Aug. 22, 1944. R. ANXIONNAZ ET AL 2,356,557

REACTION PROPELLING DEVICE WITH SUPERCHARGED ENGINE

Filed Nov. 28, 1940 2 Sheets-Sheet 1

fig. 1.

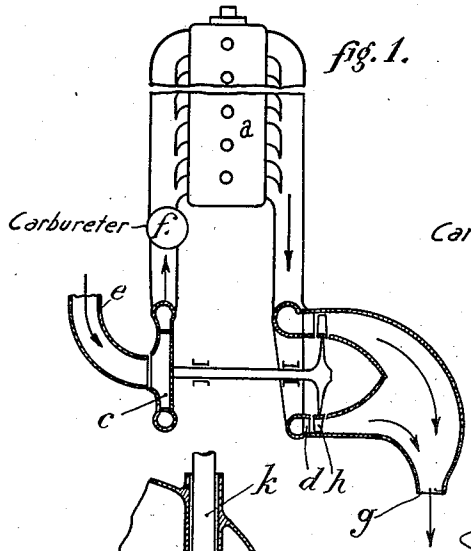


fig. 2

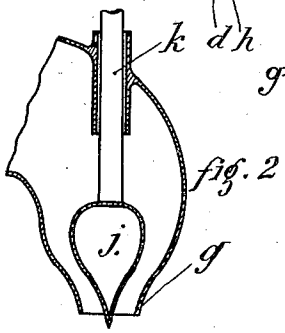


fig. 3

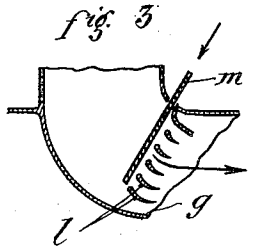


fig. 4

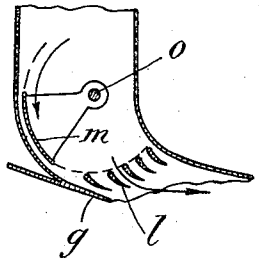


fig. 5

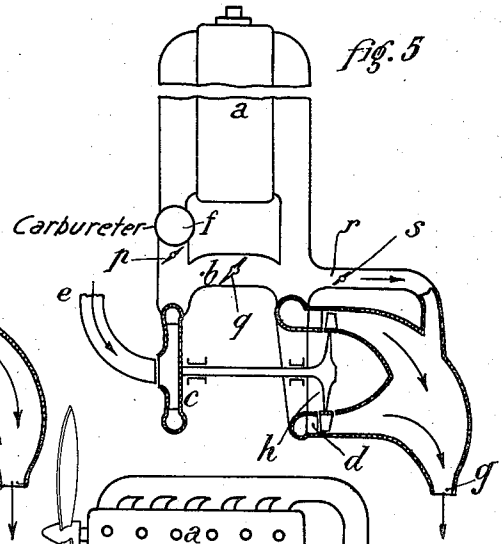


fig. 6

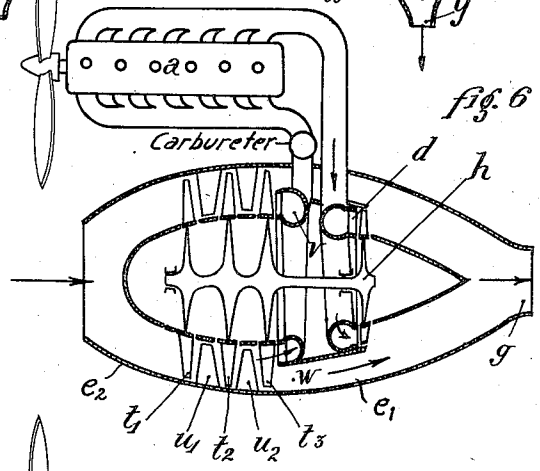
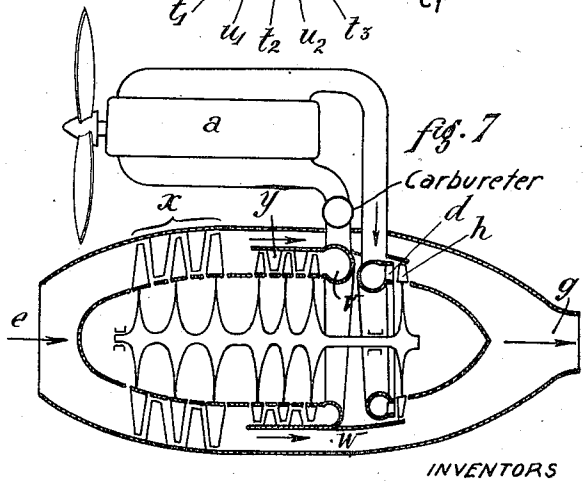


