentioned brake is applied to the auxiliary rotor whereby the initial row or rows of compressor blading is/are caused to rotate at a low speed in the opposite direction to that of the blading carried by the main rotor, the second-mentioned brake being, of course, released; for flying at high altitudes the brake application is reversed, whereupon the initial row or rows of blading become stationary as does the internally toothed ring connected thereto, while the auxiliary rotor with its blade row or rows rotates in the same direction as that of the main rotor and at speed which is less than that of the main rotor.

In order that the invention may be fully understood, reference will now be made to the accompanying diagrammatic drawing, the two fig-

ures of which are respective simplified sectional views of the upper half of alternative forms of axial flow compressor constructed and arranged in accordance with the invention and which are such as may be used, with advantage, in conjunction with internal combustion plant for effecting propulsion of aircraft, although also applicable for other purposes, like parts in the two figures, when referred to in the description, being indicated by like reference characters.

In the form of compressor illustrated in Fig. 1, the main rotor comprises a hollow cylinder R attached to, or at least solid with, a shaft RS and carrying a plurality, in this case two, of rows of blades r_0, herein referred to as initial main rotor blades in that they are disposed at the inlet end of the compressor, and being accordingly low pressure blades, together with a plurality, in this case five, of higher pressure rows of blades r, of progressively lower mean diameter as is customary. Surrounding the main rotor is a stationary casing S carrying rows of high pressure blades s for co-operating with the corresponding main rotor blades r. This casing S extends axially beyond the main rotor cylinder R at the inlet end as shown S_0 and is attached by circularly distributed webs, one of which is indicated at g, to an inner disc SD supporting a bearing B for the main rotor shaft RS. The casing S will also provide a mounting for a bearing for the main rotor at the outlet or high pressure end of the compressor.

Within the stationary casing S at the inlet end of the compressor and just in rear of the webs g which act as guides for the intake, there is disposed a cylinder A, mounted for rotation concentrically with the main rotor, and carrying rows of blades a for co-operating with the initial rows of main rotor blades r_0. In this case, the cylinder A is attached by a further row of blades a_0, to an inner ring AR mounted on bearings BA carried by the main rotor shaft RS. The inner ring AR carries a plurality of axles, one of which is indicated at PS, extending parallel with the axis of the main rotor and circularly distributed therearound, each axle PS carrying a planet wheel P. These planet wheels engage peripherally at a lesser radius with a toothed wheel RW fast to the main rotor shaft RS and at a greater radius with an internally toothed ring SW which, in this embodiment of the invention, is represented as being fast with the part SD of the stationary casing. Conveniently a labyrinth gland G is interposed between the auxiliary rotor cylinder A and the interior of casing S_0 in order that substantially the whole of the air or gas intake shall be constrained to pass between the co-operating main rotor initial blades r_0, and the auxiliary rotor initial blades r_0, and the auxiliary rotor blades a_0, a.

With this arrangement, when the rotor shaft RS is rotating, thereby to rotate the blades r_0 and r carried thereby in a given direction, the auxiliary rotor together with the blades a_0 and a carried thereby will be constrained to rotate in the same direction and at a rotational speed which is less than that of the main rotor shaft, air or gas drawn into the compressor being acted upon by the relatively rotating initial main rotor blades r_0 on the one hand and the auxiliary rotor blades a_0 and a on the other hand, and being further compressed by the action of the higher pressure co-operating main rotor blades r and main stator blades a before being finally discharged from the compressor.

The rotation auxiliary rotor may be threaded over the main rotor in accordance with the application of Joseph Stanley Hall, Serial No. 518,181, filed January 13, 1944.

The form of compressor illustrated in Fig. 2 is generally similar to that of Fig. 1 in that it involves the provision, at the inlet end of the compressor, of an auxiliary rotor comprising rotor cylinder A carrying blades a_0, and a for mutual reaction with an initial row of blades r_0 carried by the main rotor cylinder R, and whereof the blades a_0 connect said auxiliary rotor cylinder R to an internal ring AR which is journalled upon the main rotor shaft RS and carries the axles PS for circularly-distributed planet wheels P engageable at a lesser radius with a toothed wheel RW fast with the rotor shaft RS and at a greater radius with a toothed ring SW. However, in this form of the invention the outer toothed ring SW is not fast to the stator casing SD as in the form of Fig. 1, but is mounted through a bearing BA_1 on the rotor shaft RS and is attached by blades a_1 to an outer ring A_1. Moreover, a band-brake A' is provided for engaging the outer periphery of the auxiliary rotor cylinder A and a band-brake A'_1 is provided for engaging with the outer periphery of the ring A_1 which as described, is attached through blades a_1 to the freely rotatable internally toothed ring SW.

With this arrangement, when the band-brake A' is operated accordingly to restrain the auxiliary rotor against rotation notwithstanding rotation of the main rotor, and with the band-brake A'_1 inoperative, the blades a_1 will be rotated in opposite direction to that of the main rotor blades r_0, with which they co-operate but at a rotational speed less than that of said blades r_0; in the case of a compressor embodied in internal combustion plant for the propulsion of an aircraft, this will be the condition established at take-off and low altitude flying. Conversely, with band-brake A' inoperative and the band-brake A'_1 operated to restrain rotation of the bladed ring A_1, the initial blades a_1 will be stationary whilst the auxiliary rotor blades a_0 and a will be rotated in the same direction as that in which rotate the main rotor blades r_0, r but at a rotational speed which is less than that of said main rotor blades.

