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2,818,223

JET PROPULSION OF HELICOPTERS

Original Filed April 9, 1947

2 Sheets-Sheet 1

Fig. 1.

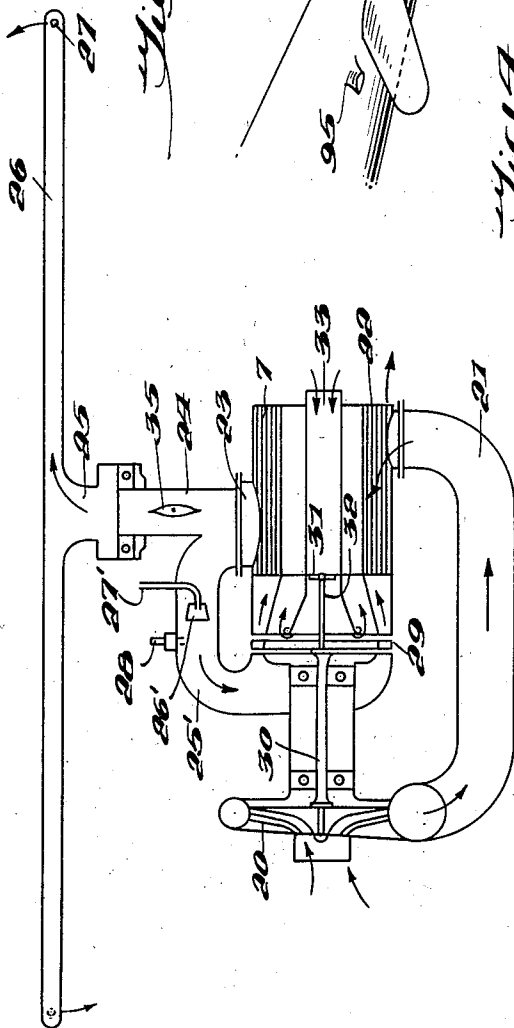


Fig. 3.

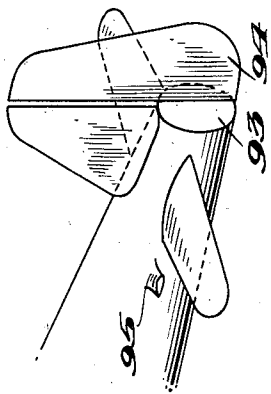


Fig. 4.

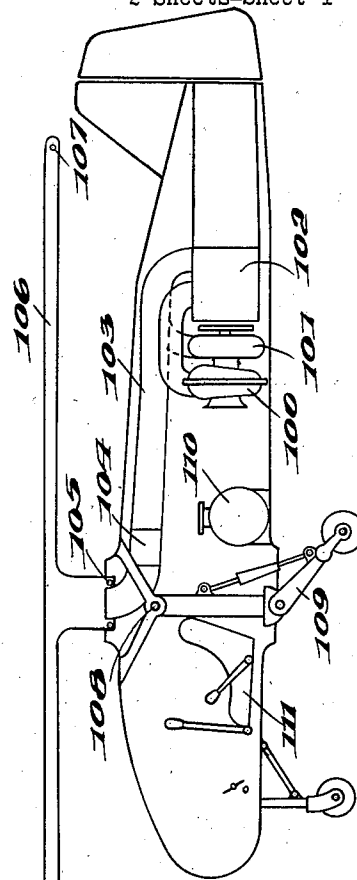
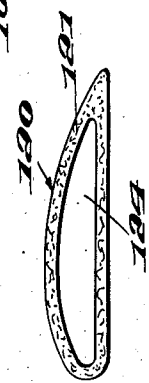


Fig. 5.



