March 25, 1952 R. POUIT 2,590,457

JET PROPULSION DEVICE FOR AIRSCREWS OR ROTARY WINGS

Filed April 9, 1947 2 SHEETS—SHEET 1

Fig. 1.

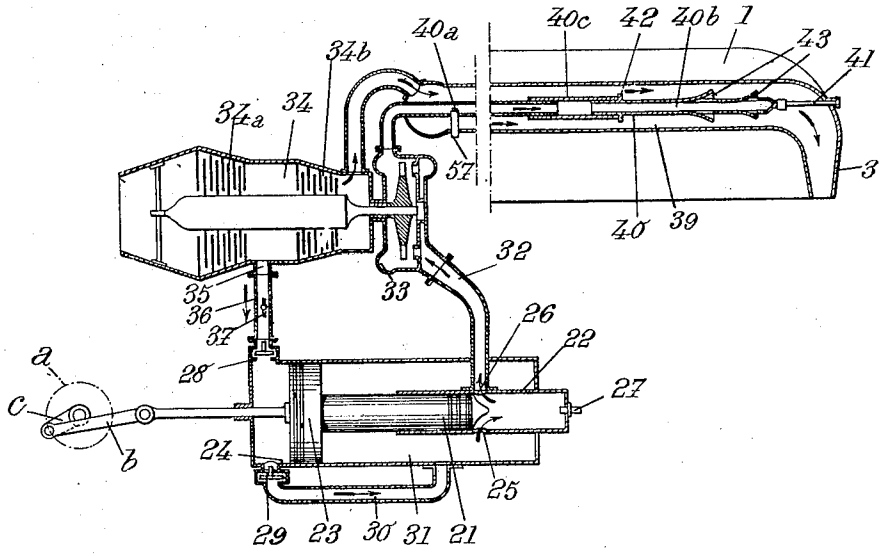
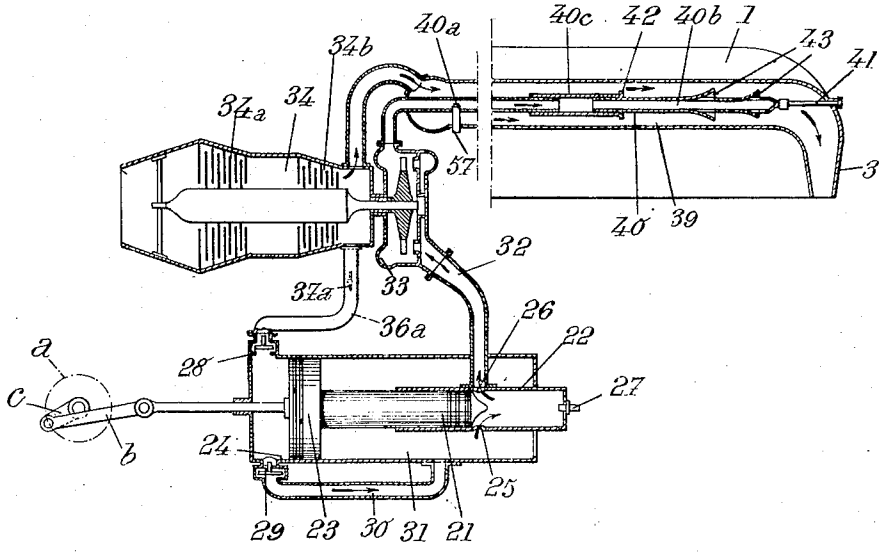


Fig. 2.



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Fig. 3.

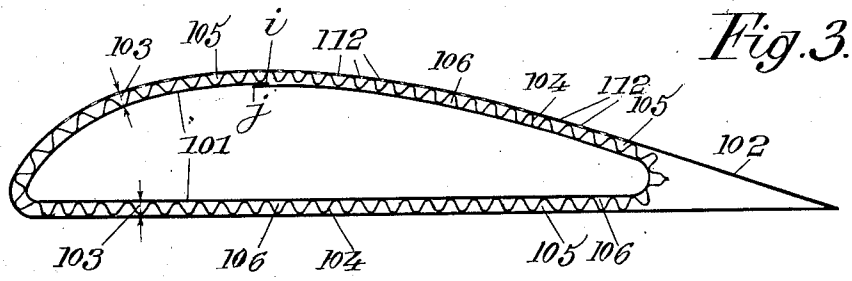


Fig. 4.

