PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Propulsion Units for Aircraft

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I, WILLIAM JOHN TENNANT, a British subject of 111/112, Hatton Garden, London, E.C.1., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to propulsion units for aircraft and has for its object to provide means for increasing the propulsion power of the unit in the shortest possible time. This is of great importance not only for starting aircraft but also in landing, for instance if the pilot miscalculates the distance to the landing point or if there is a risk of colliding with an obstacle.

According to the invention a propulsion unit for aircraft comprises one or more rotary compressors for compressing motive fluid, one or more combustion chambers for heating the compressed motive fluid, one or more gas turbines for driving the compressor or compressors which during the operation of the propulsion unit are always mechanically connected to and rotating with the turbine or turbines and means for controlling the supply of fuel to the combustion chamber or chambers, and is provided with means for producing propulsion power and with means for increasing at will the ratio of the power input to the compressor or compressors to the power available for the propulsion of the aircraft so as to allow a rapid increase of the quantity of fuel supplied to the combustion chamber.

Under normal operating conditions, the energy required for driving the compressor and producing the propulsion power is controlled by varying the supply of fuel injected into the combustion chamber of the gas turbine aggregate. To increase the output of the gas turbine and the propulsion power, more fuel is supplied to the combustion chamber, and vice versa. A certain portion of the energy delivered by the gas turbine is absorbed by the compressor for the purpose of providing motive fluid, such as air, in a quantity and at a pressure corresponding to the load conditions. The remainder of the energy is utilized for the propulsion of the aircraft either by driving an air screw or by producing a rocket effect or by utilizing a combination of both driving forces.

If the aircraft is to be rapidly accelerated from a more or less low velocity of flight to a higher velocity, a sudden and considerable increase of the fuel supply would cause the initial temperature of the motive fluid to exceed safe values, since the speed and the output of the compressor cannot be increased so rapidly that the compressor would be able immediately to deliver a quantity of air corresponding to the increased supply of fuel. In order to render possible a rapid acceleration of the aircraft, the invention provides means for increasing the ratio of the power input to the compressor or compressors to the power available for the propulsion of the aircraft. In a preferred form of embodiment of the invention the power input to the compressor or compressors is temporarily increased, and the power available or the propulsion of the aircraft is simultaneously decreased, also temporarily.

By increasing the input to the compressor at the expense of the propulsion power, the compressor will be able very rapidly to produce compressed air in a quantity considerably exceeding the quantity corresponding to the amount of fuel supplied to the combustion chamber per unit of time. The initial temperature of the driving fluid will then be lowered accordingly, thus allowing a sudden increase of the fuel supply without risk of obtaining non-permissible high temperatures of the motive fluid. When thereupon the fuel supply is increased to a value corresponding to the increased quantity of compressed air, the normal ratio of power input to the compressor to the propulsion power is reestablished, and the aircraft will be accelerated to an extent depending upon the increase in fuel and compressed air. The time required for accelerating the aircraft in the manner described above is considerably shorter than the time which would be necessary for increasing the compressor output by gradually increasing the supply of fuel to the desired amount.

To start the aircraft, the input to the compressor is increased until the speed of the turbine and the compressor has attained the desired value. During this operation only a relatively low amount of fuel is supplied to the combustion chamber, and the greatest portion of the energy derived from the fuel is absorbed by the compressor, the means producing the propulsion power of the aircraft operating at no-load conditions or practically so. If the inlet to the compressor is left fully open, a relatively great amount of air is consequently delivered to the combustion chamber, and the temperature of the motive fluid will be considerably lower than at normal operating conditions. If now the supply of fuel is suddenly increased to a value corresponding to full-load operation, and if the means for producing the propulsion power are simultaneously adjusted to their normal positions so that the ratio of the input to the compressor to the propulsion power attains its normal value, the aircraft will be speeded up very rapidly.

The mode of operation of the aggregate for accelerating the aircraft at landing, for instance to avoid an obstacle, is substantially the same as that described above for the purpose of starting. If the aggregate is assumed to run at half load, for instance, an increase of the compressor input as compared with the propelling power will enable the fuel supply to be suddenly increased to the value corresponding to full-load conditions, and the aircraft can thus rapidly be accelerated, in order to avoid an obstacle or to correct the direction of landing.

If the aircraft is driven only by the rocket effect produced by the turbine exhaust gases being discharged rearwards at high velocities, the ratio of the compressor input to the propulsion power may be increased, according to the invention, by decreasing the back pressure of the turbine exhaust gases or by decreasing the quantity of air compressed by the compressor. In both cases the compressor unit will absorb relatively more power from the turbine than at normal operation.

