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2,620,882

HELICOPTER WITH JET-PROPELLED ROTOR

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2 SHEETS—SHEET 1

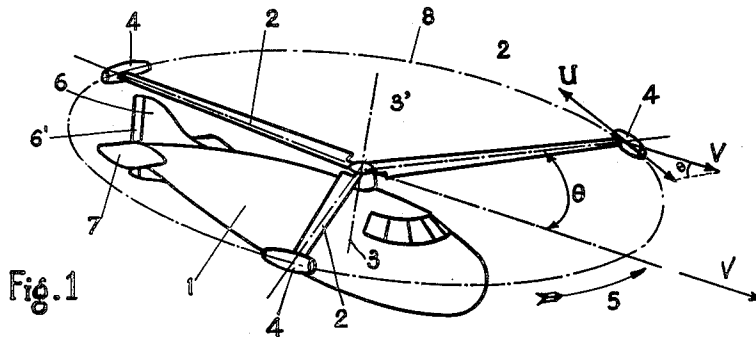


Fig. 1

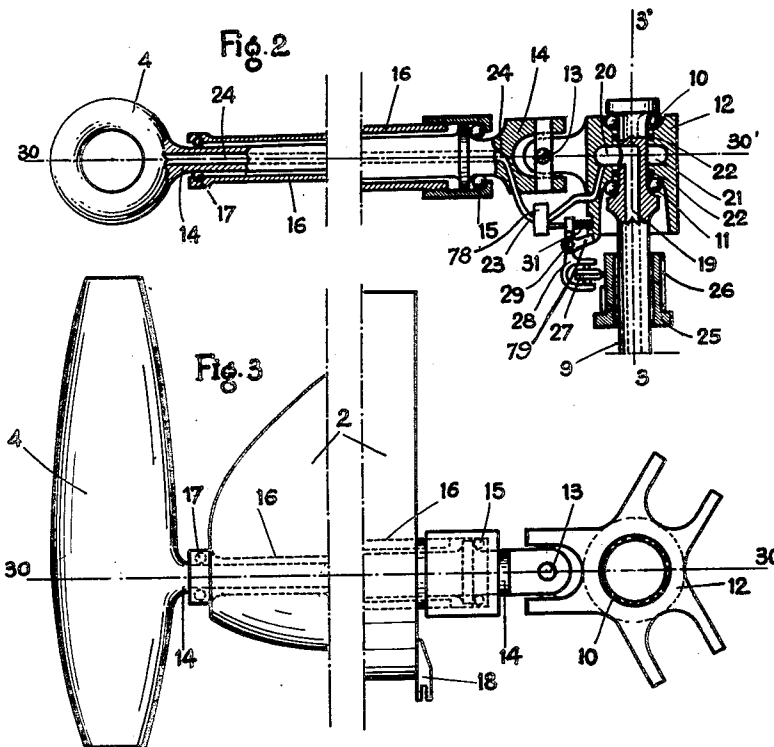


Fig. 2

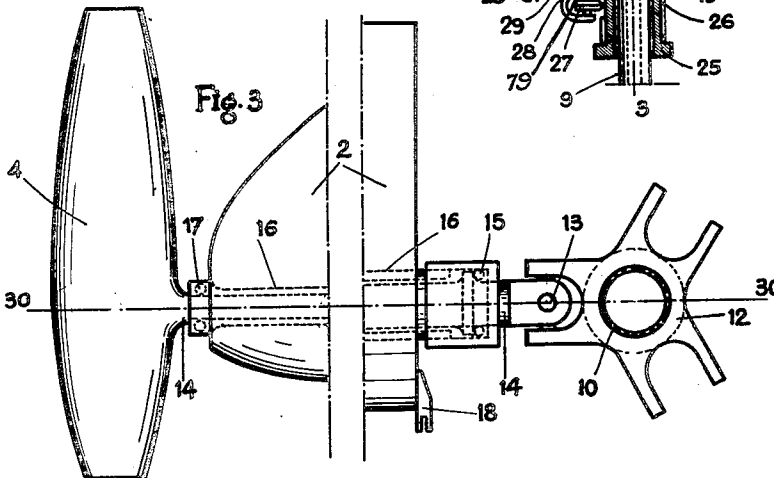


Fig. 3

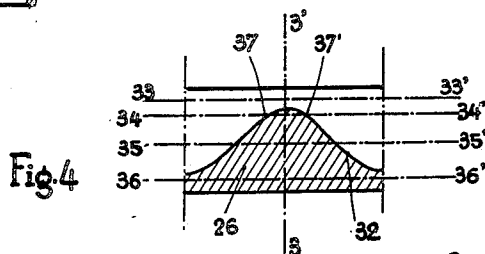


Fig. 4

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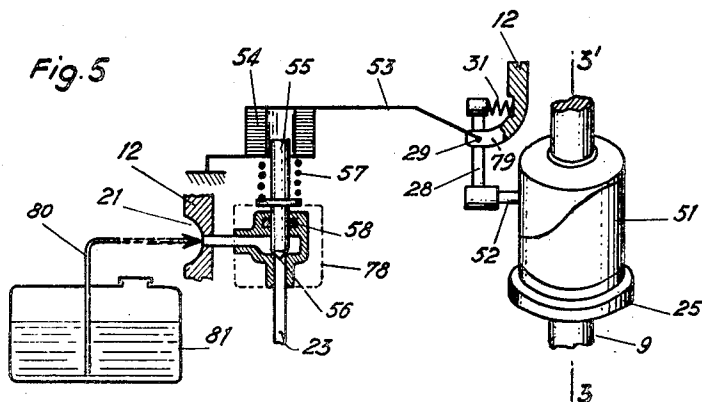
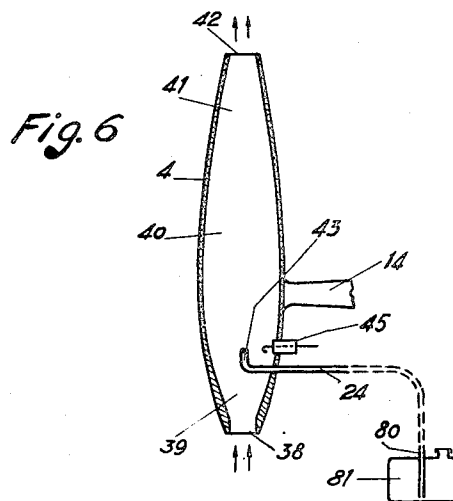
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HELICOPTER WITH JET-PROPELLED ROTOR

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2 SHEETS—SHEET 2



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HELICOPTER WITH JET-PROPELLED ROTOR

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4 Claims. (Cl. 170—135.4)

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My invention relates to helicopters with jet-propelled rotor.

It has already been suggested to arrange a pulse-jet power unit at or near the tip of each rotor blade and to utilize their jet-reaction motive force to propel the rotor. The application of such pulse-jet power units resulted however in many serious disadvantages particularly in view of their intricate design and of the varying propulsion thrust owing to the intermittent firing.

The main object of my invention is to avoid the said disadvantages and to provide helicopters with jet-propelled rotors which are simple and reliable in construction and capable to operate continuously and in which the fuel supply to the power-units is metered and controlled by the rotating rotor.

According to my invention I provide a ram-jet reaction power unit or athodyd at or near the tip of each propeller arm or blade and I regulate the fuel supply thereto in accordance with the orbital position of each of said power units in such manner that fuel is supplied thereto in variable time intervals at least while the power unit advances in its rotational movement in the direction of the forward movement of the helicopter.

The said and other objects of my invention will be more fully understood from the following specification when read with the accompanying drawing in which

Fig. 1 is a schematic perspective view of a helicopter,

Figs. 2 and 3 show in a vertical axial section and in a top view, respectively, the rotor hub mounted upon the rotor shaft and one rotor arm or blade with a ram-jet propulsion unit or athodyd attached thereto at the top thereof,

Fig. 4 is a developed view of a cylindrical cam for the cyclical control of the fuel supply to the athodyd,

Fig. 5 illustrates in a schematic perspective view, partly in section, an electric regulating mechanism for the fuel supply to the athodyd, and

Fig. 6 shows schematically in a longitudinal sectional a ram-jet propulsion unit or athodyd for propelling the rotor according to my invention.

The same reference characters indicate the same or equivalent parts in all figures of the drawing.