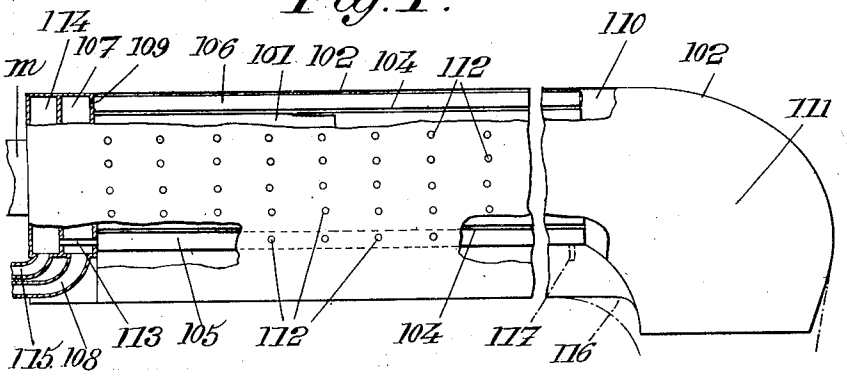


Fig. 5.

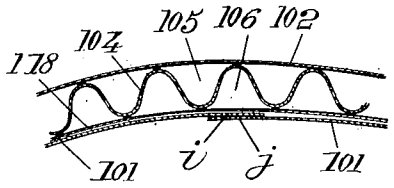


Fig. 6.

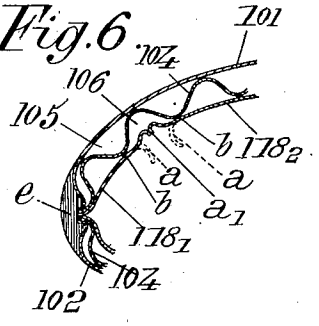
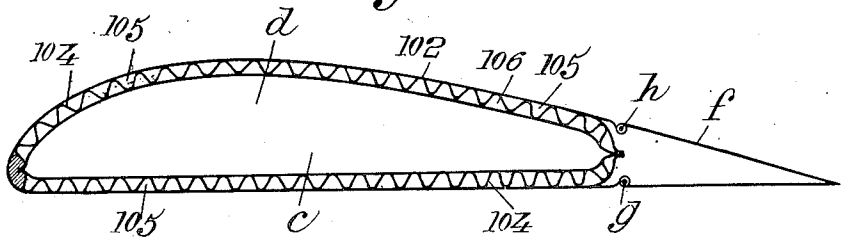


Fig. 7.



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JET PROPULSION DEVICE FOR AIRSCREWS OR ROTARY WINGS

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9 Claims. (Cl. 170—135.4)

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The present invention relates to jet propulsion devices for airscrews or rotary wings and it is more especially, although not exclusively, concerned with propulsion devices of this kind for the rotary wings of helicopters.

The object of the invention is to provide a device of this kind which is better adapted to meet the requirements of practice than those used up to this time, particularly from the points of view of simplicity, power per unit of weight and efficiency.

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

Fig. 1 diagrammatically shows a jet propelled rotary wing made according to my invention.

Fig. 2 shows a modification;

Fig. 3 diagrammatically shows, in a cross section, a wing blade made according to another embodiment of the invention;

Fig. 4 is a plan view, partly in section, of a rotary wing blade of the kind shown by Fig. 3, shown on a smaller scale;

Figs. 5 to 7 are sectional views of constructional details of a wing made according to the invention.

The rotary wing is of any suitable construction, constituted for instance by two blades 1, each being provided at its tip with a bent nozzle 3 through which are expelled gases fed from the hub and producing a reaction effect which causes the blade to rotate.

The plant shown by Fig. 1 shows a construction which comprises an auto-generator including a motor piston 21 working in a motor cylinder 22 and a compressor piston 23 working in a compressor cylinder 24, and these pistons are rigid with each other and constitute a single movable unit. The motor cylinder is provided with inlet ports 25 and exhaust ports 26 controlled by the motor piston 21, and also with a fuel injector 27, ignition taking place by compression of the charge enclosed in the motor cylinder, which works on the two-stroke cycle.