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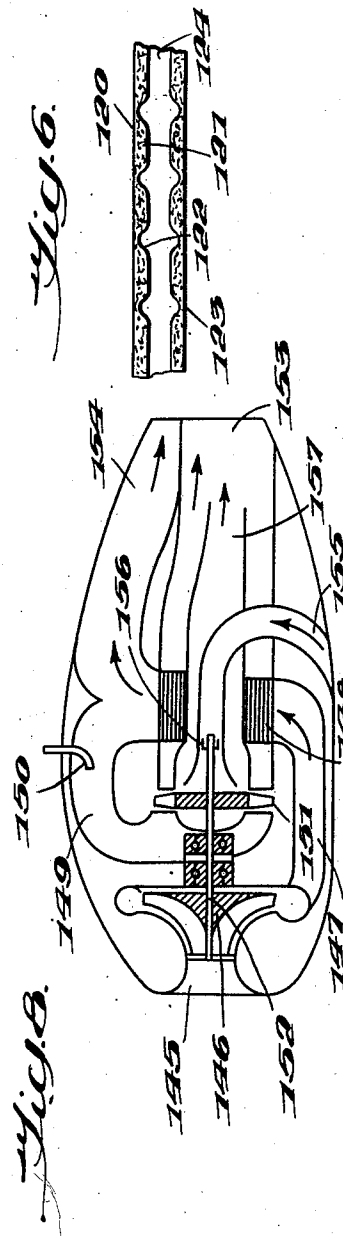
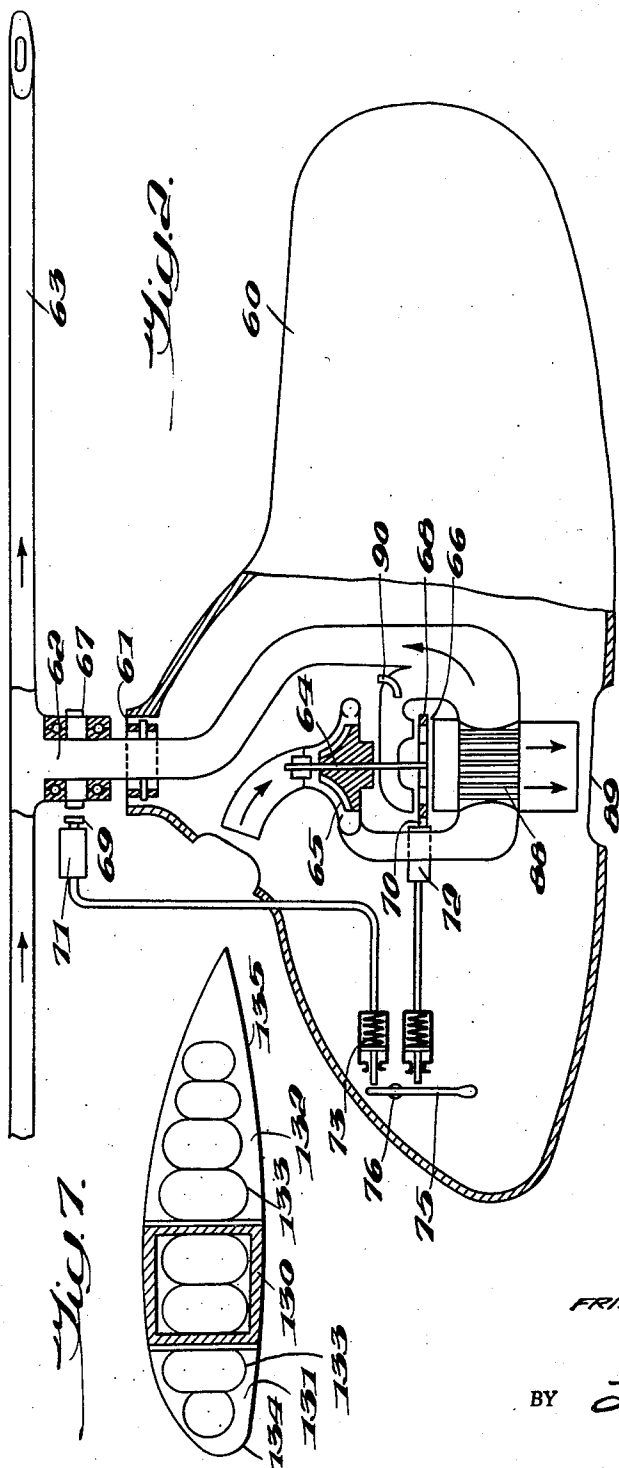
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JET PROPULSION OF HELICOPTERS

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2 Sheets-Sheet 2



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JET PROPULSION OF HELICOPTERS

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Original application April 9, 1947, Serial No. 740,366, now Patent No. 2,667,226, dated January 26, 1954. Divided and this application January 27, 1953, Serial No. 342,622

3 Claims. (Cl. 244—17.19)

This application is a division of my application Serial No. 740,366, filed April 9, 1947, for Jet Propulsion of Helicopters, now Patent No. 2,667,226.

