PATENT SPECIFICATION

406,713

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COMPLETE SPECIFICATION.

Improvements in or relating to a Method and Means for the Propulsion of Aircraft.

I, SECONDO CAMPINI, a Subject of the King of Italy, of 3, Viale Cossica, Milan, Italy, 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:—

This invention is for improvements in or relating to the propulsion of aircraft on the known dynamic reaction principle, wherein a fluid which is caused to flow from a conduit in the form of a jet produces an impulse reaction in a direction opposite to that of the jet.

Attempts to propel aircraft on this principle have hitherto not been successful. It has been found that the thrust generated by the compressors of the propulsion plant has been insufficient of itself for the purposes of taking off; also in flight the efficiency of the plant is low due to the numerous friction losses that obtain in the air conduits and bends leading to and from the compressors and owing further to the high velocity of the intaken air, the excessive weight of the parts of the plant serving to increase the energy of the intaken air and the low efficiency of the thermal means (when provided) to this end.

The object of the present invention is to provide certain improvements in the method and means of propulsion of an aircraft on the dynamic reaction principle referred to, which will ensure both the taking-off of the aircraft and a higher order of efficiency of propulsion than has been possible hitherto in the aforesaid known attempts and, in short, will permit the attainment of a high velocity and great heights.

According to the invention, a method of reaction propulsion of aircraft consists in causing inflow of the air for propulsion, preferably by relative motion alone or mainly of the craft through the air, by way of an air intake which is of such form and position that the air flows into it without substantial change of direction of flow and the kinetic energy of the inflowing air is substantially entirely transformed into pressure energy, increasing the pressure of the intaken air by mechanical compression after it has passed through the intake and so heating the intaken air so compressed and at the same time permitting its discharge into the surrounding atmosphere in a direction opposed to the direction of movement of the craft, that the pressure of the compressed air is not substantially increased by the heat imparted to it and the total energy of the heated air becomes substantially entirely transformed upon its discharge into the atmosphere into kinetic energy.

The invention includes, moreover, a propulsion plant for aircraft, operable in accordance with the foregoing improved method of aircraft propulsion, which plant comprises in combination an air intake of such form and position in the craft as to avoid imposing upon the incoming air substantial change of direction of flow and also to occasion transformation of the kinetic energy of the incoming air substantially entirely into pressure energy, a mechanical compressor for the intaken air, a heater for imparting heat to the compressed air and thereby still further increasing its total energy and a discharge outlet for the heated compressed air, the said outlet terminating in a nozzle directed away from the direction of motion of the craft and being of such a form as to ensure substantial avoidance of increase of pressure in the compressed air as it becomes heated in the heater and at the same time transformation of the total energy of the compressed and heated air substantially entirely into kinetic energy at the orifice of the nozzle.

According to a feature of the invention, the air intake of the propulsion plant is preferably of progressively increasing cross sectional area substantially entirely throughout its length.

According to a modification, more especially in the case of aircraft intended for exceptionally high speed of travel, the said air intake may be of progressively decreasing cross sectional area for a part of its length at the inlet end and then for the remainder of its length of progressively increasing cross sectional area.

The inlet orifice of the intake is, according to another feature of the invention, of narrow elongated form. Thus, in a preferred embodiment of the invention, the inlet orifice of the intake faces the direction of normal motion of the craft extends along the girth of the skin surface of the craft and is of narrow elongated form so that the fluid drawn in is the layer of air immediately adjacent said skin surface.

Conveniently, in the case of an aeroplane, the inlet orifice of the air intake may extend substantially completely around the fuselage of the craft.

Other features of novelty will appear in the following further description of the invention and will be severally claimed in the accompanying statement of claim.