A decrease of the back pressure of the exhaust gases may be effected by increasing the cross-sectional area of the opening through which the exhaust gases from the turbine leave the aircraft or by opening one or more by-pass conduits for the exhaust gases. In both cases, the back pressure, at which the gas turbine exhausts, and the velocity of the gases discharged from the aircraft will be reduced, whereby also the propulsion power will be simultaneously reduced. The reduction in the back pressure results in an increased heat drop and pressure drop in the gas turbine. The turbine will thus be able to produce more mechanical energy which entirely is absorbed by the compressor. If the amount of fuel supplied to the combustion chamber is the same as that supplied prior to the increase of the outlet opening of the aircraft, the speed of the turbine and the compressor will be increased. If it is desired, however, to maintain constant or substantially constant the speed of the turbine and compressor during the time required for increasing the ratio of the compressor input to the propulsion power, the fuel supply may be decreased accordingly at the instant when the back pressure is lowered. To this end, means may be provided for varying the supply of fuel independently of the normal fuel supply. The said means should be adapted to decrease the supply of fuel if the ratio of the power input to the compressor or compressors to the power available for propulsion of the aircraft is to be increased and to increase the supply of fuel if the normal ratio is to be re-established. If the supply of fuel is decreased, the total amount of energy produced by the aggregate will be lowered accordingly, but, due to the reduction of the back pressure of the exhaust gases, a relatively greater amount of energy than at normal operation will be converted into mechanical power and imparted to the compressor as compared with the power available for the propulsion of the aircraft.

As pointed out above, the ratio of the compresor input to the propulsion power may be increased by decreasing the quantity of air compressed by the compressor. To this end, the compressor intake may be provided with a throttle valve or the like adapted to vary the amount of air drawn in by the compressor. If the air quantity is reduced the quantity of the motive fluid and, consequently, the velocity of the exhaust gases leaving the aircraft and the rocket effect produced by exhaust gases will be decreased. If the fuel supply and thus also the total amount of energy supplied to the unit is assumed to be unaltered, the amount of energy by which the rocket effect has been decreased will be imparted to the compressor and will cause an increase in the compressor speed. From this it follows that the amount of energy converted into mechanical power and imparted to the compressor will be relatively greater than the power available for the propulsion of the aircraft.

Obviously, both methods described above for increasing the ratio of the compressor input to the propulsion power, that is reducing the back pressure of the exhaust gases and decreasing the amount of air to be compressed by the compressor, may be used in the same aggregate, in which case the effects of the same will be summarized.

The means described above for varying the compressor input to the propulsion power will also give the desired result if the propulsion power is produced partly by one or more air screws driven by the gas turbine and partly by the rocket effect of the exhaust gases leaving the aircraft.

Assuming the driving aggregate consisting of a gas turbine driving a compressor and a propeller, and the exhaust gases of the turbine being discharged rearwards at high velocities, the energy supplied to the system by means of fuel injection will be utilized to drive the compressor and the propeller and to produce the rocket effect, the propulsion power thus consisting of the sum of the tractive force exerted by the propeller and the rocket effect produced by the exhaust gases. By reducing the back pressure of the exhaust gases below the value corresponding to normal operation the rocket effect will be diminished or entirely taken away. Assuming the fuel supply remaining unaltered, the amount of energy lost for the purpose of producing a rocket effect will be imparted to the compressor and to the propeller. Thus the power input to the compresser will be increased and the sum of the propulsion effects will be decreased accordingly. If the fuel supply is decreased, in order to keep the speed of the gas turbine aggregate constant or substantially constant during the operation for accelerating the aircraft, rocket effect, the compressor input and the tractive force of the propeller will be decreased in accordance therewith. By simultaneously decreasing the back pressure and the fuel supply the ratio of the compressor input to the propulsion power may thus be increased at substantially constant speed of the turbine and propeller. As in the examples described above, a rapid acceleration of the aircraft is then effected by rapidly increasing the fuel supply.

Instead of or in addition to decreasing the back pressure of the exhaust gases the increase of the ratio of the compressor input to the propulsion power may be attained by decreasing the amount of air to be compressed in the compressor. The operation will be substantially the same as that described above with reference to an aggregate utilizing the rocket effect only, and the amount of energy corresponding to the decrease in rocket effect will be imparted partly to the compressor and partly to the propeller, thus increasing the compressor input relatively to the sum of the propulsion powers.

