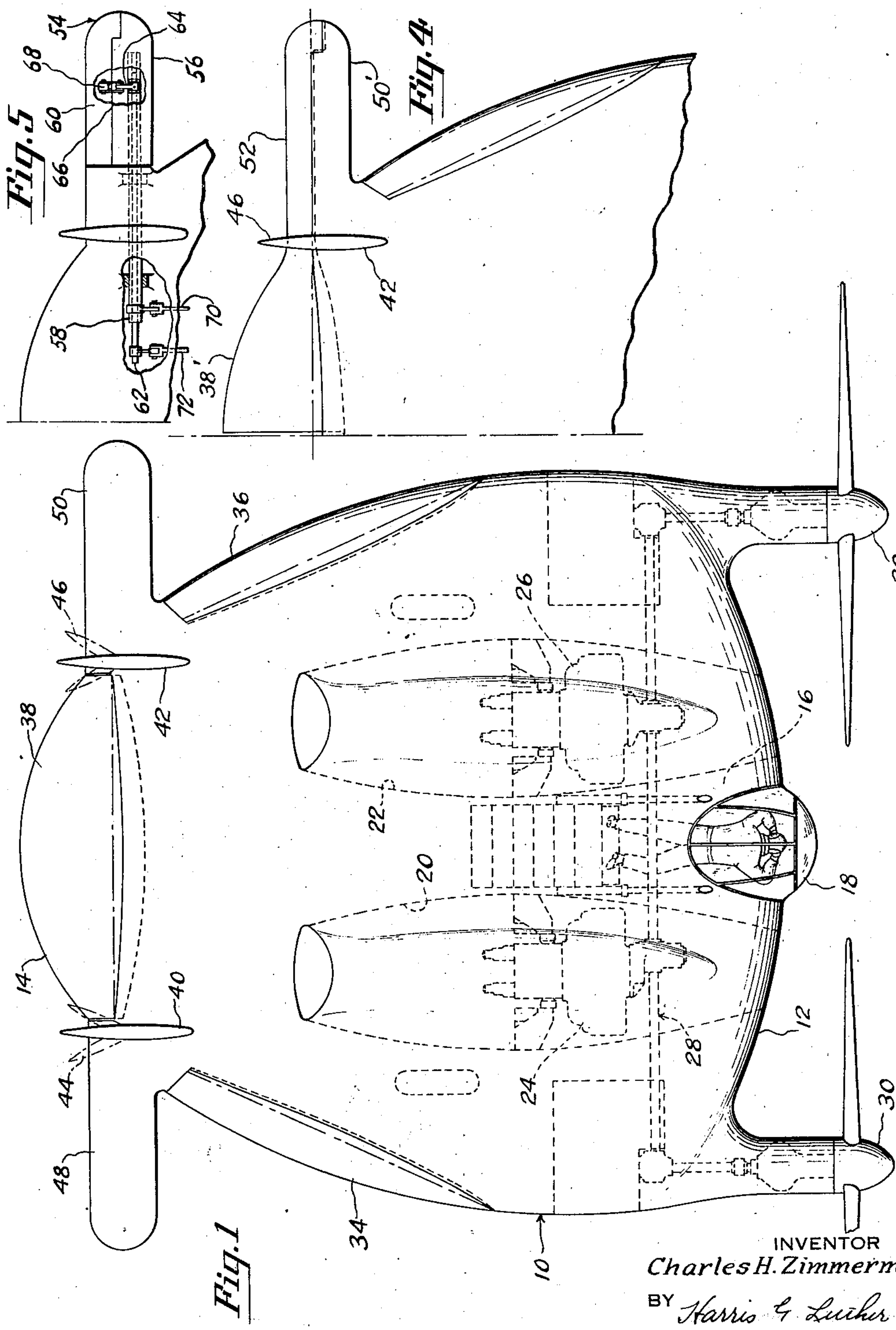
Nov. 18, 1947. C. H. ZIMMERMAN 2,431,293

AIRPLANE OF LOW ASPECT RATIO

Filed Dec. 18, 1940 2 Sheets-Sheet 1

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Nov. 18, 1947. C. H. ZIMMERMAN 2,431,293