Fuel combustion in motor cylinder 22 produces the outward stroke of the piston unit 21–23, whereas the inward stroke is obtained, in the plant shown by Fig. 3, by means of a fly-wheel *a* fixed on a rotating shaft connected to said piston unit through a crank *b* and a connecting rod *c*. Of course, the auto-generator may be of the free piston type, without crank or connecting rod, the same motor cylinder cooperating, for instance, with two opposed pistons each rigid with at least one compressor piston working in a corresponding compressor cylinder.

Compressor cylinder 24 is provided with suction valves 28 and valves 29. The downstream side of valves 29 communicates, through a conduit 30, with the inside of a casing 31 which surrounds motor cylinder 22 and communicates therewith when piston 21 clears ports 25.

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The exhaust gases from motor cylinder 22 are evacuated through an exhaust conduit 32 which leads to a gas turbine 33 operated by these gases.

Turbine 33 is coupled with a compressor 34 including two stages 34*a* and 34*b*, with an outlet 35 between these two stages connected through a conduit 36 with the suction valve 28 of compressor cylinder 24, the amount of air that is thus diverted being adjustable by means of a valve 37. The remainder of the air from the first stage 34*a* is further compressed by the second stage 34*b* so as to be given, at the output of compressor 34, a pressure substantially equal to the pressure with which the gases supplied by the auto-generator leave turbine 33, after having expanded therein. The air fed by the second stage 34*b* of the compressor and the gases flowing out from turbine 33 therefore constitute the two gas streams which, after being mixed together, serve to feed nozzles 3.

According to a modification shown by Fig. 2, compressor cylinder 24 is supercharged, not with air collected between the stages 34*a* and 34*b* of compressor 34 but with air collected at the output of the high pressure stage 34*b* of said compressor, this output being connected with the inlet of compressor cylinder 24 through a conduit 36*a*, provided with a control valve 37*a*. Of course, the compressor cylinder might be fed directly from the atmosphere.

In certain systems, I may also provide both conduits 36 and 36*a* for supercharging the compressor element of the auto-generator either with air collected from an intermediate stage of compressor 34, for low altitude flying of the aerodyne, or with air collected from the high pressure stage of compressor 34, for flights at high altitude, according to the respective positions of control valves 37 and 37*a*.

According to my invention the hot gases coming from the gas turbine and the relatively cold compressed air from the rotary compressor are mixed together only immediately before reaching the reaction nozzles. The hot gases travel inside the blades through tubes which are themselves located inside the colder compressed air stream conduits, this air thus constituting an insulating medium which protects the blade elements against the action of the hot gases. Preferably, the tubes that contain these gases are adapted to expand freely, especially in the longitudinal direction.

An example of such an arrangement is shown

by Fig. 1. Pure air supplied by compressor 34 is fed through a suitable sliding joint (not shown) to a conduit 39 which surrounds a tube 40 to which the hot gases from gas turbine 33 are fed, also through a suitable sliding joint not shown, this conduit and this tube being located inside blade 1 and extending in a direction parallel to its axis. As the hot gases inside tube 40 and the colder air that surrounds said conduit are substantially at the same pressure, it is possible without any risk of detrimental leaks, to arrange this conduit in such manner that it can expand freely, in particular in the direction of its axis. For this purpose, conduit 40 is made of at least two portions 40*a* and 40*b* connected together by a sleeve 40*c* which engages the respective opposite ends of portions 40*a* and 40*b*. The outer end of portion 40*b* is fixed at 41 to the tip of the blade, whereby the outer end of this portion can expand inwardly, whereas the inner end of portion 40*a* is fixed to the hub of the rotary wing, whereby its outer end can expand freely in the outward direction. Portion 40*b* carries an abutment 42 which keeps sleeve 40*c* in position against the action of the centrifugal force. Finally, ports 43 are provided near the outer end of the portion 40*b* of tube 40 to enable the hot gases, which flow through tube 40 in the direction of the arrows, to mix with the air flowing through conduit 39, immediately ahead of nozzles 3.

According to another feature of the invention, a certain amount of fuel is burned in the gases intended to produce the reaction effect, prior to their leaving reaction nozzles 3, this combustion serving to increase, preferably temporarily and especially during the take-off period, the reaction thrust at the tips of the blades, and therefore to supply a supplement of power.