The drawings appended hereto illustrate several embodiments of the invention by way of example. In the drawings,

Figure 1 diagrammatically represents an airship gondola fitted with a reaction propulsion plant in accordance with the invention;

Figure 2 illustrates a detail hereinafter described;

Figure 3 is an outside elevation of an aeroplane fitted with a propulsion plant in accordance with the invention;

Figure 4 is a longitudinal central section through the aeroplane shown in Figure 3;

Figure 5 illustrates a further detail hereinafter described, this detail relating to the arrangement shown in Figures 3 and 4;

Figure 6 is an inverted plan of the aeroplane shown in Figures 3 and 4;

Figure 7 is a longitudinal central section through an aeroplane embodying a modified form of propulsion plant in accordance with the invention, and

Figures 8 and 9 are transverse sections through the craft illustrated in Figure 7, these sections being taken on the section lines 8—8, 9—9 respectively, of said Figure.

Referring first to Figure 1, the propulsion plant comprises an air intake 3 having an inlet orifice 1, a mechanical compressor 4 for imposing an increase of pressure upon the intaken air, a heater 5 for imposing a further increase of pressure upon the intaken and now compressed air and a discharge outlet 6 for the compressed air terminating in a nozzle 7. The nozzle 7 is of decreasing cross sectional area towards its orifice end and the intake 3 is of progressively increasing cross sectional area in the direction away from its inlet orifice 1.

The compressor 4, which may be of any suitable type, for example may be a centrifugal pump or a rotary vane pump or a helical pump, is driven by a motor 0, which may also be of any convenient kind.

The air intake 3 may, according to another feature of the present invention, be provided with an auxiliary inlet 2^1 controlled by a suitable valve operable either manually or else automatically, for example by a device incorporating a servo-motor, during the period of starting of the craft or during its travel through the air at relatively low speeds, the said valve being opened or arranged automatically to open upon the pressure within the intake failing below that of the atmosphere outside.

The said auxiliary inlet may be situated at any desired position on the external surface of the craft, and its valve is arranged automatically to close upon the pressure within the air intake increasing, owing to increased velocity of the craft through the air, to the pressure of the external atmosphere.

As previously indicated herein, the air intake of the improved aircraft propulsion plant according to this invention, may be of progressively decreasing cross sectional area for a part of its length at the inlet end and then for the remainder of its length of progressively increasing cross sectional area. Figure 2 represents a convenient arrangement embodying this feature. As shown in this Figure, the inlet orifice 1 of the air intake 3 is located just beyond the external surface of the craft and the general longitudinal axis of the air intake approximately coincides with the direction of lines of flow of the layer of air immediately surrounding said external surface of the craft. The said layer of air therefore enters the intake substantially without interruption or disturbance of flow. Upon entry into the intake, the air flows along the diverging intake, losing velocity on the way, into a pressure conduit 9, the form and length of which may vary substantially to suit requirements in any given case. The immediate foregoing, in referring to the air upon entry into the intake flowing along the diverging intake, assumes the parts represented in Figure 2 in the full-line positions. The arrangement shown in Figure 2, however, is one in which by an appropriate adjustment of the parts the intake may at will be either a wholly divergent intake (the full-line position referred to of the parts) or a partially convergent and partially divergent intake. To this end, the wall 12 of the intake comprises a movable extension portion 13 which is capable of sliding from the full-line position shown to the dotted-line position or to any position between, according to the speed of the craft and correspondingly to the extent of adjustment required of the form of the intake from a wholly divergent form to a partly convergent and partly divergent form.

With further reference to Figure 2, the auxiliary inlets to the air intake 3 are several in number as shown extending circumferentially around the skin surface of the craft, and they are arranged to be opened and closed by rotation of a valve plate 2*a* about the axis of said skin surface, the said plate 2*a* being formed with apertures 2*b* corresponding in shape and position to the inlet apertures 2^1 so that by rotation of the plate the said apertures 2^1 may be partially or entirely closed at will according to the extent of rotation of the plate, or the apertures may be closed by means of a cylindrical sleeve disposed externally or internally of the plate 2*a* and capable of opening or closing, simultaneously, all the supplementary ports through simple axial displacement.

The air intake of the plant is preferably sub-divided longitudinally by a series of partitions 16 (Figure 3) into separate air channels serving to divide the stream of air flowing along the intake into small sub-streams and thereby, in virtue of consequent avoidance of turbulence and eddy currents, to convey the air with greater efficiency of energy transformation into the pressure conduit 9. The said partitions 16 further serve to reinforce the walls of the intake.