Fig. 1 of the drawing shows diagrammatically a helicopter comprising a conventionally shaped body or fuselage 1 and a rotor having for instance three arms or blades 2 rotatable about

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the axis 3—3' of the rotor shaft. The tip of each rotor blade or arm 2 supports a ram-jet propulsive unit or athodyd 4 which causes the rotor to rotate in the direction of the arrow 5 by the reaction force against the surrounding atmosphere. As known in the art such ram-jet propulsive units (athodyds) to become operative have to receive a certain initial velocity which may be imparted thereto by any known and suitable means. The fuselage 1 is rearwardly provided with vertical and horizontal tail-fins 6 and 7, respectively, adapted to impart satisfactory stability thereto. Moreover the vertical tail-fin 6 is provided with a pivoted flap 6' the setting of which effects the compensation of the friction torque which tends to carry the fuselage around in the direction of rotation of the rotor.

The rotor arms 2 rotate about said axis 3—3' either in a plane perpendicular thereto or in conical superficies and the intersecting point of the longitudinal axes of each arm 2 and of the athodyd attached thereto, respectively, moves in a circular path indicated by the dotted line 8. The longitudinal axis of each athodyd is tangential to said circular path 8. If the angle between the most advanced position of the longitudinal axis of a rotor arm 2, considered in the direction of the forward speed V of the helicopter, and a temporary orbital position of such axis during the rotation of the rotor arm 2 is indicated by the reference θ then it will be well understood that the momentary relative speed of the athodyd in respect to said forward speed V of the helicopter will be defined by the equation $U - V \sin \theta$ wherein U indicates the peripheral speed of the athodyd along its circular path. The said relative speed $U - V \sin \theta$ will reach a maximum value when θ equals

$$\frac{3\pi}{2}$$

or 270° and at or near this position each athodyd will react with highest efficiency upon the respective rotor arm. Therefore the most effective supply of fuel to the athodyds will occur when the respective rotor arm is at or in the neighborhood of said position that is in the time interval which includes said position defined by $\theta = 270^\circ$. The continuous rotation of the rotor will be ensured by the successive action of the individual athodyds upon the respective rotor arms and by the inertia of the rotor which is greater than that of hitherto conventional rotors in view of the additional mass of the power units arranged at the top of each rotor arm. The said cyclical interrupted fuel supply to the athodyds pro-

vides the further advantage of an efficient cooling between succeeding firings and consequently the application of higher temperatures. From the foregoing it will be well understood that the drive power of the rotor may be controlled by varying the said fuel supply period which, however, if necessary may coincide with a full rotation of the rotor to effect a continuous operation of the power units. It is further contemplated according to my invention to control the start of an adjusted fuel intake period with regard to the initial position of the power units.

Figs. 2 and 3 illustrate one arm of the rotor which rotates about the shaft 9 stationary mounted in the fuselage 1. Each rotor arm 2 comprises a shaft 14 which is with its inner forked end connected to the rotor hub 12 by means of a universal joint 13 and which has rigidly connected to its tips a ram-jet propulsion unit or athodyd 4. The rotor hub 12 is supported on the rotor shaft 9 by ball bearings 10 and 11. Each of said arm shafts 14 supports rotatably by means of ball bearings 15 and 17 a tubular shaft 16 to which the actual rotor blade 2' is fixed. The pitch of the blades 2' may be controlled by a lever 18 connected to a conventional mechanism not shown in the drawing for example of the type disclosed in Hafner's Patent No. 2,150,969.

The rotor shaft 9 is provided with an axially extending duct 19 connected to the fuel supply tank not shown in this figure but shown in Figs. 5 and 6 and marked 81. A port 20 in said duct 19 connects the same with a circular distribution chamber 21 arranged in the rotor hub 12. A tight seal is maintained between the rotor hub 12 and the rotor shaft 9 for example by the rotary joints 22 to prevent any escape of fuel from said chamber 21. Each rotor arm shaft 14 is provided with an axial duct 24 leading with one end into the athodyd 4 and connected at its other end to said distribution chamber 21 by means of a flexible piping or other connection 23 which bypasses the universal joint 13.