Advantageously, I make use of a fuel having a high velocity of combustion, such as acetylene.

Combustion of a supplementary fuel can be caused to take place in the hot gases that flow through the inner tube 40 in view of the fact that these gases contain a high percentage of uncombined oxygen due to the excess of scavenging air in the motor cylinder from which these gases come. In this case, combustion may be caused to take place either at the inner ends of the blades, by injecting through an injector 57 atomized fuel which burns spontaneously in the hot gases, or in said blades or near their outer ends, the fuel being then preferably introduced in the form of a gas or vapor.

In all cases, the thermal insulation of the inner conduit with respect to the structural elements of the blade protects the outer surface of the latter against excessive heating.

I may also burn, near the end of the blade, a certain amount of gaseous or atomized fuel either in the air surrounding the inner tube 40, or in the mixture of gas and fuel that is produced at the outlet of tube 40.

I might burn both an atomized liquid fuel at the inner ends of the blades and a gaseous or atomized fuel in the blades themselves, for instance near the ends thereof.

According to another feature of the invention, in order to reduce losses of pressure in the inner conduit through which hot gases flow from hub to tip of the blade, this inner conduit is given a section such that only a small interval is left between the wall of said conduit and the outer surface of the blade. In this interval, I provide a multiplicity of adjoining tubular passages through at least some of which a portion

of a relatively cold stream constituted by air under pressure is caused to flow, advantageously with a velocity ensuring a laminar flow, whereas the hot gases, coming from the engine combustion chamber and having already expanded in the gas turbine, flow through the inner conduit together with a portion of said stream of air under pressure mixed with said gases.

For instance (Fig. 3) the cross-section of this inner conduit 101 is given a shape similar to that of the outer wall of the blade, so as to leave, between the outer surface of conduit 101 and the inner surface of blade an interval 103 of small thickness in which I provide an intermediate undulated partition 104 which thus forms in this interval a multiplicity of adjoining tubular ducts each of small section. The tubular ducts 105 that have their bases along to the outer wall 102 of the blade constitute the "outer" ducts, whereas the ducts, designated by 106, that have their bases along the wall of conduit 101 constitute the "inner" ducts.

I may cause a portion of the compressed air stream to flow through both ducts 105 and 106, but preferably this portion of the air stream flows merely through the inner ducts 106.

In both cases, the volume and therefore the velocity of the air stream flowing through these ducts is chosen to maintain a laminar flow.

In the embodiment shown by Figs. 3 and 4, the relatively cold stream of air under pressure is caused to flow through the inner ducts 106 which are fed, preferably, from a chamber 107 located close to the inner end of the blade (Fig. 4) and to which air under pressure is delivered through a conduit 108.

In order to determine the amount of air entering each of ducts 106, I provide, between chamber 107 and each of these conduits, a partition provided with a calibrated orifice 109. Ducts 106 open at their outer ends into chamber 110, located ahead of reaction nozzle 111 and into which the hot mixture of gas and air that has flown through the inner conduit 101 is also fed.

Concerning said inner conduit 101, which is fed through a conduit *m*, it is preferably made of several longitudinal sections slidable with respect to one another to permit longitudinal expansion of the whole, as already described with reference to Fig. 1. Furthermore, preferably, free transverse expansion of the wall of said conduit 101 is permitted by relative sliding of two lips *i* and *j* provided on said wall over its whole length (Fig. 3).

According to another feature of the invention, the outer ducts 105 are placed in communication, on the one hand, through apertures 112, with the outer side of the wing and on the other hand with a space at a pressure either higher or lower than atmospheric pressure, so as thus to exert on the friction boundary layer on the outer side of wall 102, a blowing or a suction effect. This effect considerably reduces the drag of the wing.

The inside of ducts 105 may be connected, through calibrated tubes 113, with a common chamber 114 which is itself in communication with blowing or sucking means, through a conduit 115 (as shown in solid lines in Fig. 4). Eventually suitably loaded valves may be provided on said tubes 113.

According to another feature of the invention, the pressure conditions in ducts 105 for sucking in, through apertures 112, the boundary layer on the outer surface of wall 102, are obtained

through the suction exerted by the gases issuing from nozzle 111 in an annular chamber 116 which surrounds said nozzle and which communicates, through calibrated orifices 117, with ducts 105 (as shown in dotted lines in Fig. 7).