Referring now to Figures 3, 4, 5, 6 more specifically, 1 is the inlet of the air intake, 3 the intake itself, 4, 4^1 are a pair of centrifugal compressors arranged in series with one another within the fuselage of the aircraft, 5 is a combustion chamber supplied with compressed air delivered from the compressors 4, 4^1, by way of a heat radiator 25 for cooling the water circulating through the water jackets of the motor O driving the pumps 4, 4^1, and burners 20, 21, arranged to consume pulverised fuel or if desired liquid fuel, and 7 is the discharge nozzle of the propulsion plant, this nozzle being controlled at will, as to its cross sectional area, by means of a conical valve 22 movable axially along the axis of the nozzle 7 after the manner of the adjustable nozzle of a Pelton turbine.

The air for propulsion enters the intake 3 by way of the inlet 1 thereof, flows along the intake and by way of the pressure conduit 9 into the first of the compressors 4. This compressor, as also the other compressor 4^1, is of the type having increased diametral dimensions of the fan, inclusive of the bend 17, whereby the air is compelled to leave the pump in the same axial direction as that in which it entered, namely in a direction parallel with the fore-and-aft axis of the craft, the air thence being discharged through an annular outlet 18 the discharge nozzle 19 of which is of annular form corresponding to the internal contour of the aeroplane fuselage.

It may be remarked that it is characteristic of the improved propulsion plant for aircraft according to the present invention that the suction conduit of the compressor of the plant normally operates with a positive pressure.

The purpose of the burners 20 aforesaid is to raise the temperature of the compressed air pumped into the chamber 5 by the compressors. By so increasing the temperature of this air, the pressure remaining constant, the discharge velocity of the air is increased. The provision, therefore, of a combustion chamber as described, located between the compressors and the discharge nozzle of the propulsion plant, is equivalent to the provision of one or more other mechanical compressors, but with the advantage that the increase in discharge velocity of the compressed air is obtained without expenditure of mechanically applied energy. Also, the arrangement referred to enables extremely high discharge velocities of the compressed air to be obtained with relatively low air pressures. Moreover, by the employment of a combustion chamber or chambers in place of an additional compressor or compressors, a substantial saving in weight of plant is realised.

The combustion chamber 5 may be lined with refractory material, and its form will, as will be appreciated, depend upon the contour of the aeroplane fuselage.

The pulverised or other fuel is projected by the burners 20 into the lined combustion chamber where it immediately burns by the heat imparted to it by the walls of the chamber, these walls being arranged to retain and inwardly radiate the heat derived from the combustion of the fuel within the chamber.

The fuel is admitted into the interior of the burners 20 by way of a number of minute apertures and the burners, projecting their supply of fuel into the combustion chamber 5 under the action of the blast of air from the compressors 4, 4^1, assist in preventing back-firing from the combustion chamber.

Conveniently, the fuel is arranged to be drawn into the burners 20 by ejector action, the burners being constructed with throats as shown and the fuel being entrained into these throats by way of the apertures aforesaid by the current of air blowing through the burners from the compressors.

The combustion chamber 5, or more particularly the portion thereof subjected to high temperatures, is preferably thermally isolated, either by an internal refractory lining consisting of a metal sheet spaced from the wall of the chamber by a space filled with air or insulating material, or by means of a thin ring 24 of refractory material separated from a sheet metal casing surrounding it by an air space, through which is circulated air under pressure drawn from the interior of the combustion chamber at the cooler (forward) end thereof; by this means, the sheet metal casing referred to is prevented from becoming red hot and high temperatures may safely be attained in the combustion chamber without undue heat losses and without weakening of the heat-resisting parts.

If desired, this annulus of refractory material may be built up of thin superposed annular layers of the material, separated by intersticial air spaces communicating with the interior of the combustion chamber for equalisation of air pressure on both faces of each layer with the pressure obtaining in the chamber and consequent relief of mechanical stress upon the component parts of the annulus.

The parts of the craft in the neighbourhood of the combustion chamber which would tend to become over-heated may be cooled by heat transference to a cooling medium circulated to and from a radiator carried either within the fuselage or other body of the craft or situated externally thereto.

