Oct. 2, 1962 F. C. I. MARCHANT ETAL 3,056,258

AIRCRAFT PROPULSION POWER UNITS

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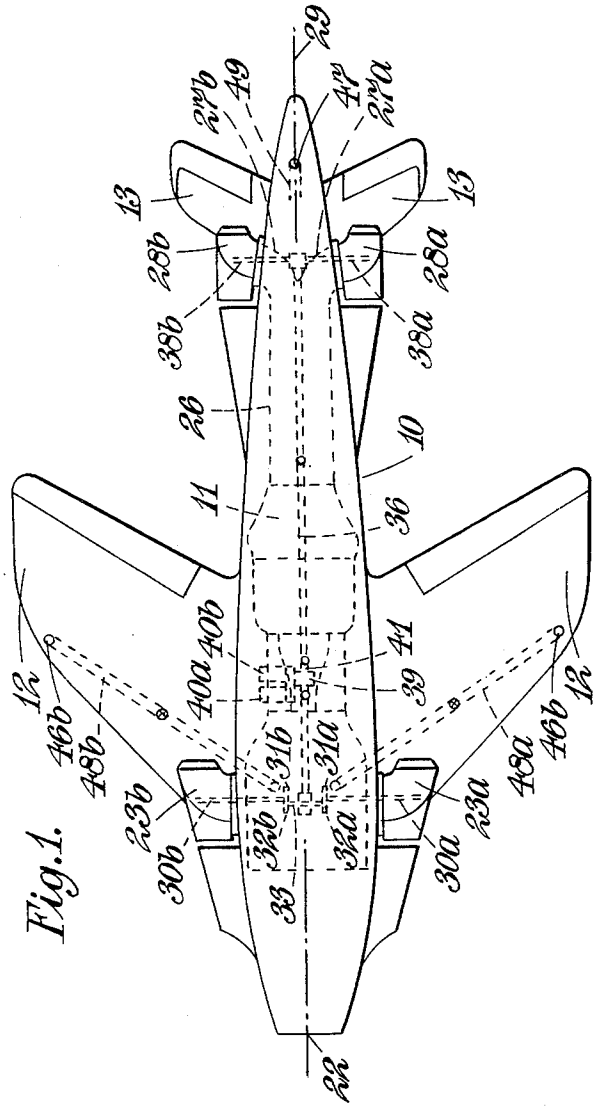


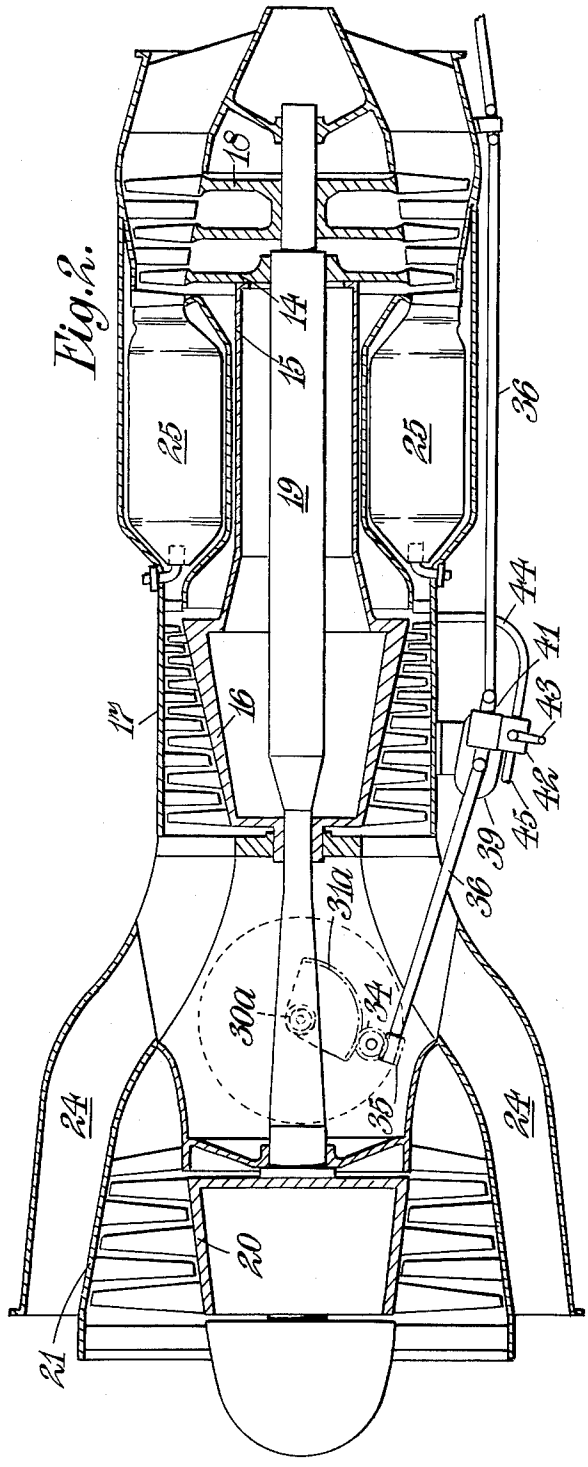
Fig. 1.