The control means for the fuel supply to the athodyds as shown in Figs. 2 and 3 comprise a cylindrical bush 25 which is adjustably mounted upon the rotor shaft 9. The position of said bush 25 relative to the rotor shaft 9 may be adjusted in axial direction as well as angularly by proper and well known means which are not illustrated. Said bush 25 is provided with a circumferential cylindrical cam portion 26 which cooperates with follower rollers 27 each of which actuates a check valve 78 in the fuel supply line leading to one athodyd, for example within the flexible connection 23. Each follower roller 27 is mounted upon one arm of a lever 28 swingable about the pin 29 which rests in a projection 79 of the rotor hub 12 and rotates therewith. A spring 31 acting upon the other arm of said lever 28 presses the roller 27 against the surface of the bush 25. The rollers 27 driven around the bush 25 by the rotating rotor hub 12 are thus lifted from the cylindrical surface of the bush 25 in a plane perpendicular to the axis 3-3' of the rotor shaft 9 if and when the roller 27 runs upon the raised cam portion 26 thereof thus causing said swing arm 28 to tilt about the pin 29. This tilting movement of the lever 28 is utilized to effect the opening and closing of the said check valve 78 within the fuel supply line leading to the athodyd 4 for example in the piping 23. To this effect said valve 78 is connected to and actuated by said lever 28 in such manner that the valve 78

is opened when the roller 27 is lifted by the cam 26. However said valve 78 may be actuated by said roller 27 or its supporting lever in any other suitable manner by mechanical, hydraulic, pneumatic or electric means known per se in the art.

Fig. 4 shows the developed view of the cam 26 raised from the cylindrical surface of the bush 25. As illustrated the effective cam contour 32 may for example have the shape of a sinusoidal curve. According to the axial position of the bush 25 relative to the rotor shaft 9 each of the rollers 27 will ride around the bush 25 along any circumferential path such as indicated for example by the lines 33-33', 34-34', 35-35', 36-36'. When the rollers 27 ride along the circumferential line 33-33' avoiding the raised cam portion 26, the roller arms 28 will not be tilted and will not actuate the valve 78 for the fuel supply thus preventing any fuel delivery to the athodyds during the entire revolution of the rotor. If the rollers 27 ride along the line 34-34' a short fuel supply will be effected while the rollers pass over the cam between the points 37, 37'. While riding along the line 35-35' the rollers 27 will effect a fuel supply to each athodyd lasting for about a half revolution of the rotor. And while riding along the line 36-36' situated entirely below the contour line 32 of the cam the rollers 27 will remain lifted from the cylindrical surface of the bush 25 and the fuel supply to each athodyd will continue during the full revolution of the rotor. Accordingly the axial displacement of the bush 26 along the rotor shaft 9 makes it possible to completely control the fuel supply to the athodyds from a complete shut off to a continuous supply during a full revolution of the rotor. In addition thereto an angular displacement of the bush 26 relative to the rotor shaft 9 will permit to adjust the start of the fuel intake period by the athodyds during their revolution.

Fig. 5 illustrates schematically partly in section an electrically operated control mechanism for the fuel supply to each athodyd which mechanism may be substituted for the mechanically operating control mechanism shown in Figs. 1 and 2 and described above. In fact the Fig. 5 should be considered for better understanding together with the more complete Figs. 1 and 2. Fig. 5 shows a portion of the rotor hub 12 and of the distributing chamber 21 arranged therein. The fuel is supplied to said chamber 21 through a pipeline 80 from a fuel tank 81 and passes thereafter through a valve 78 arranged in a connecting piping 23 which leads into the axial duct 24 of each arm shaft 14 and from there into the respective athodyd 4. The valve 78 as illustrated is a pin valve comprising a pin 56 attached to a valve rod 55 and sealed in the valve body by a packing ring 58. A helical spring 57 keeps the valve in closed position. The valve is opened by the action of the solenoid 54 which lifts the valve rod 55 when energized by electric current incoming through the wire 53 which is connected to the swing lever 28. This swing lever 28 is rotatable about the pin 29 mounted in a projection 79 of the rotor hub 12. One arm of said lever 28 carries an electric brush 52 which is pressed against the slipring 25 by the force of a spring 31 acting upon the other arm of said swing lever. The said slipring 25 is mounted upon the rotor shaft 9 and may be axially and/or angularly adjusted thereupon as explained above with regard to the bush 25 shown in Figs. 2 and 3. The cylindrical surface of said slipring 25 is divided in an electri-

cally conductive surface portion 51 and an electrically non-conductive surface portion which surface portions adjoin each other along an essentially sinusoidal line as shown in Fig. 4, the raised cam portion 26 referred to earlier corresponding to the electrically conductive surface portion 51. It will be well understood that the brushes 52 will run along a shorter or longer path on the electrically conductive surface portion 51 according to the axial position of the slipring 25 with regard to said brush and while doing so will close the electric circuit energizing the solenoid 54 and thereby actuating the valve 78 for a shorter or longer period as explained above with regard to Fig. 4.