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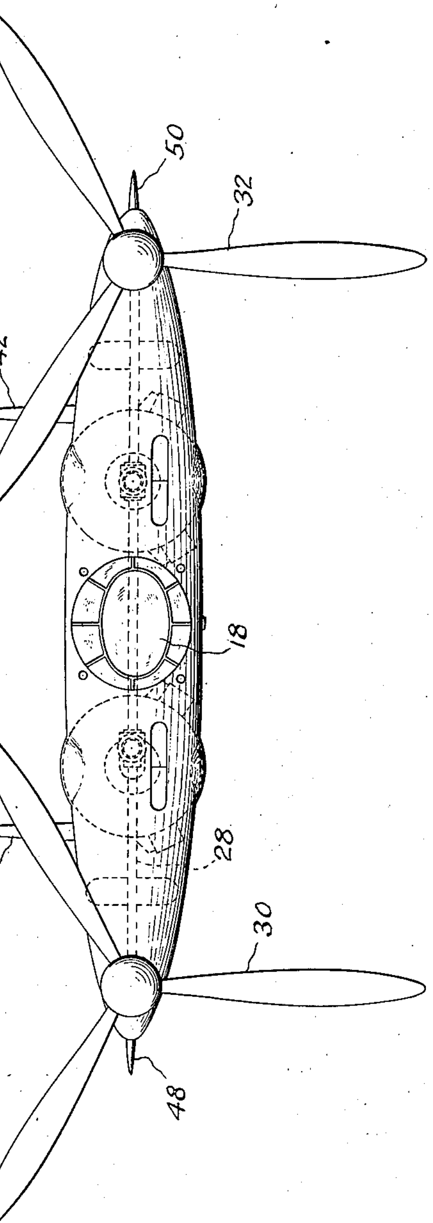


Fig. 2

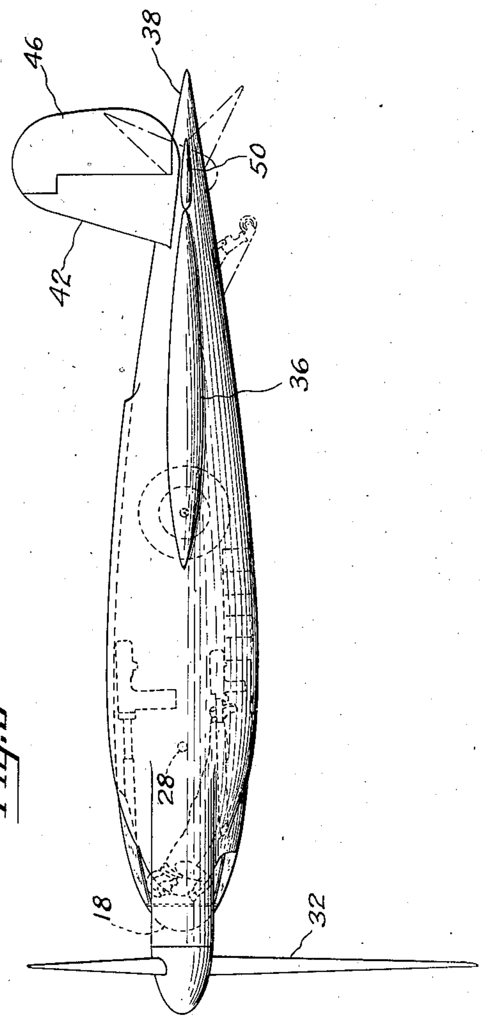


Fig. 3

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Patented Nov. 18, 1947

2,431,293

# UNITED STATES PATENT OFFICE

2,431,293

## AIRPLANE OF LOW ASPECT RATIO


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Application December 18, 1940, Serial No. 370,646

15 Claims. (Cl. 244—13)


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This invention relates to improvements in aircraft and has particular reference to an improved aircraft of low aspect ratio.

An object of the invention resides in the provision of an improved aircraft of low aspect ratio having improved fore and aft or pitching stability.

A further object resides in the provision of an improved aircraft of low aspect ratio having rearwardly disposed lift increasing and stabilizing members positioned to utilize the energy of the vortex in the wake of the main wing portion for increasing the lift and stabilizing the aircraft with no substantial loss in aircraft efficiency.

A still further object resides in the provision of an improved aircraft of low aspect ratio having rearwardly disposed lift increasing and stabilizing members positioned to utilize the energy of the wing tip vortex in which said members or suitable portions thereof are made movable about suitable axes to provide longitudinal and lateral control for said aircraft.

Other objects and advantages will be more particularly pointed out hereinafter or will become apparent as the description proceeds.

In the accompanying drawings, in which like reference numerals are used to designate similar parts throughout, there is illustrated a suitable structural embodiment for the purpose of disclosing the invention. The drawings, however, are for the purpose of illustration only and are not to be taken as limiting or restricting the invention since it will be apparent to those skilled in the art that various changes in the illustrated embodiment may be resorted to without in any way exceeding the scope of the invention.

In the drawings,

Fig. 1 is a top plan view of an aircraft constructed according to the invention.