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.

The principal feature of the present invention consists in utilizing as the reaction fluid for propulsion compressed air taken between the compressor and the combustion chambers, the latter serving at the same time to heat the remainder of the compressed air which drives the turbine, which in turn drives the compressor. Preferably, the air directed to the reaction jets is first heated in a heat exchanger traversed by the exhaust gas from the turbine and recovering the heat carried by these gases.

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It is a primary object of the invention, accordingly, to provide a reaction system as described in the preceding paragraph.

This improvement presents several advantages. From the beginning the thermodynamic cycle is, from the point of view of efficiency, almost independent of the pressure of the compressor and of the temperature of the burners or combustion chambers. The compressor can be used at low pressure and consequently can be light in weight. The temperature of the turbine can be lower than the temperatures that are usually necessary resulting in, from the point of view of the resistance of the materials used, important advantages in safety, advantages which are very important in aeronautics generally, both in helicopters and in ordinary aircraft. Because of the fact that the turbine functions at atmospheric pressure, it is easy to cool, for example by means of a special small cooling fan blowing air from the atmosphere on to the turbine wheel. Cooling can also be carried out by making the turbine blades hollow so that they suck in air at the center of the turbine rotor and blow it out at their outer ends, operating as a centrifugal ventilation system.

In a helicopter constructed in accordance with the invention, the cross sectional area of the conduits located within the rotor blades for the purpose of conducting the reaction fluid can be small because of the high pressure of the fluid and of its low temperature, even after taking into account the necessity for reducing to a minimum the losses taking place through friction. The invention permits the avoiding of the increase in the cross section of the blades beyond the aerodynamic optimum. The fluid transported through the hub and through the blades of the helicopter is hot air, thereby avoiding the difficulties caused by unburned products of combustion as in systems where the products of combustion are directed through the helicopter blades. Also, the temperature of the blades is moderate.

The free escape of the exhaust gases from the turbine produces a slight thrust, as does the gas being cooled. This thrust can be used for controlling the orientation of the helicopter about a vertical axis, as by blowing these gases on the control surfaces or by conducting them to reaction jets directed to port and starboard.

Another object of the invention is to provide improved stability in helicopters by utilizing the gyroscopic forces inherent in the high speed rotation of the turbine and compressor. This obviates the need for special heavy gyroscopes which have previously been used for stabilizing helicopters. In securing the gyroscopic effect of the turbine and compressor, it is advantageous to locate the turbine and the compressor coaxially with the hub of the helicopter rotor.

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 schematic vertical section through the rotor of a helicopter and through a turbine and compressor device for directing reaction fluid to the rotor blades;

Fig. 2 is a vertical sectional view through a helicopter showing a modification of the embodiment shown in Fig. 1, the modification having the axis of the turbine positioned vertically. This figure also shows a simple device for orienting the helicopter about its vertical axis;

Fig. 3 is a perspective view of the tail of a helicopter showing an arrangement for directing the exhaust gases of the turbine against the control surfaces;

Fig. 4 is a vertical sectional view through a helicopter showing a modified disposition of the turbine and compressor arrangement;

Fig. 5 is a cross sectional view taken through a flexible helicopter rotor blade particularly adapted for use with the invention;

Fig. 6 is a detailed longitudinal section view taken through a portion of Fig. 8 and somewhat enlarged;

Fig. 7 is a cross sectional view through a rigid type of blade for use with the invention; and

Fig. 8 shows a form of the novel reaction propulsion system described herein applicable to use with ordinary aircraft.

In the preferred form of the invention shown in Fig. 1 a compressor 20 discharges compressed air through tubing 21 to a heat exchanger 22 where the compressed air passes about the tubes of the heat exchanger and out through an outlet 23. The air passing from outlet 23 is divided into two portions, one portion passing upwardly through tube 24 through the hub 25 at the rotor, and outwardly through hollow rotor blades 26, until it is finally discharged through jet nozzles 27 at the ends of the rotor blades.

The other branch 25' of the tubing connected to the outlet 23 contains a burner 26' for fuel supplied through tube 27' for ignition by igniter 28. The products of combustion are directed against the blades of a turbine 29 from which the gases pass through the tubing of heat exchanger 22 where they heat compressed air being passed into the heat exchanger through tube 21.