Fig. 6 shows schematically a longitudinal section through a ram-jet propulsion unit or athodyd mounted at the outer end of each rotor wing 2. Each athodyd comprises a combustion chamber within streamlined walls. The air enters into the combustion chamber through the frontal intake opening 38 and the combustion gases leave said chamber through the rear exhaust opening 42. The incoming air is compressed and has its velocity commuted into the static pressure or ram while passing through the divergent portion 39 of the combustion chamber into the burner section 40. The fuel which is taken from a storage tank 31 by a conduit 30 is introduced into the said combustion chamber through the duct 24 arranged in each rotor wing shaft 14 (see Fig. 2) and is atomized therein by an injector 43. The fuel burns continuously in the said central burner section 40 of the combustion chamber and the pressure energy of the combustion gases is transformed into kinetic energy while said gases pass through the convergent conical section 41 of the combustion chamber towards the exhaust 42. A spark plug 45 serves to start the combustion of fuel within the combustion chamber and the power unit thereafter operates continuously.

Having shown and described specific embodiments of my invention to illustrate the application of the principles thereof it will be well understood that my invention may be constructed in various other embodiments which come within the scope of the appended claims.

What I claim as my invention is:

1. In a helicopter with a rotor propelled by jet-reaction power units the improvement comprising in combination a plurality of rotor blades; ram-jet propulsion units or athodyds containing a combustion chamber situated between a divergent and a convergent duct; each propulsion unit mounted at the tip of one rotor blade; the common longitudinal axis of said ducts being essentially tangential to the circle of rotation described by the ends of the rotor blades; a fuel tank; conduits connecting said tank and each of said combustion chambers; regulating means in each of said conduits to control the fuel supply passing therethrough; and actuating means for said regulating means operably associated therewith and with said rotor and operated in accordance with the orbital position of the ram-jet unit to coincidentally control the injection of fuel into the combustion chamber in such manner that the fuel is supplied in variable time intervals at least while the rotor blade supporting the respective ram-jet unit advances in its rotational movement in the direction of the forward movement of the helicopter.

2. In a helicopter with a rotor propelled by jet-reaction power units the improvement compris-

ing in combination a fuselage; a fixed shaft upstanding from said fuselage; a rotor hub rotatably mounted on said shaft; radially extending arms jointed to said hub; a ram-jet power unit or athodyd mounted at the tip of each of said arms; a pitch-variable rotor blade mounted upon each of said arms; a fuel tank; conduits connecting said tank with each of said ram-jet power units; said conduits passing through said shaft, said hub and each of said arms; a valve in each of said conduits to control the fuel supply to each of said power units; and actuating means for said fuel supply valves operably associated therewith and with said rotor and operated in accordance with the orbital position of the ram-jet unit to coincidentally control the injection of fuel into the ram-jet unit in such manner that the fuel is supplied in variable time intervals at least while the rotor blade supporting the respective ram-jet unit advances in its rotational movement in the direction of the forward movement of the helicopter.

3. In a helicopter according to claim 2, actuating means for the fuel supply valves comprising a sinusoidal cam mounted on said shaft; cam-follower means cooperating therewith; each of said cam-follower means jointed to said rotor hub and actuating one of said fuel supply valves; and means to vary the angular and axial setting of said cam on said shaft to adjust the cooperation between said cam and its followers in order to regulate the fuel supply.

4. In a helicopter according to claim 2, actuating means for the fuel supply valves comprising a plurality of solenoids each actuating one valve; a slipring slidably and rotatably mounted on said shaft and electrically insulated therefrom; the cylindrical surface of said slipring having an electrically conducting surface portion and a non-conductive surface portion; said surface portions adjoining each other along a sinusoidal line; a plurality of contact brushes sliding upon the cylindrical surface of the slipring and each electrically connected with one solenoid; the contact brushes being supported by said rotor hub; an electric circuit connecting said slipring, said brushes and said solenoids; and means to vary the angular and axial setting of said slipring upon said shaft to adjust the cooperation between the slipring and the brushes in order to regulate the action of the solenoids actuating the fuel supply valves.

PAUL HENRI LÉON MORAIN.

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