The ratio of the compressor input to the propulsion power may also be increased by increasing the slip of the propellor. To this end the propeller is provided with adjustable blades for varying the pitch. By adjusting the blades in such a manner that the resistance to the rotating movement thereof is reduced the propelling power will be decreased and a relatively greater portion of the gas turbine output will be absorbed by the compressor. The arrangement of adjustable blades may obviously be combined with one or more of the means described above for varying the back pressure of the exhaust gases and for varying the quantity of air drawn in by the compressor.

If the aircraft is driven only by means of an air screw, the ratio of the compressor input to the propulsion power may be varied either by adjusting the blades of the air screw or by varying the air quantity drawn in by the compressor or by utilizing both means at the same time. The mode of operation is substantially the same as that described in conjunction with the previous examples and needs no further explanation.

The accompanying drawing shows diagrammatically three embodiments of the invention.

Fig. 1 illustrates a propulsion unit for an aircraft driven partly by an air screw and partly by the rocket effect of the exhaust gases and provided with means for varying the back pressure of the gas turbine and the pitch of the air screw. Fig. 2 shows a propulsion unit for an aircraft driven by the rocket effect only, and Fig. 3 shows an example for varying the quantity of air drawn in by the compressor.

In the embodiment illustrated in Fig. 1, the driving aggregate is enclosed in a casing 1 which is substantially formed on stream-lines. 2 designates a rotary compressor of the centrifugal type, which is mounted on a shaft 3 supported in bearings 4 and 5. Air which is drawn in through inlets 6 and 7 is conducted after compression through an annular space 8 surrounding the combustion chamber 9 and into the latter. The fuel, such as oil, is supplied by means of a fuel pump 37 through the fuel pipe 38 and through nozzles 10 and 11 into the combustion chamber 9. From the combustion chamber in which the compressed air is heated by the fuel, the combustion gases enter the gas turbine 12, which is also mounted on the shaft 3, and pass through the same, and then leave the turbine through the outlet channel 13, which is freely open toward the rear in the axial direction. Connected to the inner portion of the turbine outlet 14 is an end cap 15 which is restricted rearwardly, preferably on stream-lines. The channel 13 formed between the cap 15 and the outer wall 16 of the outlet decreases in cross section towards the outlet opening 17 of the aeroplane so that the exhaust gases discharged from the turbine 12 at relatively high back pressure and low velocities will leave the outlet 17 at high velocities and thereby produce the desired rocket effect. In the embodiment illustrated, the propulsion power is produced partly by the rocket effect of the exhaust gases and partly by means of an air screw 19. The propeller shaft 20 is connected to the shaft 3 by means of a speed reduction gear 21.

A portion 22 of the wall of the outlet channel 13 is movable about a pivot 23 so that, by means of a suitable link or the like adjustable from the pilot's cockpit, it may be brought into the position denoted at 22^1, in which the outlet opening 17 is considerably increased. With the flap 22 in the position 22^1 the outlet velocity of the gases leaving the channel 13 and the rocket effect produced by the gases will obviously be reduced, and the back pressure behind the turbine will be lowered. From this it follows, as pointed out introductorily, that the compressor will receive a greater percentage of power from the turbine and that the propulsion power due to the rocket effect will be less than with the flap in its normal position 22. If the supply of fuel has not been decreased, the total propulsion power will also be momentarily decreased and the gas turbine aggregate will increase its own velocity and consequently that of the air screw. If, on the other hand, the supply of fuel is decreased simultaneously with the opening movement of the flap 22, the speed of the turbine aggregate and the propeller may be kept substantially constant, the ratio of the compresser input to the sum of the propulsion power being increased only.

Instead of or in addition to the flap 22 at the outlet of the channel 13 a flap valve 24 may be arranged adjacent to the turbine outlet 14. If this flap valve is opened, a certain portion of the exhaust gases are directly conducted through the by-pass conduit 25 to the atmosphere, and the back pressure as well as the rocket effect are then decreased accordingly.

Fig. 1 also shows schematically a device 26 suitably connected to the pilot's cockpit and adapted for varying the angular position of the propeller blades for the purpose of reducing the resistance to rotation.

