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JET-DRIVEN HELICOPTER ROTOR

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Fig. 1.

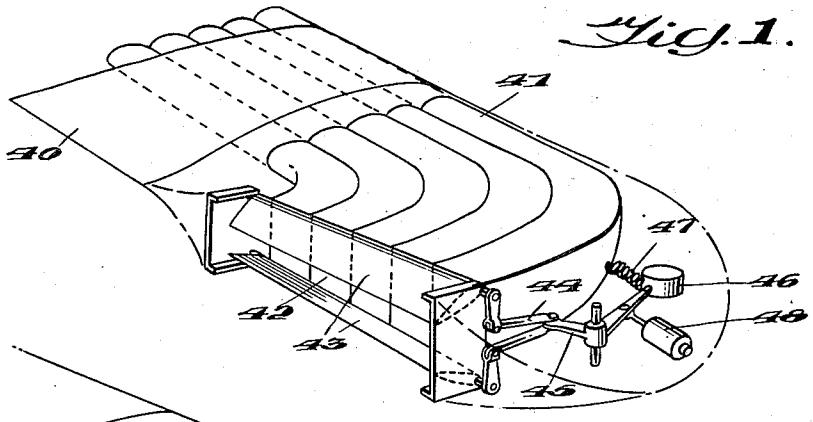
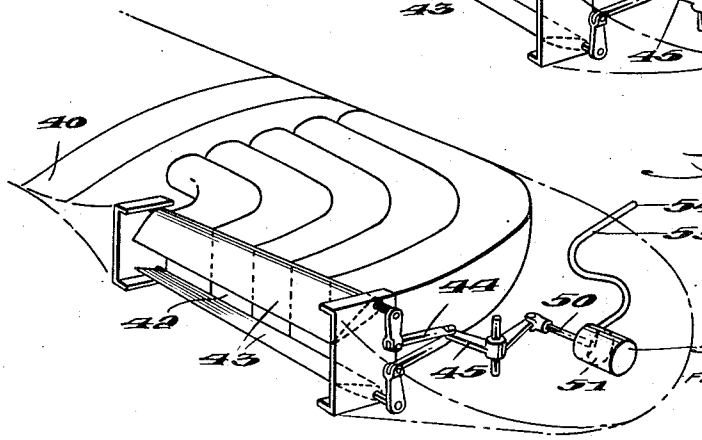


Fig. 2.



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JET-DRIVEN HELICOPTER ROTOR

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8 Claims. (Cl. 170—135.4)

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This invention relates to improvements in reaction propulsion particularly adapted for use with helicopters, but also useful with ordinary aircraft.

It is known that the use of reaction propulsion in helicopters permits the avoidance of the couple which occurs with the mechanical drive of the rotors, and the avoidance of the need for anti-couple devices such as tail propellers and double rotors. Reaction propulsion also does away with the weight, the costs of construction, and the maintenance of reciprocating motors, and greatly reduces the number of mechanical elements involved.

It is known to use reaction propulsion which utilizes a compressor driven by a turbine. Such devices utilize a portion of the pressure furnished by the compressor and a portion of the energy produced by combustion chambers located between the turbine and the compressor, the exhaust gases of the turbine being conducted through the hub of the rotor and through a system of pipes through the blades to jets situated at the extremity of the blades where the gases are finally expelled and furnish the reaction which produces the desired rotation of the rotor blades. These known propulsion devices present numerous serious inconveniences.

The turbine necessitates quite a high temperature in order to operate well. The obtaining of such a high temperature is difficult for the following reasons: Because of the high temperature and of the low pressure, the specific volume of the exhaust gas is so large that the blades of the helicopter need to be much larger than can operate at maximum aerodynamic efficiency, and particularly if one takes into consideration the fact that reaction propulsion necessitates high linear speeds at the extremity of the blades.

Another difficulty is involved in constructing the rotor hub with its conduits and its articulated joints conducting the gas in the blades in a manner so that it can function at high temperature. The same difficulty is present with the blades.

Another trouble is the considerable waste of energy due to the cooling of the gases caused by the large surfaces of the blades.

Certain of these difficulties do not exist where the turbines or combustion chambers are disposed in the extremities of the blades, but such dispositions give rise to serious gyroscopic problems as well as weight problems involving the inertia of the blades.

An object of the invention is to provide a jet

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or nozzle cross-sectional area which can be varied as the speed of the tip of the blade varies. This permits power control by merely changing the pitch of the blades as the rotational speed of the rotor would therefore automatically remain practically constant.