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Fig. 2.



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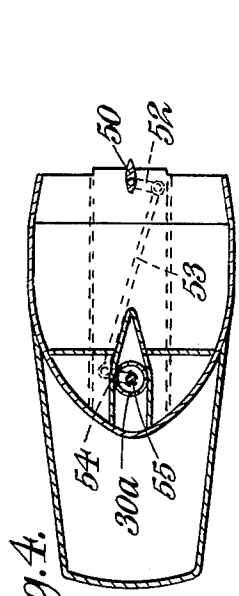


Fig. 4.

Fig. 3.

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AIRCRAFT PROPULSION POWER UNITS

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3 Claims. (Cl. 60—35.55)

This invention relates to aircraft jet propulsion systems.

According to this invention there is provided a jet propulsion system comprising rotary compressor means for compressing a working fluid for the system, combustion equipment for receiving compressed working fluid from the compressor means and heating the working fluid by burning fuel therein, turbine means which is arranged to be driven by the heated working fluid from the combustion equipment and which is drivingly coupled to the compressor means, a jet propulsion nozzle connected to be supplied with pressurised working fluid from the system to form a propulsive jet, and means for adjusting through a servo device the direction of discharge of the propulsive jet, which servo device is connected to receive pressurised working fluid from the system and is adapted to use it to produce the required power output.

Thus in a conventional gas turbine arrangement the working fluid used in the servo device may comprise air or a mixture of air and combustion products.

The nozzle or one or more parts of it is mounted for rotation about a suitably disposed axis so that such rotation alters the direction of discharge of the propulsive jet, the servo device being connected to the movable part or parts to effect such rotation.

The servo device may comprise a compressed air motor driven by compressed air tapped off from said compressor means. The compressor means may comprise a high pressure compressor for supplying compressed working fluid to the combustion equipment as aforesaid, the pressurised working fluid for the servo device being tapped off from the delivery of said high pressure compressor.

The nozzle may be an elbow nozzle arranged to swivel about an axis transverse to the direction of the jet and the servo device may comprise an aerofoil pivotally mounted about a spanwise axis in the working fluid flowing through the nozzle, said spanwise axis extending substantially parallel to the axis of swivelling of the nozzle, and said means for adjusting the direction of discharge of the propulsive jet comprises means for rotating the aerofoil about said spanwise axis so that the lift forces on the aerofoil cause swivelling of the nozzle about its axis.

In preferred arrangements a plurality of jet nozzles are provided. One preferred arrangement comprises one or more jet nozzles supplied with compressed working fluid from the compressor means, and one or more jet nozzles supplied with the working fluid exhausting from the turbine means, the servo device for actuating the means for adjusting the direction of discharge of the nozzles acting on coupling means coupling the adjusting means of all the nozzles together so that the jets are only adjustable in unison.

Preferably the unit includes at least two servo devices arranged so that in the event of failure of one of the servo devices the remaining servo devices can operate all the orientating means.

Two embodiments of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings. The arrangements illustrated also incorporate the invention set out in our patent application No. 711,350.

In the drawings:

FIGURE 1 is an undernearth plan view of an aircraft including a propulsion unit according to a first form of the invention,

FIGURE 2 shows the principal parts of the propulsion unit in section on a vertical longitudinal plane,

FIGURE 3 shows in plan, partly sectioned, the principal parts of a propulsion unit according to a second form of the invention,

FIGURE 4 is a section taken on the line 4—4 in FIGURE 3.