In the embodiment illustrated in Fig. 2, the aeroplane is assumed to be driven by means of the rocket effect only. As shown, the compressor may be of the screw or worm type and consists of two rotors 27 and 28 each of which cooperates with an appertaining rotor located behind the plane of the drawing. The rotors are connected to the turbine shaft 3 by means of suitable gears 29. The air inlets to the compressors 27 and 28 are indicated at 30 and 31. As in the example illustrated in Fig. 1, the compressed air is conducted through an annular space 8 into the combustion chamber 9 into which fuel is injected through nozzles 10 and 11. The exhaust gases from the turbine 12 are normally discharged at high velocity through the outlet opening 17, the cross section of which is smaller than the cross section of the turbine outlet. Two conduits 32 and 33 provided with valves 34 and 35 respectively are connected to the turbine outlet, the outlet opening of the channel 32 being substantially directed forwards and the outlet opening of the channel 33 being substantially directed downwards. A valve 36 is provided in the channel 13.

With the valves 34, 35 and 36 in the position indicated in full lines, the exhaust gases are discharged through the outlet opening 17 and thereby produce a certain rocket effect. If, however, the valve 34 and/or valve 35 are opened, the back pressure of the exhaust gases and the rocket effect will be reduced. If the valve 36 is then closed, the gases can be discharged through the channels 32 and/or 33 only and, due to the direction of the conduits 32 and 33, they will bring about a braking and/or lifting force.

In the embodiment shown in Fig. 3, the turbine 12 drives the rotary compressor 39. As in Fig. 2, the propulsion power is entirely produced by the rocket effect of the exhaust gases. The air intake 40 to the compressor is provided with a valve 41 by means of which the cross-sectional area of the air intake passage may be varied. The position of the valve 41 shown in Fig. 3

corresponds to normal operation. If it is desired rapidly to accelerate the aircraft, the valve is moved into a position in which it throttles the air intake so that only a certain portion of the normal amount of air will be sucked in by the compressor. The fuel supply is preferaby decreased to a corresponding extent, in order to prevent undue rise in the temperature of the motive fluid. Due to the reduction of the quantity of motive fluid, the propulsion power produced by the rocket effect of the exhaust gases will be reduced, while the power input to the compressor will remain substantially constant or be decreased to a lesser extent only. Upon opening the valve 41 and increasing the fuel supply the turbine and the compressor are momentarily enabled to work at full load, and the rapidly increased quantity of motive fluid will produce the rocket effect required for a sudden acceleration of the aircraft.

Obviously the outlet channel of the embodiment illustrated in Fig. 3 may also be provided with one or more of the means shown in Figs. 1 and 2 for varying the back pressure of the exhaust gases. Likewise, the embodiment shown in Fig. 3 may advantageously be used in combination with a propellor.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondents, I declare that what I claim is:—

1. A propulsion unit for aircraft comprising one or more rotary compressors for compressing motive fluid, one or more combustion chambers for heating the compressed motive fluid, one or more gas turbines for driving the compressor or compressors which during the operation of the propulsion unit are always mechanically connected to and rotating with the turbine or turbines, means for controlling the supply of fuel to the combustion chamber or chambers, means for producing propulsion power, and means for increasing at will the ratio of the power input to the compressor or compressors to the power available for the propulsion of the aircraft, so as to allow a rapid increase of the quantity of fuel supplied to the combustion chamber.

2. A propulsion unit as claimed in claim 1, having means for temporarily increasing the power input to the compressor or compressors and for simultaneously and likewise temporarily decreasing the power available for the propulsion of the aircraft.

3. A propulsion unit as claimed in any of the preceding claims, characterised by means for varying the supply of fuel independently of the normal fuel supply.

4. A propulsion unit as claimed in claim 3, in which the means for independently varying the supply of fuel is adapted to decrease the supply of fuel if the ratio of the power input to the compressor or compressors to the power available for the propulsion of the aircraft is to be increased, and to increase the supply of fuel if the normal ratio is to be re-established.

5. A propulsion unit as claimed in any of the preceding claims, characterised by means for varying the back pressure of the exhaust gases from the gas turbine.

6. A propulsion unit as claimed in claim 5, characterised in that the channel leading the exhaust gases from the gas turbine to the outlet opening of the aircraft is provided with flap valves or the like by means of which said outlet opening may be increased and/or the exhaust gases conducted into the atmosphere through by-pass conduits, the outlet openings of which are preferably directed forwards or downwards.

7. A propulsion unit according to any of the claims 1 to 4, characterized by means for varying the inlet cross section of the compressor.

8. A propulsion unit according to any of the claims 1 to 4, in which the air screw is provided with adjustable blades.

9. A propulsion unit as claimed in any of the claims 1 to 4, in whichthe ratio of the power input to the compressor or compressors to the power available for the propulsion of the aircraft is varied by simultaneously using two or more of the means claimed in claims 5 to 9.