fig. 7



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REACTION PROPELLING DEVICE WITH SUPERCHARGED ENGINE

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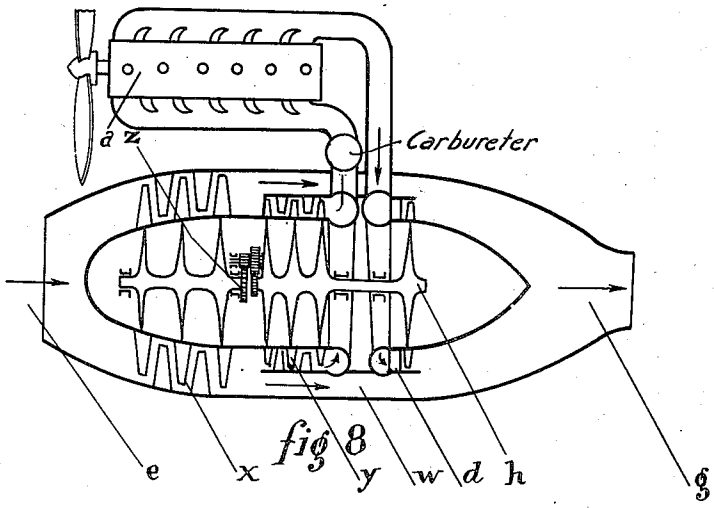


fig 8

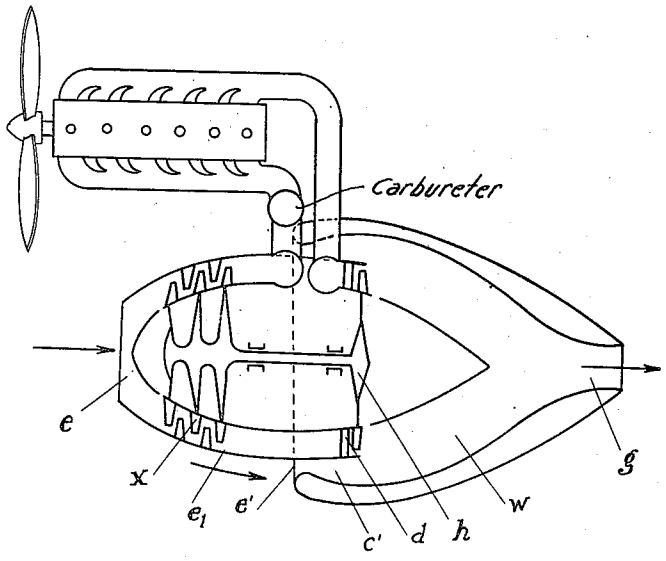


fig 9

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REACTION PROPELLING DEVICE WITH SUPERCHARGED ENGINE

René Anxionnaz, Paris, and Roger Imbert, Mantes, France; vested in the Alien Property Custodian

Application November 28, 1940, Serial No. 367,667
In France December 19, 1939

4 Claims. (Cl. 60—35.6)

The supercharging units of aviation engines, which are constituted by a turbine driven by the exhaust gases and actuating a compressor, are now capable of a very high efficiency. It follows that the power that can be supplied by the gas turbine exceeds what is strictly necessary for driving the compressor. In order to restore the power balance, a portion of the gases have been evacuated into the atmosphere, or a supplementary resistance has been created by a governor, but these arrangements involve a loss of energy.

It has also been endeavored to utilize this excess of power by intensifying the scavenging of the engine, which has been brought up to 60 per cent and even more, but the advantage of this operation is very small because the gain of power which results therefrom for the engine is negligible.

The object of the present invention is to utilize this excess of energy of the exhaust gases with the maximum efficiency in order to improve the propelling effect applied to the airplane, which is tatamount to a material increase of the output of the motor-propeller unit.