The aircraft illustrated by FIGURES 1 and 2 comprises a fuselage **10** housing the power unit **11** and provided with main wings **12** and an empennage **13**. These supporting surfaces may be provided with conventional ailerons and elevators. As more fully shown in FIGURE 2, the power unit comprises a jet propulsion engine including a single stage high pressure gas turbine rotor **14** connected by a shaft **15** to drive the rotor **16** of an engine air compressor **17**, and a two stage low pressure gas turbine rotor **18** connected by a shaft **19** to drive the rotor **20** of an axial flow additional air compressor **21**. The compressor **21** draws air in through an air intake **22** in the forward end of the fuselage and discharges it through two aerodynamically balanced swivelling air jet elbow nozzles **23***a* and **23***b* arranged symmetrically on opposite sides of the fuselage. The engine air compressor **17** draws air in from the same intake **22** through passages **24** passing over and under the compressor **21**. The engine air discharged from the compressor **17** passes through a combustion system **25**, in which it is heated by combustion of fuel, and then past the blades of the turbine rotors **14** and **18** into a tail pipe **26**. The tail pipe extends through the fuselage to near the tail of the aircraft, where it is bifurcated to form two branches **27***a* and **27***b* leading to two swivelling exhaust gas jet elbow nozzles **28***a* and **28***b* arranged symmetrically on opposite sides of the fuselage.

All four nozzles are arranged to swivel around axes perpendicular to the longitudinal plane of symmetry of the aircraft, denoted by the chain-dotted line **29**, from a position in which they are directed rearwardly to produce forward thrust to a position in which they are directed downwardly to produce upward thrust. The range of movement may be extended if desired to produce a rearward thrust component for braking. The nozzles **23** and **28** are arranged forward and aft of the centre of gravity of the aircraft at distances inversely related to the maximum gross thrust of the respective nozzles so that when the nozzles are all directed downwardly the resultant upward thrust passes through the centre of gravity of the aircraft, and the additional control forces necessary to maintain the aircraft in a horizontal attitude are reduced to a minimum. The arrangement of the swivelling nozzles on one side of the longitudinal plane of symmetry **29** is a mirror image of that on the other side of the said plane so that the changing direction of the thrust as the nozzles are swivelled in unison does not alter the attitude of the aircraft.

The nozzles are connected for movement in unison by a mechanical transmission system. For this purpose the air jet nozzles **23***a*, **23***b* have drive shafts **30***a*, **30***b* terminating inside the engine casing in toothed quadrants **31***a*, **31***b*. The two quadrants mesh with pinions **32***a*, **32***b* on a cross shaft **33** passing under the shaft **19** by which the compressor rotor **20** is driven. A gear **34** on the cross shaft meshes with a gear **35** on an articulated torque transmission shaft **36** running longitudinally under the engine to near the rear end of the tail pipe **26**, where an angle-drive gearbox and a vertical shaft (not shown) take the drive to an angle-drive gearbox **37** having output

shafts 38*a*, 38*b* connected respectively to the two exhaust gas jet nozzles 28*a*, 28*b*.

In this embodiment of the invention the articulated torque transmission shaft 36 is divided to receive a servo unit 39 which drives both parts of the shaft. The servo unit comprises two air motors 40*a*, 40*b* (see FIGURE 1) connected through differential gearing, or other equivalent means permitting each to operate independently of the other, to an output shaft 41 which is inserted in and forms part of the articulated torque transmission shaft 36. The air motors may for example be of the "Roots blower" sliding vane or other rotary type. The servo unit also includes a control valve 42, having a control lever 43 for connection to a pilot's control, whereby compressed air conveyed from the outlet of the engine air compressor 17 by a pipe 44 is admitted to the air motors 40*a*, 40*b* and exhausted through a pipe 45. The valve 42 is of the reversing kind and includes a follow-up member operated by the shaft 41 so that movement of the lever 43 from a datum position initiates a proportional number of revolutions of the shaft 41 also from a datum position. The angle of orientation of the swivelling nozzles is thereby made dependent upon the position of the pilot's control.

For use when, owing to lack of forward speed, the ailerons and elevators are ineffective for control in roll and pitch, two downwardly directed auxiliary jet nozzles 46*a* and 46*b* are provided symmetrically at or near the wing tips forward of the centre of gravity of the aircraft and a third downwardly directed auxiliary jet nozzle 47 is provided at the tail. These nozzles are supplied with air through pipes 48*a*, 48*b* and 49 from the discharge of the compressor 21 and are controlled in known manner by a suitable arrangement of valves.

Instead of the nozzles being swivelled by a central shaft, an arrangement of the kind described in the specification accompanying patent application No. 22,172, now Patent No. 3,010,770, may be used. In such arrangements each nozzle is supported by bearing rollers engaging a peripheral race on the nozzle and an adjacent race on the supporting structure. In this case each pair of nozzles is associated with a common cross shaft having a sprocket wheel at each end around which a chain passes and is attached at its ends to the adjacent nozzle. The two cross shafts are interconnected by an articulated longitudinal shaft in the manner illustrated in FIGURE 2.