Both the compressor 20 and the turbine 29 are mounted on a single shaft 30, and a small fan 31 may be mounted on a shaft 32 to draw in cooling air through an air intake 33 and direct the air against the turbine 29. After striking the turbine the cooling air passes outside the intake 33 which is centrally positioned with respect to and spaced from heat exchanger 22.

A throttle 35 is conveniently positioned in passage 24 so that the passage may be closed during starting of the device so that all the compressed air goes to the turbine. Starting may be carried out by an electric motor (not shown) or even manually through a crank and step up gear.

The system shown in Fig. 1 has numerous advantages over the prior art. The thermodynamic cycle is, as regards efficiency, practically independent from the pressure of the compressor and the temperature of the burners. For this reason, low pressure compressors can be used, making the use of light weight parts feasible. The turbine temperature can be relatively low with the obvious advantages of such low temperatures. The rotor blade cross sectional area can be relatively small due to the high pressure of the driving medium and its low temperature. The reaction fluid carried through the hub of the rotor and the blades is merely heated air so that the difficulties with residues inherent in the use of exhaust products of combustion for driving rotor blades are obviated. Since the turbine operates under atmospheric pressure, its cooling is a simple matter, for example, the use of small fan 31 drawing air in through an axial tube in the center of the heat exchanger and expelling along the exterior of the tube after the air has had cooling contact with the turbine blade. Cooling could also be accomplished by the use of hollow turbine blades connected to a central air intake and operating to expel the cooling air centrifugally through openings at the outer ends of the blades of the turbine. The relatively low temperature of the hot air passed through the blades permits the blade temperature to be moderate. Another advantage which will be discussed in more detail presently is the fact that the exhaust from the turbine can be used to produce thrust for controlling the orientation of the helicopter.

In the modification shown in Fig. 1, the axis of the turbine and compressor is disposed horizontally. This axis can also be positioned in a vertical manner, as for instance in alignment with the axis of rotation of the rotor blades 26 about hub 25 (Fig. 2). Such a vertical disposition permits use of the gyroscopic effect of the turbine and compressor which are, of course, rotating at high speed, to increase the stability of the helicopter,

thereby doing away with the gyroscopic masses which have been previously utilized for this purpose. The weight of the separate gyroscopic stabilizer is thus reduced to the weight of the turbine and compressor. This vertical disposition also permits use of a double brake arrangement for controlling the orientation of the helicopter about the vertical axis.

Such an arrangement is shown schematically in Figure 2 in which the fuselage 60 of the helicopter is suspended by a cardan joint 61 at the hollow hub 62 about which turns the rotor 63, and which carries the turbine and compressor unit in such a manner that the shaft 64 connecting the compressor 65 and the turbine 66 is coaxial with the rotor.

The means for controlling the orientation of the helicopter about the vertical axis includes annular braking surfaces 67 and 68 rotating, respectively, with a rotating part of the rotor hub, and with the turbine, the turbine in this case being constructed to rotate in a direction opposite to the direction of rotation of the rotor. If desired, the annular braking surface 68 may be solidly connected to the rotor of the turbine.

Brake shoes 69 and 70 cooperate, respectively, with the annular braking surfaces 67 and 68, hydraulic cylinders 71 and 72 being provided for urging the brake shoes against the braking surfaces as desired. The two cylinders 71 and 72 are remotely controlled by control cylinders 73 and 74 having internal pistons movable by a hand lever 75 which is pivoted at a point 76 positioned between the two cylinders 73 and 74.

It will be obvious from Figure 2 that when the handle of lever 75 is moved to the left in Figure 2, the piston of control cylinder 73 will be moved to the right to cause hydraulic cylinder 71 to press brake shoe 69 against braking surface 67.

On the other hand, the reverse movement of lever 75 causes brake shoe 70 to be urged against braking surface 68.

With this construction, when brake shoe 70 is applied against braking surface 68, the helicopter tends to turn in a direction opposite to the direction of rotation of the rotor. On the contrary, the pressing of brake shoe 69 against braking surface 67 causes the helicopter to turn in the direction of rotation of the rotor.

In the construction shown in Fig. 2, the exhaust from turbine 66 is directed through a heat exchanger 88 and then outwardly in a downward direction through an opening 89 in the bottom of the fuselage of the aircraft, opening 89 being preferably in vertical alignment with the center of gravity of the aircraft. This arrangement permits the utilization of the thrust from the exhaust gases to supplement the lift of the rotor. This thrust can be increased in case of emergency by increasing the output of the compressor, for example by an increase in the amount of fuel fed to the burner 90.