In this case, of course, tubes 113 and chamber 114 are not used.

In all cases, a good heat insulation between the inner conduit 101 and the outer wall 102 is obtained, owing to the provision of ducts 105 and 106 in the interval between said conduit and said wall.

This heat insulation is practically unaffected by the thermal conductivity of the undulated partition 104 which serves to constitute these ducts, even if this undulated wall is metallic.

However, in order further to reduce the effect of this conductivity, this undulated partition may be made of a material which is a bad conductor of heat or a layer of an insulating material may be interposed between the wall of conduit 101 and the undulated partition.

Although it is not necessary to ensure fluid-tightness between ducts 106 and inner conduit 101 since the gases flowing therethrough are substantially at the same pressure, I may, in order to improve the resistance of the structure, stiffen the assembly of outer wall 102 and undulated wall 104 by securing the latter, for instance by welding, on the one hand to the outer wall and, on the other hand, to an inner metal sheet 118, as shown by Fig. 5. Elements 102 and 104 may be assembled together by electrical spot welding. Concerning the welding of elements 104 and 118 together, it may be facilitated by dividing metal sheet 118 into separate sections such as 118_1, 118_2, etc. (Fig. 6). Each of the edges *a* of the sections of this metal sheet may be bent (edges shown in dotted lines by Fig. 6) for making first the longitudinal welds *b* between partition 104 and the metal sheet sections 118_1, 118_2, etc., and finishing the assembly by welding of the bent edges together, as shown at a_1 in solid lines.

Furthermore, it is advantageous to constitute the wing structure by assembly of two box-like half-shells *c* and *d*, forming respectively the upper side and the under side of the wing and these elements being assembled together for instance by external welding along their leading edges (see the assembly shown by Fig. 6) and their trailing edges (see the assembly shown by Fig. 7).

Finally, the profile is completed, concerning the leading edge for instance, by addition of solder *e* and, concerning the trailing edge, by assembly to the main body of the wing of a trailing edge portion *f*, this assembly being for instance obtained in any suitable manner such as welding or riveting or preferably, as shown by Fig. 7, by means of longitudinal rods *g* and *h* engaged in hinges formed alternately in the rear edge of the main body *c—d* of the wing and in the rear end portion *f*.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my 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 accompanying claims.

What I claim is:

1. In connection with an aerodynamic rotary blade, a propulsion device for said blade which comprises, in combination, an internal combustion device, a gas turbine, means for conveying the exhaust gases of said combustion device to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, a tube extending through said blade from hub to tip connected with the output of said turbine, a conduit surrounding said tube, the annular space between said tube and said conduit being connected with the output of said air compressor, and jet propulsion means at the tip of said blade supplied with the streams from said tube and said annular space.

2. In connection with an aerodynamic rotary blade, a propulsion device for said blade which comprises, in combination, an internal combustion device, a gas turbine, means for conveying the exhaust gases of said combustion device to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, a tube extending through said blade from hub to tip connected with the output of said turbine, a conduit surrounding said tube, the annular space between said tube and said conduit being connected with the output of said air compressor, said tube being provided, near the blade tip, with holes opening into said annular space, for mixing said gas and air streams, and a reaction nozzle at the tip of said blade mounted to be supplied with the mixture of said streams.

3. In connection with an aerodynamic rotary blade, a propulsion device for said blade which comprises, in combination, an internal combustion device, a gas turbine, means for conveying the exhaust gases of said combustion device to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, a tube extending through said blade from hub to tip connected with the output of said turbine, said tube being of telescopic construction to permit variable expansion under the effect of heat, a conduit surrounding said tube, the annular space between said tube and said conduit being connected with the output of said air compressor, and jet propulsion means at the tip of said blade supplied with the air and gas streams from said conduit and tube respectively.

4. A propulsion device according to claim 1 further including means for injecting fuel into said tube.

5. In a flying machine, the combination of a rotary aerofoil blade including an outer wall of aerofoil cross-section, an inner wall at least substantially parallel to said outer wall forming an inner conduit therein, an undulated partition in the interval between said inner and outer walls having its ridges running in the hub to tip direction of the blade alternately along said inner and outer walls, so as to form a multiplicity of longitudinal tubular ducts in said interval and a reaction nozzle at the tip of said blade having its inlet in communication with said inner conduit, an internal combustion engine, a gas turbine, means for conveying the exhaust gases from said engine to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, means for circulating at least a

portion of said air stream through those of said ducts a portion of the surface of which is constituted by said inner wall, and means for delivering said gas stream into said inner conduit near the hub of said blade.