For the purposes of starting combustion in the combustion chamber, any desired form of ignition means may be employed. For example, the combustion chamber may be provided with an electric spark device or with an incandescent electric wire igniter.

During normal running, it is advisable to maintain an ignition device in actual operation within the combustion chamber. This device may also be an incandescent electric wire igniter or alternatively a pilot burner consuming sprayed fuel, for example.

The cabin for the crew of the aircraft is disposed at the forward end of the craft in advance of the annular air inlet 1 of the intake. The cabin, which may be hermetically sealed, constitutes an independent unit and is secured to the fuselage in such a manner as to be readily releasable therefrom, for example, through the medium of a hand-wheel 29 located within the cabin, so that in the event of an accident, the cabin may be released from the rest of the craft and be permitted thereafter to fall independently under the support of a parachute attached to it.

An entrance 30 is provided in the forward end of the cabin. This entrance is closed by an air-tight door operable from the interior of the cabin.

Respiration within the cabin is ensured by a supply of liquid air, or by using the air that has been compressed by the compressor of the propulsion plant, the compressed air first having been cooled for example by being flowed through cooling pipes disposed upon the wings of the aircraft or around the skin surface thereof.

The air for the engine feed, that is to say for combustion in the motor O, may be drawn from the current of air flowing from the compressors to the heater of the plant, the said motor being cooled as already described by means of water circulated through the engine to and from a radiator 25 interposed between the compressors and the heater.

With this arrangement, as will be appreciated, heat calories dispersed during the cooling of the air are transferred to the air current employed for the propulsion of the craft, and in this manner an economy is effected in the fuel consumption of the burners.

Referring now to Figures 7, 8 and 9, these Figures illustrate an arrangement wherein the air inlet orifice of the intake of the propulsion plant is of non-annular form, the nose of the intake 3 being open at the front at 1*a* as shown. The air entering the inlet 1*a* flows along the divergent intake conduit 3, along the walls of the cabin 18, through the multiple pump compressor 4, impeller rings (not shown), radiator 25, burners 20, combustion chamber 5 and out through the discharge nozzle 7.

The cross sectional area of the discharge nozzle 7 may in this arrangement be varied at will either by axial movement of a conical valve 22 as above described or by adjustment of a series of vanes 23 the inclination of which relatively to the axis of the nozzle may be varied as desired.

The compressors 4 of the arrangement shown in Figure 7 are of the helicoidal type and for this reason several are employed in series as shown in order to secure the requisite delivery pressure of the compressed air.

It may be remarked with regard to the air intake of the improved propulsion plant according to this invention that if the intake were not of the gradually divergent-walled form described, the propulsion efficiency of the plant would be very materially reduced. Also, the provision of a compressor for the intaken air is essential for the starting, taking off and climbing of the craft.

The improved method and propulsion plant for aircraft which is provided by the present invention enables starting, taking off and climbing to the desired altitude to be effected in a highly efficient manner and permits flight at stratosphere regions with a higher efficiency of propulsion than has been possible heretofore.

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

1. A method of reaction propulsion of aircraft which consists in causing inflow of the air for propulsion, preferably by relative motion alone or mainly of the craft through the air, by way of an air intake which is of such form and position that the air flows into it without substantial change of direction of flow and the kinetic energy of the inflowing air is substantially entirely transformed into pressure energy, increasing the pressure of the intaken air by mechanical compression after it has passed through the intake and so heating the intaken air so compressed and at the same time permitting its discharge into the surrounding atmosphere in a direction opposed to the direction of movement of the craft, that the pressure of the compressed air is not substantially increased by the heat imparted to it and the total energy of the heated air becomes substantially entirely transformed upon its discharge into the atmosphere into kinetic energy.

2. A reaction propulsion plant for aircraft which comprises in combination an air intake of such form and position in the craft as to avoid imposing upon the incoming air substantial change of direction of flow and also to occasion transformation of the kinetic energy of the incoming air substantially entirely into pressure energy, a mechanical compressor for the intaken air, a heater for imparting heat to the compressed air and thereby still further increasing its total energy and a discharge outlet for the heated compressed air, the said outlet terminating in a nozzle directed away from the direction of motion of the craft and being of such a form as to ensure substantial avoidance of increase of pressure in the compressed air as it becomes heated in the heater and at the same time transformation of the total energy of the compressed and heated air substantially entirely into kinetic energy at the orifice of the nozzle.