Fig. 2 is a front-elevational view of the aircraft shown in Fig. 1.

Fig. 3 is a side-elevational view of the aircraft illustrated in Fig. 1, and

Fig. 4 is a top plan view of a fragmentary portion of the aircraft showing a somewhat modified form of the invention.

Fig. 5 is a top plan view of a fragmentary portion of the aircraft showing another somewhat modified form of the invention.

Referring to the drawings in detail, the aircraft has a single wing 10 of somewhat semi-circular or horseshoe outline having a forward portion provided with a slightly convex leading edge 12 and a more sharply curved rearward portion having a convex trailing edge 14. This wing con-

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tains a centrally disposed pilot cockpit 16 provided with a dome shaped transparent front end 18 and a pair of engine chambers 20 and 22 disposed one at each side of the cockpit 16 and each containing an engine, as indicated respectively at 24 and 26. The engines are connected by means of suitable shafts and gearing, as indicated at 28, with a pair of propellers 30 and 32 carried by projections disposed one at each side of the wing 10 somewhat ahead of the leading edge 12. The wing portion is provided with a pair of skewed ailerons 34 and 36, a movable horizontal elevator 38 at the rear of the wing portion and with a pair of vertical fins 40 and 42 to which are attached vertical rudders 44 and 46.

As is particularly illustrated in Fig. 1, the main wing 10 has its maximum width a short distance rearward of the leading edge 12 and from this position of maximum width gradually tapers rearwardly in a generally semi-circular or horseshoe pattern. This wing is generally known as, and will be referred to hereinafter as, one of low aspect ratio and is in the class of wings whose aspect ratio is generally less than 3. As this airfoil progresses through the air the pressure field set up by the airfoil causes air to be forced outwardly from below the lower surface and to be drawn inward toward the upper surface around the tip of the airfoil. This motion of the air, imposed on the forward motion of the airfoil gives a resultant whirling or vortex motion to the air in the region aft of the wing tip, the core or axis of the vortex trailing slightly inward and upward from the tip in the direction of the relative wind. This vortex movement of the air produces a pronounced downwash inboard of the vortex axis and a pronounced upwash outboard of the axis. While such a vortex is present at the tip of every airfoil which produces lift, its effect is much greater in the case of a low aspect ratio airfoil, such as that illustrated, since a large portion of the air beneath such a low aspect ratio airfoil flows out laterally past the airfoil tips instead of from the trailing edge. Since this vortex disturbance of the air represents a loss in aircraft efficiency it is desirable to minimize it as much as possible. An important improvement in the efficiency of an aircraft such as that illustrated can be obtained by rotating the propellers in opposite directions such that the rotational effect in the slipstream of each propeller is opposite in direction to the rotation of the vortex extending around the respective wing tip. Such a slipstream will have an outboard downwash and an inboard upwash which will react against the undersurface of the wing to improve the wing lift. Furthermore, the creation of the vortex at the wing tip will require a complete reversal of the rotation of the slipstream so that substantially all of the rotational energy of the slipstream is recovered and a much smaller amount of energy is lost in rotational movement of the air around the vortex axis. There will still, however, be a pronounced vortex extending rearwardly in the wake of each wing tip and it is among the objects of this invention to recover a further amount of energy from these vortices and at the same time materially improve the fore and aft stability of the aircraft.

Low aspect ratio aircraft of the type illustrated have always experienced more or less difficulty with fore and aft instability due to the relatively short distance between the center of lift of the main wing portion and the center of lift of the rearwardly disposed elevator and because it has not been practical to provide an independent fixed or adjustable stabilizer at the rear to damp the pitching movement of the main wing portion. This lack of damping has tended to permit the main wing portion to set up a condition of oscillation which has rendered the pitching control of such an aircraft difficult. Furthermore, in order to obtain suitable static stability in this type of aircraft and especially in one having an airfoil of substantially symmetrical cross-section, it would be necessary to locate the center of gravity further forward than is practically possible which means that actually, the center of gravity is rearward of the location at which satisfactory static stability would be obtained. In accordance with the present invention the aircraft is provided at the rear thereof with two laterally extending stabilizing members as indicated at **48** and **50**. In the arrangement shown these members extend from the portion of the main wing between the rearward ends of the ailerons **34** and **36** and the respective adjacent ends of the elevator **38** to a position somewhat beyond the maximum lateral extent of the main wing portion. These members are of generally streamlined cross section and may, if desired, be given an airfoil contour, the exact contour depending somewhat on the characteristics of the particular installation, and are so positioned and dimensioned that approximately the outer half of each member is located in a pronounced upwash of air incident to the respective vortex. By thus utilizing the energy of the upwash from the main wing to produce lift the total lift required of the main wing portion can be proportionately reduced with a corresponding reduction in drag of the aircraft. It has also been found that the portion of this upwash which flows over the top of the stabilizing members **48** and **50** produces on these members a lift having a forwardly directed component which also to some extent reduces the total drag of the aircraft or at least does not cause an increase in drag because of the provision of the stabilizing members. The additional area at the rear of the main wing provided by the addition of the members **48** and **50** provides an effective damping action so that the pitching movements of the main wing cannot occur too rapidly and any oscillating motion will be immediately damped out, and also permits a further rearward and more practical location of the center of gravity of the airplane. This correction of the usual conditions of fore and aft instability with no material increase in the total drag of the air-