According to the essential feature of the present invention, we combine a thermal engine with a turbine operated by the exhaust gases and driving a supercharging compressor and with a reaction nozzle.

This arrangement permits of utilizing in the reaction nozzle the excess of power of the exhaust gases with a very high output, even when the speed of the airplane is relatively low. It even permits of increasing the power of the motor-propeller system without modifying the engine or the fuel consumption thereof, by slightly increasing the exhaust counter-pressure. Finally, it makes it possible to obtain a good regulation of the main engine without loss of power so that said engine can thus preserve its maximum efficiency for all values of the power developed.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

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

Fig. 1 shows the general arrangement of an aviation engine system made according to the present invention;

Fig. 2 is a diagrammatical view showing a device for controlling the section of the nozzle above referred to;

Figs. 3 and 4 are views, similar to Fig. 2 showing modifications.

Fig. 5 shows a modification in which are illustrated regulating means for the gas streams;

Fig. 6 shows an embodiment of the invention provided with an air by-pass leading to a point behind the gas turbine;

Fig. 7 shows an embodiment in which the compressor is divided into two portions;

Fig. 8 is a view similar to Fig. 7, showing a modification; and

Fig. 9 shows an embodiment in which air is fed to the reaction nozzle without compressor.

Fig. 1 shows an aviation engine *a*, which, in this case is supposed to be of the usual gasoline type, with a carbureter, but which might also be of any other type, either of the explosion or combustion kind.

Compressor *c* receives air at *e* through an orifice which is preferably turned in the direction in which the airplane is travelling, in order to take advantage of the compression created by the relative velocity of air. It discharges this compressed air to the suction side of the engine, through the carbureter *f* of any known type.

The exhaust gases from the engine, which are at a pressure higher than atmospheric pressure at the height at which the airplane is travelling, are brought to the gas turbine *d*, where they expand in the distributing nozzles and drive wheel *h*. When leaving said turbine the gases again expand in reaction nozzle *g*, which is turned in the direction opposed to that in which the airplane is travelling. The gases thus produce, owing to the relatively high velocity they have, a driving impulse on the airplane. This action is equal to the product of the mass of gas delivered per second by their relative outlet velocity.

The chief advantage of this arrangement is that it produces a useful work which serves to the propulsion of the airplane, whereas the corresponding loss produced by counter-pressure at the exhaust is much lower. This results from the following calculation:

Considering for instance the case of an engine of 1000 H. P., having a scavenged volume of 600 liters per second, it is known that the output of the exhaust gases of this engine is approximately 1000 grammes per second. If the airplane is flying at a height of 5000 metres, corresponding to an atmospheric pressure of 0.5 kg. per square centimeter, the excessive pressure necessary for imparting to these gases, which are supposed to be at a temperature of 500° C.,

a velocity of 300 meters per second is about 0.097 kg. The thrust produced by these gases is then:

$$F=m\times V=\frac{1}{9.80}\times 300=30.6 \text{ kgs.}$$

If the airplane is moving with a velocity of 150 meters per second, that is to say 540 kilometers per hour, the useful work produced by this thrust is

$$\frac{30.6\times 150}{75}$$

that is to say 61.2 H. P.

This corresponds approximately to a power of 80 H. P. on the propeller shaft. Now, this negative work due to the increase of the counter-pressure of 0.097 kg. which is produced is equal to the product of this excess of counter-pressure by the volume swept, that is to say

$$0.600\times 0.097\times 10{,}000$$

which gives 582 kgm., or about 8 H. P.

Thus, the application of the reaction nozzle in this case ensures a gain of power which is quite substantial in comparison with the results obtained by means of the devices used at the present time. Furthermore, the presence of the nozzle ensures an easy self-regulation of the propelling system. It suffices to provide the reaction nozzle with a device for varying the section of the outlet orifice thereof. It is thus possible to vary the counter-pressure created by this nozzle, and, therefore, the flow through the gas turbine for a given pressure.

This arrangement has the same advantages as the arrangement which would consist in varying the section of the distributing nozzles of the gas turbine but it has the great advantage that it can be operated in flight, owing to a control placed under reach of the pilot's hand.