10. A propulsion unit for aircraft substantially as described with reference to the accompanying drawing.

Dated this 21st day of April, 1936.
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111/112, Hatton Garden, London, E.C.1.
Chartered Patent Agents.

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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1

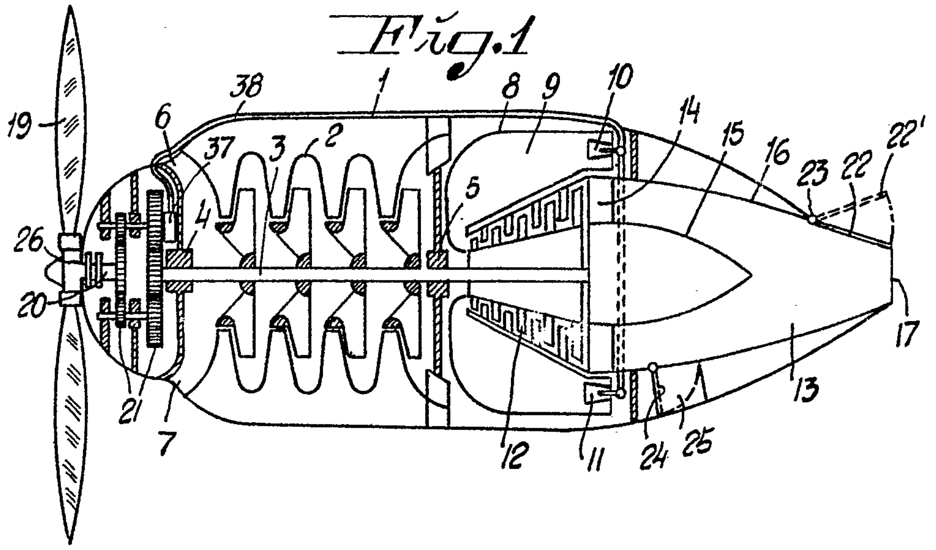


Fig. 2

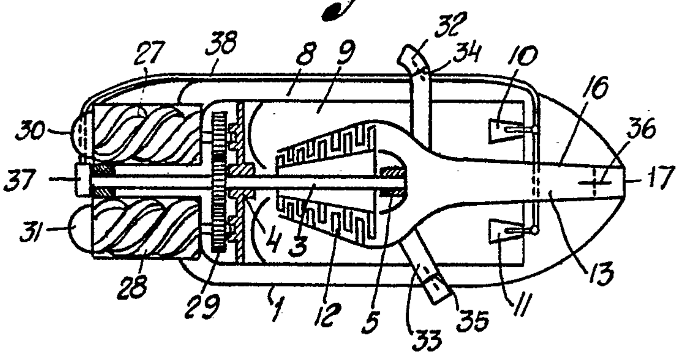
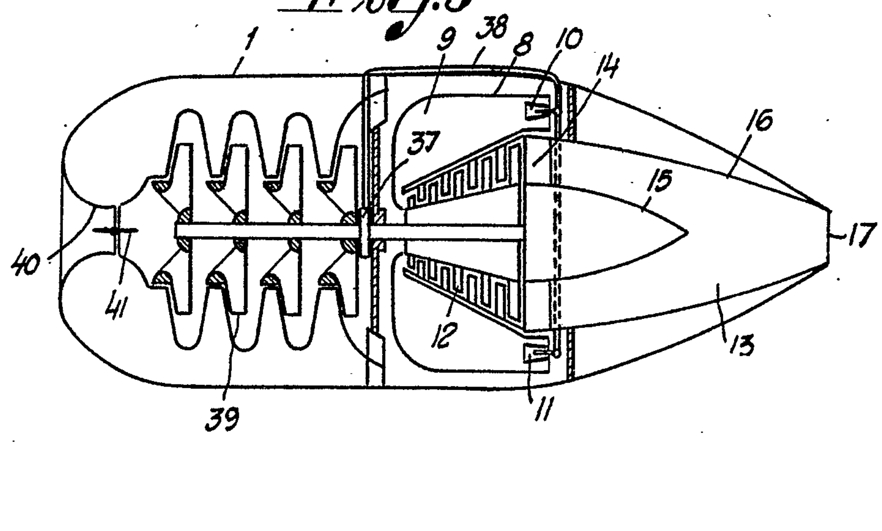


Fig. 3



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