6. In a flying machine, the combination of a rotary aerofoil blade including an outer wall of aerofoil cross-section, an inner wall at least substantially parallel to said outer wall forming an inner conduit therein, an undulated partition in the interval between said inner and outer walls having its ridges running in the hub to tip direction of the blade alternately along said inner and outer walls, so as to form a multiplicity of longitudinal tubular ducts in said interval and a reaction nozzle at the tip of said blade having its inlet in communication with said inner conduit, an internal combustion engine, a gas turbine, means for conveying the exhaust gases from said engine to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, means for circulating a portion of said air stream through those of said ducts a portion of the surface of which is constituted by said inner wall and means for delivering said gas stream flowing out from said turbine and the remainder of the air stream delivered by said compressor both into said inner conduit near the hub of said blade.

7. In a flying machine, the combination of a rotary aerofoil blade including an outer wall of aerofoil cross-section, an inner wall at least substantially parallel to said outer wall forming an inner conduit therein, an undulated partition in the interval between said inner and outer walls having its ridges running in the hub to tip direction of the blade alternately along said inner and outer walls, so as to form a multiplicity of longitudinal tubular ducts in said interval, a reaction nozzle at the tip of said blade having its inlet in communication with said inner conduit, means forming a chamber in communication with those of said ducts a portion of the surface of which is constituted by said outer wall, said outer wall being provided with holes connecting said last mentioned ducts directly with the atmosphere, and means for keeping in said chamber a pressure different from atmospheric pressure, so as at least partly to eliminate the boundary layer on the external face of said outer wall, an internal combustion engine, a gas turbine, means for conveying the exhaust gases from said engine to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, means for circulating at least a portion of said air stream through those of said ducts a portion of the surface of which is constituted by said inner wall, and means for delivering said gas stream into said inner conduit near the hub of said blade.

8. In an airplane, the combination of a rotary aerofoil blade including an outer wall of aerofoil cross-section, an inner wall at least substantially parallel to said outer wall forming an inner conduit therein, an undulated partition in the interval between said inner and outer walls having its ridges running in the hub to tip direction of the blade alternately along said inner and outer walls, so as to form a multiplicity of longitudinal tubular ducts in said interval, a reaction nozzle at the tip of said blade having its inlet in communication with said inner conduit, means forming, at the tip of said blade, a chamber in communication with those of said ducts a portion of the surface of which is constituted by said outer wall, said outer wall being provided with holes connecting said last mentioned ducts directly with the atmosphere, said chamber being connected with said nozzle so as to be placed, through an ejector-like action exerted by said nozzle, at a pressure lower than atmospheric pressure, an internal combustion engine, a gas turbine, means for conveying the exhaust gases from said engine to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, means for circulating a portion of said air stream through those of said ducts a portion of the surface of which is constituted by said inner wall and means for delivering said gas stream flowing out from said turbine and the remainder of the air stream delivered by said compressor both into said inner conduit near the hub of said blade.

9. In an airplane, the combination of a rotary aerofoil blade including two box-like half-shells, one forming the upper portion and the other the lower portion of said blade, each half-shell including an outer wall, an inner wall at least substantially parallel to said outer wall and an undulated partition in the interval between said inner and outer walls having its ridges running in the hub to tip direction of the blade alternately along said inner and outer walls respectively, means for assembling said upper and lower half-shells along the leading and trailing edges of said aerofoil component, and a reaction nozzle at the tip of said blade having its inlet in communication with said inner conduit, an internal combustion engine, a gas turbine, means for conveying the exhaust gases from said engine to the input of said turbine, a rotary air compressor driven by said turbine adapted to supply an air stream at a pressure substantially equal to that of the gas stream leaving said turbine, means for circulating at least a portion of said air stream through those of said ducts a portion of the surface of which is constituted by said inner wall, and means for delivering said gas stream into said inner conduit near the hub of said blade.

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