3. A propulsion plant for aircraft as claimed in Claim 2, wherein the air intake is of progressively increasing cross-sectional area substantially entirely throughout its length.

4. A propulsion plant for aircraft as claimed in Claim 2, wherein the air intake is of progressively decreasing cross-sectional area for a part of its length at the inlet end and then for the remainder of its length of progressively increasing cross-sectional area.

5. A propulsion plant for aircraft as claimed in Claim 4, wherein the inlet end of the air intake is adjustable at will to convert the intake from one in which in accordance with Claim 3 the cross-sectional area progressively increases from the inlet end substantially entirely along the length of the intake to an intake in which according to Claim 4 the cross-sectional area first decreases from the inlet end and then for the remainder of the length of the intake progressively increases.

6. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 5, wherein the inlet orifice of the air intake is of narrow elongated form.

7. A propulsion plant for aircraft as claimed in Claim 6, wherein the inlet orifice of the intake faces the normal direction of motion of the craft, extends along the girth of the skin surface of the craft and is of narrow elongated form so that the air drawn in to the intake is the layer immediately adjacent said skin surface.

8. A propulsion plant for aircraft as claimed in Claim 7 wherein the inlet orifice of the air intake extends substantially completely around the fuselage or other body of the craft.

9. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 8, wherein the air intake is subdivided by partitions which extend along the interior of the intake in the direction of length thereof and divides said interior into a plurality of separate intake passages leading with a minimum of tortuity from the inlet end of the intake toward the outer end thereof.

10. A propulsion plant for aircraft as claimed in Claim 5, wherein the adjustability of the intake is provided for by constructing the intake with an inlet extension movable to and from an operative position in which it extends forwardly beyond the normal position of the inlet orifice of the intake, the form of the said extension being such that with the extension in the operative position, the cross sectional area of the intake so extended progressively decreases to said normal position of the inlet orifice, and then progressively increases.

11. A propulsion plant for aircraft as

claimed in any of the preceding Claims 2 to 10, wherein the air intake is provided with a supplementary inlet for use in starting the craft, taking off and climbing.

12. A propulsion plant for aircraft as claimed in Claim 11, wherein the supplementary inlet is combined with automatic closure means operative to open the inlet upon the pressure within the intake falling below the external pressure outside and to close the inlet upon reversal of these pressure conditions.

13. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 10, wherein the air intake is provided with a plurality of supplementary inlets for use in starting the craft, taking off or climbing, combined with closure means consisting of a slidable shutter common to all of the inlets.

14. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 13, wherein the inlet orifice of the intake is located at a position upon the skin surface of the craft where the layer of air immediately adjacent said surface is moving with the craft at the greatest velocity and where, consequently, the inlet velocity of the intake air relatively to the wall of the intake is a minimum.

15. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 14, wherein the discharge nozzle is of adjustable cross-sectional area, for example by means of a conical valve (22) coaxial with the nozzle and movable endwise in relation thereto.

16. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 15, wherein the mechanical means for increasing the pressure of the intaken air comprises a centrifugal compressor or a series of helicoidal pumps.

17. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 15, wherein the mechanical means for increasing the pressure of the intaken air comprises one or more compressor units each consisting of a fan with a diffuser at the outlet end.

18. A propulsion plant for aircraft as claimed in Claim 16 or 17, wherein the motor of the compressor or pumps is an internal combustion engine, the air for the engine feed of which is drawn from the air flowing from the compressors.

19. A propulsion plant for aircraft as claimed in Claim 18, wherein the engine is cooled by a medium circulating to and from a radiator disposed in the path of the air from the compressors.

20. A propulsion plant for aircraft as claimed in any of the preceding Claims 2 to 19, wherein the heater for the compressed air comprises a combustion chamber through which the compressed air is passed, in combination with a burner for example of the liquid or solid fuel type.