In Fig. 3 there is shown another means for maneuvering the helicopter about a vertical axis during stationary flight (hovering), this comprising the blowing of the exhaust gases leaving heat exchanger 22 of Fig. 1 through suitable ducts 93 against the rudder 94 of the helicopter.

These exhaust gases could also be directed to nozzles pointing toward port and starboard and removed from the center of gravity of the aircraft to cause turning of the aircraft about its vertical axis during hovering. A nozzle directed toward the port side of the aircraft is indicated at 95 in Fig. 3.

Both of the control systems illustrated in Fig. 3 can also be used with the turbine arrangement shown in Fig. 2 if desired.

In a helicopter of the type disclosed herein in which the rotor blades are driven by a passage of heated air through the blades and out of jet nozzles at the end of the blades, it is somewhat desirable to use a smaller number of blades than in the ordinary helicopter so that the blades can each be constructed with a larger cross sectional area to facilitate

the passage of hot air through the blades. If the number of blades were to be decreased by reduction to a third of the original number, each blade would then need to be three times as wide, that is would have to have a chord three times larger, if equal density is to be obtained. The total section is then three² or nine times as large as the section of each individual blade of the rotor having the original large number of blades. The total section, therefore, is three times larger. It is thus apparent that the size of the total section increases linearly with the decrease in the number of blades at equal density.

The use of rotors having smaller numbers of blades presents vibration problems. In the case of helicopters having mechanically driven motors it is known to fix the rotor hub and the engine all on one integral part. This part which vibrates during flight will have a neutral point in which the fuselage is mounted in rubber. The same arrangement can be used with the jet engine described herein, but it would be preferable to fix the jet turbine to the fuselage or rotor hub and use another heavy object which is located at a sufficient distance from the rotor hub as a balancing weight, for example the landing gear.

Such an arrangement is shown in Fig. 4 in which 100 is the compressor and 101 is the turbine. Radiator 102 is connected to a tube 103 for passing the heated air through an elastic connection 104 to bearing and sealing means 105, and thence to hollow rotor blades 106 and nozzles 107. A hinge 108 connects the fuselage to the neutral point of the rotor and landing gear block for landing gear 109. A fuel tank is indicated at 110 while the pilot seat and controls are indicated generally by the numeral 111.

In the construction of helicopter blades, it is known that the blades can either be rigid and strong enough to resist the bending stresses caused by aerodynamic forces, or they can be flexible, in which case they need not resist the bending stresses.

In Figs. 5 and 6 there is shown a new type of flexible blade in which there is an outer sheet 120 and an inner steel sheet 121. The inner sheet is formed with spaced grooves or corrugations 122 extending entirely about the circumference of the blade. Corrugations 122 give the inside sheet a high resistance against pressure from the inside and at the same time permit considerable bending, so that most of the bending stresses must be carried by the outside sheet 120 which should be of a material having a low coefficient of elasticity, such as plastic or aluminum. The outer sheet 120 lies against the bottoms of the corrugations 122 and the hollow spaces 123 between the two sheets are filled with an insulating material. It will be apparent that the hot air passed through the blade passes through the hollow center 124 of the blade.

In case it is desired to use a rigid blade with the helicopter, a desirable blade of this type is shown in Fig. 7 in which a steel spar or longeron 130 carries the bending stresses. On the front and rear of the longeron 130 (leading and trailing edges) there are attached, for example, by electrical welding, leading and trailing structures 131 and 132. Structures 131 and 132 and, if desired, longeron 130, contain a series of hollow tubes 133 which extend the length of the blade for the purpose of carrying the hot air to the nozzles at the end of the blades. Tubes 133 are constructed in such a manner that they resist tensions produced by internal pressure but do not resist the effects of bending stresses. For this reason the tubes 133 can be made of very thin and light weight material. The outer shells of the leading and trailing structures 131 and 132 are indicated by the numerals 134 and 135. Insulation may be placed in the space between tubes 133 and shells 134 and 135.