In the embodiment of the invention illustrated by FIGURES 3 and 4 the arrangement of the propulsion unit and its installation in an aircraft are generally similar to FIGURES 1 and 2 but the servo unit 39 is replaced by an aerofoil section servo tab 50 pivotally mounted in the outlet of each swivelling nozzle. The pivoting and swivelling axes are parallel to one another so that aerodynamic lift produced on the tab produces torque on the swivelling part 51 of the nozzle about its axis. The tab is provided with an incidence control lever 52 connected by a link 53 to a lever 54 on the outer end of a shaft 55 passing through the nozzle shaft 30*a* or 30*b*, in the case of the air jet nozzles. Inwardly of the toothed quadrant 31*a*, in the case of the nozzle shown sectioned in FIGURE 3, the shaft carries a toothed quadrant 56 meshing with a pinion 57 on a cross shaft 58 passing over the compressor driving shaft 19 and linking the shaft 55 with the corresponding shaft of the opposite air jet nozzle 23*b* by means of another pinion and toothed quadrant. The cross shaft 58 is connected by bevel gearing 59 and shafting 60 with the pilot's control (not shown). An equivalent arrangement is provided for the control of the exhaust jet nozzles. Rotation of the shafting 60 by the pilot's control rotates the shafts 55 and sets the servo tabs 50 to cause the nozzles to follow up the movement of the shafts 55. The mechanical transmission including the shafts 33 and 36 links all the nozzles together so that they must move in unison, but the torque transmitted is normally very small. Should a fault develop in the servo tab system of one of the nozzles the torque necessary to operate that nozzle will be transmitted to it from the other nozzles. The shafts 55 may have sufficient torsional resilience to ensure that seizure of one of the servo tabs does not prevent the others being operated by the pilot's control.

If desired, the pilot's control may operate directly on the mechanical transmission interconnecting the nozzles, the swivelling parts of the nozzles being connected to the shafts 30*a*, 30*b*, 38*a*, and 38*b* with a small degree of lost motion which is used, in well known manner, to operate the servo system. With such an arrangement it is important to ensure that the small differences in orientation of the nozzles which can occur do not produce rolling or pitching movements which the auxiliary control nozzles cannot compensate.

We claim:

1. A jet propulsion power plant comprising axial flow air compressor means, combustion equipment arranged to heat air from the compressor means by the combustion of fuel therein, turbine means arranged to be driven by gas from the combustion equipment and drivingly coupled to the compressor means; said compressor means, combustion equipment and turbine means defining a passage system for air and gas as working fluids of the plant; a pair of oppositely directed outlets from the compressor means, a pair of oppositely directed outlets from the turbine means, a swivelling elbow nozzle connected to each of said outlets, a rotary shaft mechanical transmission positively interconnecting all the nozzles for swivelling only in unison, a servo aerofoil pivotally mounted in each nozzle for movement about a spanwise axis substantially parallel to the axis of swivelling of the nozzle, and a mechanical transmission connecting all said servo aerofoils together for operation in unison.

2. A jet propulsion power plant as claimed in claim 1, in which the transmission connecting the servo aerofoils includes, between each servo aerofoil and the remainder of the transmission, a member having sufficient resilience to premit the remaining servo aerofoils to be adjusted by the transmission should one of the aerofoils become jammed.

3. A jet propulsion power plant comprising axial flow air compressor means, combustion equipment arranged to heat air from the compressor means by the combustion of fuel therein, turbine means arranged to be driven by gas from the combustion equipment and drivingly coupled to the compressor means; said compressor means, combustion equipment and turbine means defining a passage system for air and gas as working fluids of the plant, a pair of oppositely directed outlets from the compressor means, a pair of oppositely directed outlets from the turbine means, a swivelling elbow nozzle connected to each of said outlets, a rotary shaft mechanical transmission positively interconnecting all the nozzles for swivelling only in unison, rotary compressed air motive means connected to drive said transmission, and air supply ducting connecting said motive means to a part of said working fluid passage system downstream of said compressor means, said mechanical transmission including a first rotary shaft interconnecting the pair of swivelling nozzles connected to the compressor means, a second rotary shaft interconnecting the pair of swivelling nozzles connected to the turbine means, and a third rotary shaft interconnecting said first and second rotary shafts, said rotary compressed air motive means being connected by gearing to said third rotary shaft.

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