This results from the following considerations: If the pilot increases the section of the nozzle, the counter-pressure produced by said nozzle is reduced. Consequently, the output of the gas turbine will tend to increase for an unchanged pressure supplied by the compressor therefore, as the driving power of the turbine comes to exceed the resisting power of the compressor, the turbo-blower unit will tend to accelerate and thus increase the supercharging of the propelling engine, which permits of increasing the power supplied by said engine when the throttle valve of carbureter *f* has already been, for instance, fully opened. On the contrary, the same operation in the reversed way, that is to say the reduction of the section of nozzles *g*, reduces the power supplied by engine *a*.

This regulation of power takes place under truly economical conditions, because if the carbureter throttle valve remains fully opened, despite the reduction of the power of the engine, this avoids the losses by wiredrawing which would otherwise take place if the throttle were partly closed, and the efficiency of the propelling engine remains practically constant.

This arrangement is particularly advantageous when it is combined with the provision of a by-pass connecting together the intake and the exhaust of the engine, as shown in Fig. 5 at *b*.

Various means may be employed for varying the section of the outlet nozzle. Figs. 2, 3 and 4 show some of these arrangements.

In the embodiment of Fig. 2, a piece *j* of pointed shape is placed in the central part of the nozzle and it can be moved through a rod *k* controlled by the pilot through suitable means. When moving forward piece *j* toward the aperture of nozzle *g*, the section of said aperture is reduced, and inversely.

In the embodiment of Fig. 3, the nozzle *g* is divided into a plurality of elementary nozzles by means of blades 1. A movable shutter *m* operated by the pilot through any suitable control means permits of obturating a variable number of nozzles formed between blades 1. I thus obtain, according to the number of elementary nozzles left in operation, an adjustment of the section of nozzle *g*.

In the embodiment of Fig. 4, the principle is the same, but shutter *m* is of circular section and pivots about an axis *o*. Owing to the circular shape of the shutter *m* the resultant of the forces, produced by the difference of the pressures existing on the respective faces of the shutter, intersects the axis *o*. The said forces are thus without effect on the moving of the shutter, which is extremely easy.

In all cases, nozzle *g* is suitably directed, so that the jet of gas escaping through the nozzle is turned in the direction opposed to the direction of travel of the airplane.

Fig. 5 shows various other adjustment means.

First, the pilot can operate the throttle valve *p* provided on the intake and which may be combined with carbureter *f*. It is also possible to provide a control valve *q* in bypass *b*, so as to create a difference of pressure between the discharge of the compressor and the intake of the gas turbine, which thus produces an unbalance of the power of these two elements and consequently involves the acceleration of the group when valve *q* opens and a slowing down when it closes.

Furthermore, we may place, on the intake of the gas turbine or on the exhaust of engine *a*, a discharge into the atmosphere, *r*, provided with an adjustment valve *s*. When this valve is opened, a portion of the gases is deviated from the turbine, which therefore tends to reduce the speed of the turbine and consequently the supercharging of the engine.

In order to avoid completely loss of the gases thus discharged into the atmosphere, when the discharge port is to be opened for a long time, it is possible to return the discharged gases into nozzle *g*, but behind the turbine. The gases can thus expand in said nozzle, adding their propelling effect to that of the gases which have passed through the turbine. This arrangement is the one shown by Fig. 5.

As the efficiency of the reaction turbine is the higher as the velocity of the gases which escape therefrom is closer to the velocity of the movement of the airplane, and as the velocity of the gases is as a rule much higher than that of the airplane, it is advantageous, in order to improve the efficiency, to produce in the reaction nozzle only a relatively small expansion, which, therefore, corresponds to a relatively low drop of temperature of the gases.

As the exhaust gases of the engine are very hot, they carry along with them into the atmosphere a relatively important amount of heat, which is thus lost. In order to recuperate a portion of the power corresponding to this heat, the exhaust gases, upon leaving the gas turbine, may be mixed with a certain amount of air, previously compressed but which has not flowed through the engine. This air is heated by its mixing with the gases, and it expands in the nozzle

together with said gases, which improves the propelling effect.

This air may be obtained at the outlet of the supercharging compressor, as shown by Fig. 6. In this embodiment, the compressor is of the axial type, with helicoidal wheels t_1, t_2, t_3 and guides u_1, u_2. The air enters at e in a duct e_1 comprising a forwardly facing entry part e_2 with a divergent form and a rearwardly facing reaction nozzle g with a convergent form. The air entering at e is compressed by the compressor and is collected at the outlet in tore-shaped conduits v which leads it to the intake of engine a. The discharge or exhaust of the engine is connected with the nozzles d of the gas turbine h and upon leaving said turbine, the exhaust gases are mixed with the cold air directly discharged by the compressor through conduit w. This mixture of air and gas then expands in nozzle g to produce the reaction effect.