In Fig. 8 I have shown an axial sectional view of a reaction propulsion device of the type disclosed herein as applied to an ordinary aircraft. In this figure, air enters by an intake 145 and is compressed by a compressor 146 and directed through tubing 147 to a heat exchanger 148. The air heated by the heat exchanger is divided into two

portions, one portion passing to a conduit 149 which contains a burner 150. The products of combustion of the burner pass through and drive a turbine 151 which in turn drives compressor 146 by means of a shaft 152. The products of combustion pass from tubing 151 through the tubing of heat exchanger 148 and then out through a nozzle 153 directed rearwardly with respect to the aircraft. The other portion of the air passed through the heat exchanger 148 is directed rearwardly through another nozzle 154 also directed rearwardly. Turbine 151 is cooled by air taken in through an inlet 155 and blown against the turbine by a fan 156 driven by the turbine. Air from inlet 155 passes through an axially positioned tube in which fan 156 is positioned, and after operating upon turbine 156, the cooling air passes rearwardly outside the inlet tube and is intermingled with the products of combustion passing out of nozzle 153 in such a manner that a suction is produced in exit tubing 157 which assists in the flow of cooling air. If desired, auxiliary burners or other heating means could be located in nozzle 154.

The auxiliary burners or other types of heating means just referred to and also mentioned previously herein are particularly useful when an emergency surge of power is needed. In the case of helicopters, it is also feasible to locate combustion chambers or other heaters near the blade tips for heating the air being passed to the blade nozzles.

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 a vehicle, comprising a compressor, a heat exchanger having an inlet connected to receive the output of said compressor and an outlet for the fluid entering at said inlet, a conduit receiving fluid from said outlet, said conduit being divided into two branches, combustion means in a first branch of said conduit, a turbine drivably connected to said compressor, means for directing the compressed fluid and exhaust gases from said combustion means against said turbine to drive the turbine, means for passing said exhaust gases and compressed fluid from said turbine to said heat exchanger to heat the fluid entering said inlet, helicopter blades mounted on a vehicle, at least one of said blades having an internal passage in communication with said second conduit branch to receive heated propulsion fluid therefrom, and a propulsion nozzle in said blade in communication with said internal passage, said heated fluid being expelled through said nozzle to cause rotation of said blades, said compressor and turbine being rotary and arranged coaxially with the axis of rotation of said helicopter blades, whereby the rotation of said compressor and turbine exerts a gyroscopic effect having a stabilizing effect on the helicopter.

2. A reaction propulsion device for a vehicle, comprising a compressor, a heat exchanger having an inlet connected to receive the output of said compressor and an outlet for the fluid entering at said inlet, a conduit receiving fluid from said outlet, said conduit being divided into two branches, combustion means in a first branch of said conduit, a turbine drivably connected to said compressor, means for directing the compressed fluid and exhaust gases from said combustion means against said turbine to drive the turbine, means for passing said exhaust gases and compressed fluid from said turbine to said heat exchanger to heat the fluid entering said inlet, helicopter blades mounted on a vehicle, at least one of said blades having an internal passage in communication with said second conduit branch to receive heated propulsion fluid therefrom, and a propulsion nozzle in said blade in communication with said internal passage, said heated fluid being expelled through said nozzle to cause rotation of

said blades, said compressor and turbine being rotary and arranged coaxially with the axis of rotation of said helicopter blades and arranged to expel the exhaust gases from said turbine in said axial direction downwardly, whereby the rotation of said compressor and turbine exerts a gyroscopic effect having a stabilizing effect on the helicopter and the downward expulsion of exhaust gases exerts an upward thrust on the helicopter.

3. A reaction propulsion device for a vehicle, comprising a compressor, a heat exchanger having an inlet connected to receive the output of said compressor and an outlet for the fluid entering at said inlet, a conduit receiving fluid from said outlet, said conduit being divided into two branches, combustion means in a first branch of said conduit, a turbine drivably connected to said compressor, means for directing the compressed fluid and exhaust gases from said combustion means against said turbine to drive the turbine, means for passing said exhaust gases and compressed fluid from said turbine to said heat exchanger to heat the fluid entering said inlet, helicopter blades mounted on a vehicle, at least one of said blades having an internal passage in communication with said second conduit branch to receive heated propulsion fluid therefrom, and a propulsion nozzle in said blade in communication with said internal passage, said heated fluid being expelled through said nozzle to cause rotation of said blades, a rudder on said helicopter, and means for directing the

exhaust gases from said turbine against said rudder, whereby orientation of the helicopter about a vertical axis is achieved during hovering.

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