The control of the cross-sectional area of the nozzle can be accomplished by utilizing centrifugal force, in which case the rotational speed of the rotor would remain constant. Control can also be accomplished by utilizing the dynamic pressure of the atmospheric air, in which case the speed of revolution of the rotor would depend upon the rotor tip speed and the density of the air. In thinner air (higher altitudes) the speed of revolution of the rotor would automatically increase, thus compensating for the loss in lift which would occur if the aircraft continued ascending into the thinner atmosphere without any variation in the speed or pitch of the blade.

When the cross-sectional area of the jets or nozzles is increased, a greater amount of air will flow therethrough. This necessitates the compressor's being driven with greater power. This can be accomplished by an automatic device which maintains the turbines R. P. M. and therefore the compressor R. P. M. fairly constant by varying the fuel pressure in the fuel line leading to the combustion chambers, or by adjusting the position of the stator blades of the turbine.

The above and other objects of the invention will be apparent from the following specification and the accompanying drawings, in which:

Fig. 1 is a perspective view, partially schematic, of the tip of a helicopter rotor blade showing a device operating in response to centrifugal force for controlling the cross sectional area of the jet nozzle at the end of the blade;

Fig. 2 is a view similar to Fig. 1 but showing a device operating in response to atmospheric pressure of the air in which the rotor is operating.

An important part of the invention is the automatic control of the cross sectional area of the jet nozzles at the ends of the rotor blades. As shown in Fig. 1 a rotor blade **40** has in its interior a plurality of hot air conducting tubes **41** which are bent at the end of the blade **40** in the direction of the trailing edge of the blade so that their open ends **42** direct the hot air under pressure in such manner as to cause rotation of the blades about the central axis of the rotor. The area of the open ends **42** of tubes **41** may be controlled by a pair of shutters **43** mounted on parallel shafts and extending along the upper and lower edges of the openings **42**. Both of

the shutters 43 are connected by linkage 44 to one end of a bell crank lever 45 pivoting about a vertical axis, the other end of lever 45 carrying a weight 46. A spring 47 is attached to lever 45 at the end bearing weight 46 in such a manner as to urge that end of the lever inwardly toward the axis of rotation of the rotor blade 40, thereby tending to retain shutters 43 in their wide open positions.

When the rotor of the helicopter is rotating, centrifugal force will act on weight 46 in opposition to the pull of spring 47 so that the higher the speed of rotation of the rotor, the further outwardly will move weight 46, causing shutters 43 to move toward each other. This of course results in a decrease in the cross sectional area of the openings 42 with a corresponding lessening of the thrust and a decrease in the speed of rotation of the rotor. As the rotational speed decreases, the centrifugal force acting on weight 47 also decreases and spring 47 will cause movement of shutters 43 to more open positions. In this manner automatic control of the speed of rotation of the blades may be achieved.

In order to avoid "hunting" (too rapid oscillation of weight 46) there is provided a buffing or movement retarding device 48 connected to bell crank lever 45 so as to exert a steadying effect thereon.

When shutters 43 are open to increase the active cross sectional area of openings 42, it is necessary for the compressor 20 to furnish a greater mass of fluid, and consequently the turbine must be driven with greater power. This can be accomplished by an automatic device which maintains the speed of rotation of the turbine, and therefore of the compressor, fairly constant. Such a device could operate, for example, from the pressure of an oil pump driven by the shaft 30 of the turbine for supplying lubrication to the shaft bearings, or could be accomplished by a centrifugal governor driven by shaft 30. The chosen regulating device, oil pressure or centrifugal force, can be connected to control the supply of fuel to burners 26, or to change the pitch of the blades of the stator of the turbine.

As shown in Fig. 2, the variation of the cross sectional area of openings 42 at the end of blades 40 can be controlled in response to air pressure. In such an installation, the shutters 43 are connected as in Fig. 2 by a linkage 44 to a bell crank lever 45. However in this case, the other end of the bell crank lever is connected by a rod 50 to a piston 51 within a cylinder 52. A Pitot tube 53 having its open end 54 facing in the direction of rotation of the blade is connected to cylinder 52 in such manner that the air pressure in tube 53 controls the position of piston 51 in cylinder 52 and thereby controls the positions of shutters 43. If desired, a spring (not shown) may be mounted in opposition to the effect of the pressure in cylinder 52 on the position of the shutters.

It will be apparent that the pressure in tube 53 is a function of the speed of rotation of the rotor blades and of the density of the air, so that as the aircraft rises to higher altitudes and the air becomes thinner, shutters 43 will be opened wider to give a greater thrust and thereby to increase the speed of rotation of the rotor.