21. A propulsion plant for aircraft as claimed in Claim 20, wherein the parts of the craft in the neighbourhood of the combustion chamber which would tend to become over-heated are cooled by heat transference to a cooling medium circulated to and from a radiator carried either within the fuselage or other body of the craft or situated externally thereto.

22. A propulsion plant for aircraft operating upon the reaction propulsion principle, constructed, arranged and adapted to function substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 4th day of August, 1933.

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Agents for the Applicant.

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

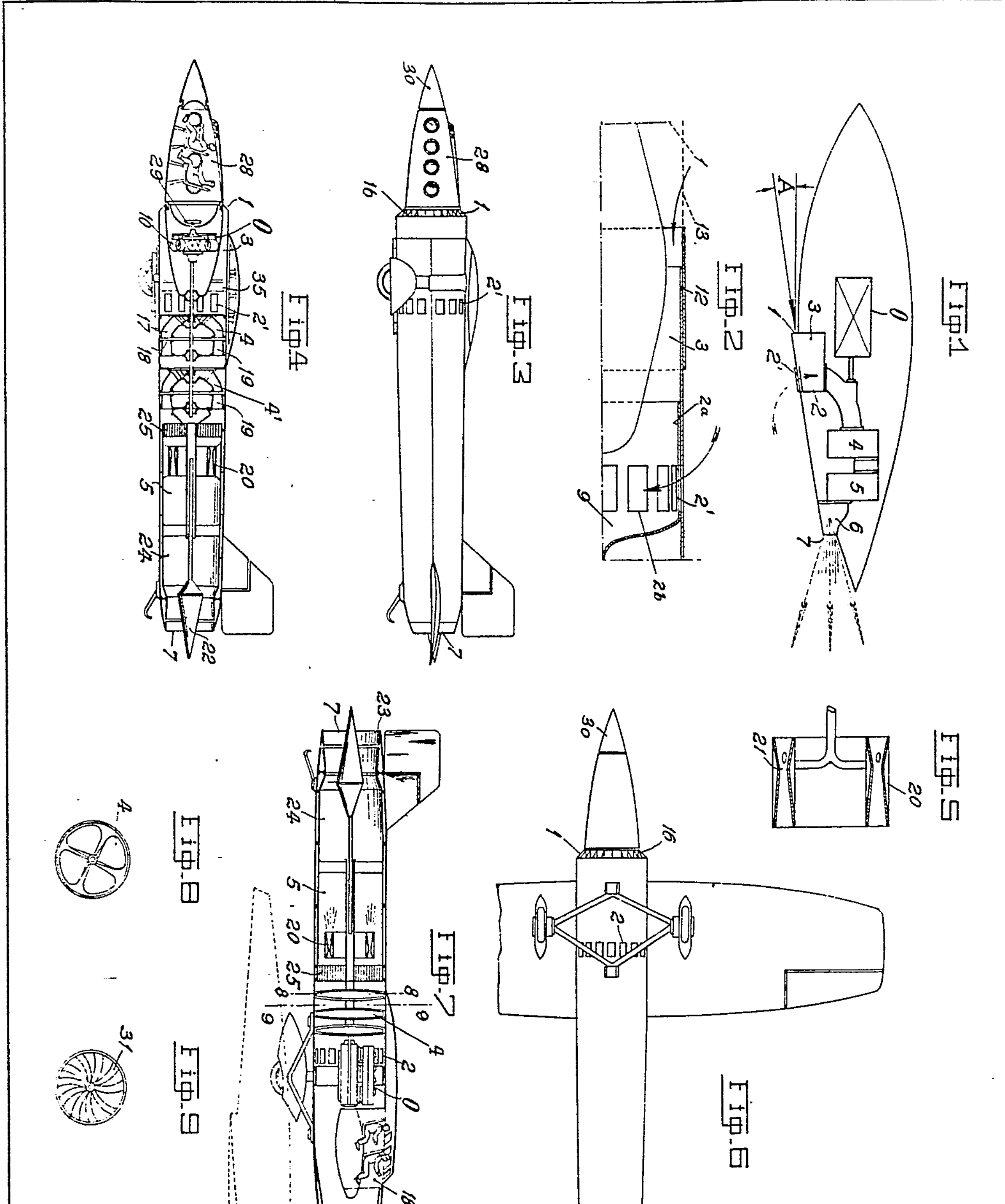


Fig. 1

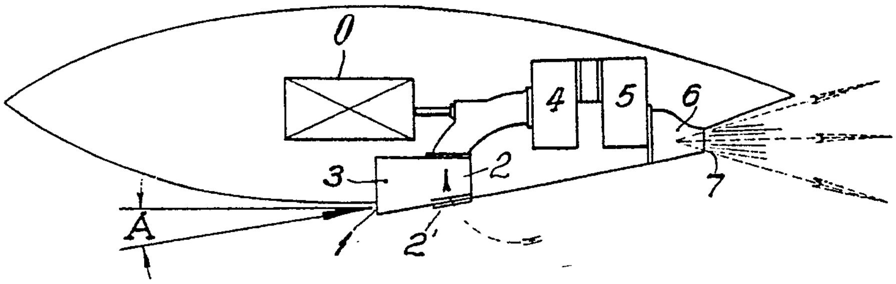


Fig. 2

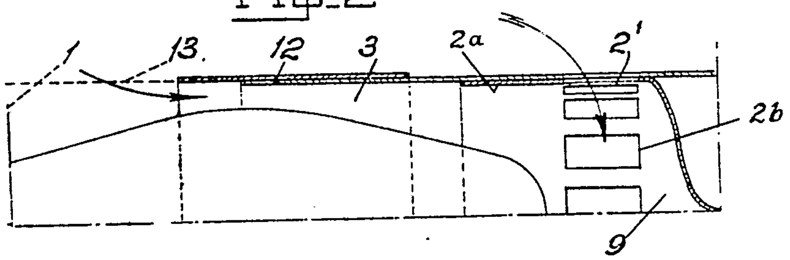


Fig. 3