craft renders this type of aircraft highly practical and desirable since it has been known for some time that aircraft of this type are materially faster than conventional aircraft with the same amount of power.

The exact fore and aft location of the stabilizing vanes is not critical so long as the vanes intercept the upwash incident to the above described wing tip vortex.

Looking at this stability problem from a little different angle, it has been found that satisfactory stability in a low aspect ratio airplane may be obtained under high speed conditions with a Clark V type of airfoil with the center of gravity located at approximately twenty-three percent of the chord but at the expense of control at high angles of attack. In order to maintain the high angles of attack in such an airplane large moments are required with the consequent difficulty of control and load on the structure.

With a substantially symmetrical airfoil shape such as is shown in this application it was found that the aerodynamic center, which is a point stationary with respect to the airfoil, about which the moment coefficients of the airfoil are substantially constant, was so located in a low aspect ratio airfoil that the center of gravity had to be placed at ten percent to fifteen percent of the chord in order to obtain stability at high speeds. Location of the center of gravity at such a point produced major design problems and with the present available equipment was impractical. With the discovery that stabilizing vanes placed in the vortex upwash did not materially affect the drag, and under some conditions actually decreased the drag, and at the same time changed the aerodynamic center of the combination to a more favorable position, it was possible to construct a low aspect ratio airplane in which the center of gravity was located at a practical distance from the wing leading edge. The moments required to maintain the airplane at high angles of attack with the symmetrical airfoil are reasonable and in fact approach zero.

In the form of the invention shown in Fig. 4 the general arrangement is the same as that described above in connection with Figs. 1, 2 and 3 but in the modified form the movable elevator **38'** is provided with lateral extensions, one of which is indicated at **52**, which constitute the rearward portion of the corresponding stabilizing members **48'** and **50'**. These extensions materially increase the effect of the elevator **38** since they are positioned in the free airflow to the sides of the main wing **10** and also because they change the airfoil shape of the lateral stabilizing members and thereby change the lift effect of these members. Whether or not these lateral extensions are provided will depend on the characteristics of the particular design of airplane. If it is found desirable to increase the sensitivity of the pitching control such extensions may be provided but, if the control by the horizontal elevator above is sufficiently sensitive, the stabilizing vanes will be provided without movable portions. Differential operation of separate movable rearward portions of the extensions **48'** and **50'** to serve as ailerons instead of or in combination with the wing carried ailerons **34** and **36** is also contemplated. That these movable members would operate effectively as ailerons is evident from the fact that they are disposed further outboard than the conventional ailerons for this type of aircraft, and are disposed in relatively high velocity airstreams.

If desired, instead of hinging the rear portion only of the stabilizing members 48 and 50, the entire stabilizing member may be mounted so as to turn about an axis extending longitudinally of the member and located at any convenient and suitable position, such as approximately twenty percent of the chord from the leading edge. In such an arrangement the two members may be differentially operated to act as ailerons as well as being operated together to act as pitching control members.

In the modification shown in Fig. 5, the vanes, one of which is generally indicated at 54, constitute the sole means for lateral and longitudinal control of the aircraft as well as for providing the above described damping and stabilizing effect. In this arrangement each member may conveniently comprise a forward portion 56 carried by a rotatable shaft 58 the axis of which extends longitudinally of the forward portion somewhat to the rear of the leading edge thereof, and a rearward portion 60 hinged to the forward portion rearwardly of the shaft 58. The portion 60 may be inclined relative to the portion 56 by suitable means such as a shaft 62 concentric with the shaft 58 and having at its outer end an arm 64 projecting through a slot in the shaft 58 and connected by a suitable link 66 with a horn 68 secured to the portion 60. The shafts 58 and 62 may be connected with a suitable manual control by respective link or cable means as indicated at 70 and 72. The manual control may conveniently be such that both forward portions are moved coextensively in the same direction for longitudinal control and stabilization and may, if desired, be given a limited differential movement for adjusting the trim of the aircraft while the rear portions are given a differential movement for lateral control.