I claim:

1. A multi-stage axial-flow compressor comprising a stationary casing carrying a row of blades and having an inlet at one end for the admission of fluid, a main rotor housed within the casing and carrying a row of blades for co-operating with the stationary blades to increase the pressure of fluid admitted at the inlet end of the casing, an auxiliary rotor housed within the casing at the inlet thereof at which fluid is admitted and carrying a row of blades positioned in advance of said row of blades on the main rotor, and differential mechanism comprising two sun wheels and a planet wheel intermeshing with said sun wheels whereof one sun wheel is attached to, for rotation with, the main rotor, while the planet wheel is rotatably mounted on the auxiliary rotor, and means for restraining the other sun wheel against rotation.

2. A multi-stage axial-flow compressor comprising a stationary casing carrying a row of blades and having an inlet at one end for the admission of fluid, a driving shaft rotatably mounted in said casing, a main rotor attached to said shaft and housed within said casing and

carrying a row of blades for co-operating with the stationary blades to increase the pressure of fluid admitted at the inlet end of the casing, an auxiliary rotor mounted on said driving shaft at the fluid-admission end of the casing and carrying a row of blades positioned in advance of said row of blades on the main rotor, a gear wheel coaxially mounted on, and fast with, said driving shaft, an internally-toothed gear wheel coaxially mounted on said driving shaft, a planet wheel meshing with said gear wheels and rotatably carried by said auxiliary rotor, and means for restraining said internally-toothed wheel against rotation.

3. A multi-stage axial-flow compressor comprising a stationary casing carrying a row of blades and having an inlet at one end for the admission of fluid, a driving shaft rotatably mounted in said casing, a main rotor driven by said shaft within said casing and carrying a row of blades for co-operating with the stationary blades to increase the pressure of fluid admitted at the inlet end of the casing, an auxiliary rotor mounted on said driving shaft at the fluid-admission end of the casing and carrying a row of blades positioned in advance of said row of blades on the main rotor, a gear wheel coaxially mounted on, and fast with, said driving shaft, an internally-toothed gear wheel coaxial with said driving shaft and fast with the casing, and a planet wheel meshing with said gear wheels and carried on said auxiliary rotor.

4. A multi-stage axial-flow compressor as claimed in claim 3, wherein said internally-toothed gear wheel forms an inner wall surrounded by the casing to provide an annular passage for admission of fluid.

5. A multi-stage axial-flow compressor comprising a stationary casing carrying a row of blades, a driving shaft rotatably mounted in said casing, a main rotor attached to said shaft within said casing and carrying a row of blades for co-operating with the stationary blades to increase the pressure of fluid admitted at one end of the casing, an auxiliary rotor mounted on said driving shaft at the fluid-admission end of the casing and carrying a row of blades for co-operating with the row of blades on the main rotor, an externally-toothed gear wheel coaxially mounted on said driving shaft, an internally-toothed gear wheel rotatable coaxially with respect to said driving shaft, a planet wheel meshing with said gear wheels and carried on said auxiliary rotor, a releasable band-brake acting on the outer periphery of the internally-toothed gear wheel and a releasable band-brake acting upon the outer periphery of the auxiliary rotor.

6. A multi-stage axial-flow compressor comprising a stationary casing carrying a row of blades, a driving shaft rotatably mounted in said casing, a main rotor rotated by said shaft within said casing and carrying a row of blades for cooperating with the stationary blades to increase the pressure of fluid admitted at one end of the casing and also carrying an additional row of blades at the fluid-admission end of said main rotor, a ring journalled on the shaft within the casing at the end thereof at which fluid is admitted, an outer ring surrounding said inner ring and attached thereto by a row of blades adapted to co-operate with the said additional row of blades on the main rotor, a gear wheel coaxially mounted on, and fast with, said driving shaft, an internally-toothed gear wheel coaxial with said driving shaft, a planet wheel meshing with said gear wheels and journalled on a shaft carried by said inner ring, and means for restraining said internally-toothed wheel against rotation.

7. A multi-stage axial-flow compressor comprising a tubular casing having attached thereto a plurality of axially-spaced rows of blades, a driving shaft rotationally mounted in said casing and having attached thereto a main rotor carrying a plurality of axially-spaced rows of blades for co-operating with the stationary blades to increase the pressure of fluid admitted at one end of the casing, together with an auxiliary rotor enclosed within the casing at the end thereof at which fluid is admitted, said auxiliary rotor comprising an inner ring journalled on the shaft, an outer ring and a plurality of axially-spaced rows of blades carried by said outer ring for co-operating with rows of blades on the main rotor and of which one row is attached also to the inner ring, a plurality of gear wheels journalled at circularly distributed locations on the inner ring, a gear wheel fast with the driving shaft and meshing at a lesser radius with the circularly distributed gear wheels, and a gear wheel with which the driving shaft is relatively rotatable and which meshes at a greater radius with the circularly distributed gear wheels, and means for restraining the gear wheel at the greater radius against rotation.

8. A multi-stage axial-flow compressor comprising a casing having attached thereto a plurality of axially-spaced rows of blades, a driving shaft rotationally mounted in said casing, a main rotor fast with said driving shaft and carrying a plurality of axially-spaced rows of blades for co-operating with the stationary blades to increase the pressure of fluid admitted at one end of the casing, an auxiliary rotor rotationally mounted within said casing on said driving shaft and carrying a row of blades for co-operating with the end row of main rotor blades at the fluid-admission end, a second auxiliary rotor mounted within said casing at the fluid-admission end and journalled on said driving shaft independently of the first-mentioned auxiliary rotor, and carrying a row of blades, a differential gear mechanism connecting said driving shaft with said second auxiliary rotor and the differential element of which is connected to the first-mentioned auxiliary rotor, a band-brake peripherally engageable with said first auxiliary rotor and a band-brake peripherally engageable with said second auxiliary rotor.

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