It may be of interest, in order to obtain a good efficiency, to collect the air which is not to flow through the engine at a pressure lower than that necessary for the supercharging of the engine. This results from the fact that, as above stated, the pressure that can be utilized in nozzle g is relatively low. Consequently, when the compressor is of the multi-stage type, it will be advantageous to take the air in question from an intermediate stage. Such an arrangement is shown by Fig. 7. In this embodiment, the compressor is divided into two parts the first of which, x, acts on the whole of the air that is drawn in. This air is subsequently divided into two streams, one of which passes through the second part, y, of the compressor and serves to the supercharging of the engine. The exhaust gases from said engine drive turbine h and, upon leaving said turbine, are mixed with the cold air from compressor stage x, which flows directly through conduits w. The mixture expands in nozzle g and produces the propelling effect.

In view of the difference of output and of pressure that is necessary for the two compression stages x and y, it may be advantageous to constitute them by machines running at different speeds. Fig. 8 shows an arrangement of this kind in which compressor y is driven directly by gas turbine h, for instance through a shaft common to both of them, while compressor x is driven through a gear train z which makes it possible to drive it at a different speed better adapted to the characteristics required therefrom.

As the drop of pressure utilized in the reaction nozzle is relatively low, the additional air may also be supplied by the very displacement of the airplane in the atmosphere, without making use of a compressor. The air from the atmosphere enters, owing to its relative velocity, through an inlet orifice e' of the rear portion of the duct system designated w' (Fig. 9) in which a portion of its kinetic energy is transformed into pressure. It mixes with the hot gases coming from the exhaust of the turbine, which raise its temperature; then it expands, together with said gases, in nozzle g.

This produces a positive work, although the expansion is in this case equal only to the relative velocity of the inflowing air, because, in the meantime the air has been heated and the speed it acquires in nozzle g for a given expansion is the higher as its temperature is higher. This arrangement might even be employed in the case of an engine which is not supercharged, in which the heating of the air would be directly produced by mixing with the exhaust gases from the engine.

In a general manner, while we have, in the above description, disclosed what we deem to be practical and efficient embodiment of the present invention, it should be well understood that we 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 appended claims.

What we claim is:

1. In combination with an aircraft engine which is adapted to receive supercharging air and which discharges its exhaust gases at a substantially controlled pressure, a motive unit to supply supercharging air to the engine by extracting energy from exhaust gases and also to exert an auxiliary propelling force for assisting in driving the aircraft comprising, a shroud structure extending parallel to the direction of flight adjacent the aircraft engine and having at its forward end an air inlet and at its trailing end a jet outlet, a compressor case positioned within said shroud structure and having an outer surface corresponding to the inner surface of the shroud structure but spaced therefrom whereby a substantially annular passage-way is provided for the passage of the air through the shroud structure about the compressor case, a rotary air compressor mounted within the forward end of said annular passage-way and effective to partially compress the air passing through said passage-way, a second compressor positioned in trailing relationship with respect to the first-named compressor to receive a portion of the partially compressed air discharged therefrom and to deliver its compressed air to the engine, a turbine connected to drive both of said compressors positioned in trailing relationship with respect to the second-named compressor and to receive exhaust gases from the engine, said turbine having a substantially annular discharge at the rear portion of said compressor case whereby it directs a stream of exhaust gases into the annular stream of patrially compressed air which comprises the partially compressed air not received by said second compressor, whereby the exhaust gases and the associated stream of partially compressed air forms a propelling gas mixture which is directed from the jet outlet of said shroud structure to exert a propelling force.

2. Apparatus as described in claim 1 wherein both of said compressors and said turbine are mounted in alignment upon a single rigid shaft.

3. Apparatus as described in claim 1 wherein both of said compressors and said turbine are mounted in alignment and said second turbine is geared to the first-named turbine through a gear reduction assembly.

4. Apparatus as described in claim 1 wherein said shroud structure has a divergent inlet and a convergent outlet.

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