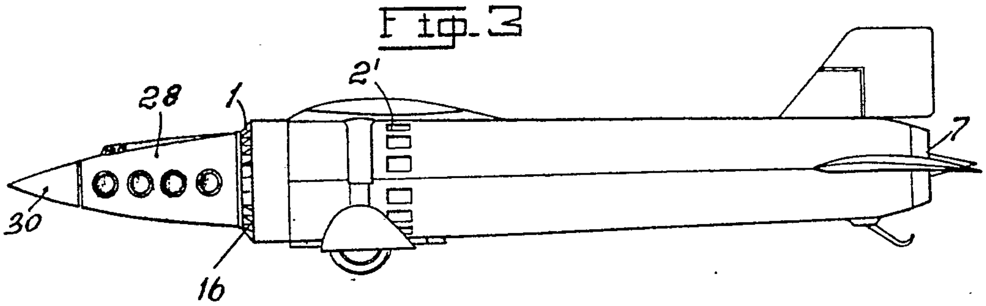


Fig. 4

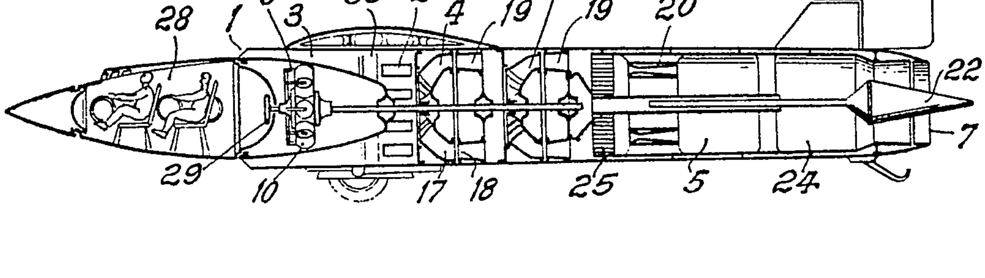


Fig. 5

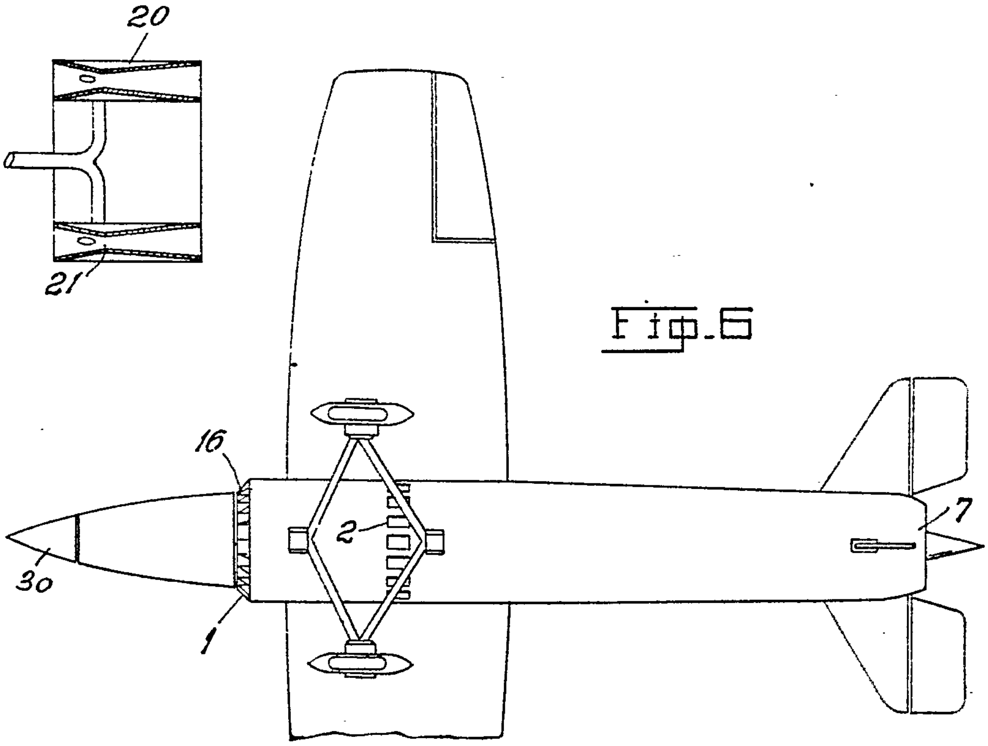


Fig. 6

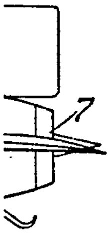
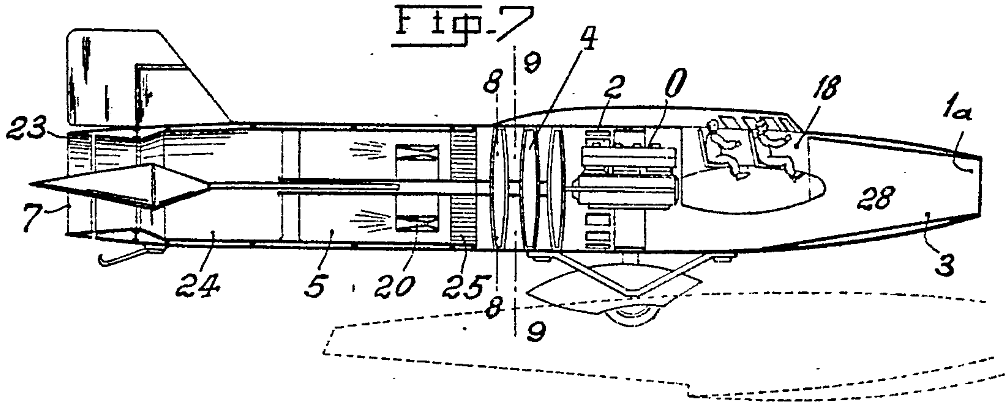


Fig. 7



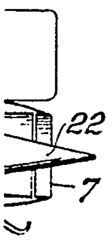


Fig. 8

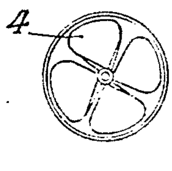
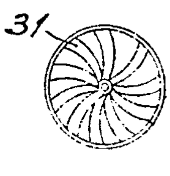


Fig. 9



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