I wish it to be understood that the construction I have described herein is shown only in an exemplary sense and is not to be construed as the only manner of carrying out my invention. It is my intention to cover all modifications falling within the inventive concept as defined by the appended claims.

I claim:

1. A reaction propulsion device for helicopter rotor blades adapted to be supplied with a propulsion fluid comprising, means forming an internal passage in at least one of said blades to receive heated propulsion fluid, a propulsion nozzle in said blade in communication with said internal passage for expelling said heated fluid to cause rotation of said blades, closure means cooperating with said nozzle for varying the effective cross sectional area of the opening of said nozzle, and control means connected to said closure means and substantially operable in response to the speed of rotation of the rotor for controlling the position of said closure means, said control means being operable to move said closure means to decrease the area of the opening of said nozzle when the speed of rotation of the rotor increases beyond a predetermined value, and to move said closure means to increase the nozzle area when the speed of rotation of the rotor decreases below said value.

2. A reaction propulsion device for helicopters as set forth in claim 1, said control means comprising a weight, means mounting said weight to said blade for movement away from the rotor axis by centrifugal force, resilient means connected to said blade and said weight tending to resist said movement of the weight, and a linkage connecting said weight to said closure and operable by said weight for moving said closure means to decrease the cross sectional area of the nozzle opening upon outward movement of said weight in response to an increase in the rotational speed of the rotor beyond a predetermined value and for moving said closure means to increase the cross sectional area of the nozzle opening upon inward movement of said weight by said resilient means in response to a decrease in the rotor speed below said value.

3. A reaction propulsion device for helicopters as set forth in claim 2, and damper means connected to said linkage to control the speed of operation of said control means.

4. A reaction propulsion device for helicopters as set forth in claim 1, said control means comprising a cylinder, a piston in said cylinder, a linkage connecting said piston with said closure means whereby the position of said piston controls the effective opening of said nozzle, and a Pitot tube communicating with the interior of said cylinder and open to the exterior of the blade in the direction of the direction of rotation of the rotor, whereby the air pressure in said Pitot tube controls the position of said piston and thereby the position of said closure means as a function of the speed of rotation of the rotor and the density of the air in which the rotor is operating.

5. In a rotating helicopter blade having a reaction nozzle near its outer end for rotating the blade about a roter hub, an arrangement for controlling the size of the nozzle opening to control the speed of rotation of the rotor, comprising closure means mounted adjacent the outlet end of said nozzle, and control means independent of mechanical linkage to said rotor hub and substantially operable in response to the speed of rotation of the rotor for controlling the position of said means connecting said control means to said closure means, said control means being operable to move said closure means to diminish the effective nozzle opening when the

speed of rotation of the rotor increases beyond a predetermined value, and to move said closure means to enlarge the effective nozzle opening when th speed of the rotor decreases below said predetermined value.

6. The combination set forth in claim 5, said control means comprising a weight, means mounting said weight to said blade for movement away from the rotor axis by centrifugal force, resilient means connected to said blade and said weight tending to resist said movement of the weight, and a linkage connecting said weight to said closure and operable by said weight for moving said closure means to decrease the cross sectional area of the nozzle opening upon outward movement of said weight in response to an increase in the rotational speed of the rotor beyond a predetermined value and for moving said closure means to increase the cross sectional area of the nozzle opening upon inward movement of said weight by said resilient means in response to a decrease in the rotor speed below said value.

7. The combination set forth in claim 5, said control means comprising a weight, means mounting said weight to said blade for movement away from the rotor axis by centrifugal force, resilient means connected to said blade and said weight tending to resist said movement of the weight, and a linkage connecting said weight to said closure and operable by said weight for moving said closure means to decrease the cross sectional area of the nozzle opening upon outward movement of said weight in response to an increase in the rotational speed of the rotor beyond a predetermined value and for moving said closure means to increase the cross sectional area of the nozzle opening upon inward movement of said weight by said resilient means in response to a decrease in the rotor speed below said value, and damper means connected to said linkage to control the speed of operation of said control means.

8. The combination set forth in claim 5, said control means comprising a cylinder, a piston in said cylinder, a linkage connecting said piston with said closure means whereby the position of said piston controls the effective opening of said nozzle, and a Pitot tube communicating with the interior of said cylinder and open to the exterior of the blade in the direction of the direction of rotation of the rotor, whereby the air pressure in said Pitot tube controls the position of said piston and thereby the position of said closure means as a function of the speed of rotation of the rotor and the density of the air in which the rotor is operating.

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