While a suitable mechanical arrangement has been hereinabove described and illustrated in the accompanying drawings for the purpose of disclosing the invention, it is to be understood that the invention is not limited to the particular embodiment so illustrated and described, but that such changes in the size, shape and arrangement of the various parts may be resorted to as come within the scope of the sub-joined claims.

Having now described the invention so that others skilled in the art may clearly understand the same, what it is desired to secure by Letters Patent is as follows:

1. In an airplane, a wing including forward and rearward portions forming a low aspect ratio wing, said forward portion providing the leading edge and having said leading edge merging into laterally extended wing tips, and said rearward portion having a convex margin including the trailing edge and also merging with said wing tips, and a pair of oppositely laterally extending stabilizing vanes secured to the margin of said rearward portion rearwardly of the center of lift of said wing and extending outwardly a substantial distance beyond the maximum span dimension of said wing.

2. In an airplane, a wing including forward and rearward portions forming a wing of low aspect ratio, said forward portion including the wing tips which, when the airplane is in flight, produce wing tip vortices characterized by an inboard downwash and an outboard upwash about an axis trailing rearwardly from each wing tip, and said rearward portion having a convex margin the forward ends of which merge into said wing tips, and a pair of oppositely laterally extending stabilizing vanes secured to said rearward wing portion a substantial distance to the rear of said wing tips and extending substantially beyond the maximum span dimension of said wing into the region of aerodynamic upwash of the outboard portions of the respective wing tip vortices.

3. In an airplane, a wing having an aspect ratio of three or less which in flight produces wing tip vortices characterized by an inboard downwash and an outboard upwash along an axis trailing rearwardly from each wing tip, an aileron along each side of said wing, a tiltable flap hinged to the rearward edge of said wing having its ends spaced from said ailerons to provide marginal portions on said wing between the ends of said flap and the rearward end of each aileron, and a stabilizing vane extending laterally from each of said marginal wing portions sufficiently beyond the maximum span dimension of said wing to dispose the outer half of each vane in the upwash of the respective wing tip vortex.

4. A low aspect ratio airplane having a main wing, a tiltable flap hinged to the rearward edge of said main wing, and a pair of stabilizing vanes extending laterally from the rearward portion of said main wing one at each side thereof each of said vanes comprising a forward portion fixed relative to said main wing and a tiltable rearward portion, said tiltable rearward portions being disposed one at each end of said rear wing flap.

5. In an airplane, a wing including forward and rearward portions, said forward portion having wing tips from which rearwardly trailing wing tip vortices extend, when said airplane is in flight, and said rearward portion forming an extension of said forward portion and having a convex margin merging with said wing tips, stabilizing means for said airplane comprising, a pair of airfoil vanes disposed one at each side of the longitudinal center line of said wing a substantial distance rearwardly of said wing tips and having a substantial portion thereof extending laterally beyond the axes of the respective wing tip vortices.

6. In an airplane, a wing having wing tips from which rearwardly trailing wing tip vortices extend when said airplane is in flight, an aileron along each side of said wing, an elevator at the rear of said wing, stabilizing means comprising, a pair of rigidly attached airfoil vanes disposed one at each side of the longitudinal center line of said airplane between the ends of said elevator and said ailerons, said vanes extending laterally beyond the axes of the respective wing tip vortices to an extent such that a substantial portion of each stabilizing vane is located in the aerodynamic upwash of the outboard portion of the respective wing tip vortex.

7. In an airplane having a wing of low aspect ratio having wing tips from which rearwardly trailing wing tip vortices extend when the airplane is in flight, and a rear control surface tiltable about an axis substantially parallel to a line joining said wing tips, stabilizing means for said airplane comprising, a pair of airfoil vanes disposed one at each side of the longitudinal center line of said airplane adjacent said wing rearwardly of said wing tips and extending laterally beyond the axes of the respective wing tip vortices, a portion of each stabilizing vane being fixed relative to said wing and a portion being integral and movable with said rear control surface.

8. The arrangement as set forth in claim 7 including means supporting said vanes for tilting movements about axes extending longitudinally of the respective vanes.

9. The arrangement as set forth in claim 7 including stabilizing vanes each comprising a relatively fixed forward portion and a movable rearward portion tiltable about an axis extending longitudinally of the vane.

10. The arrangement as set forth in claim 7 including stabilizing vanes each comprising a forward portion tiltable about an axis extending longitudinally of the vane and a rearward portion carried by said forward portion and tiltable relative thereto.

11. The arrangement as set forth in claim 7 including stabilizing vanes each comprising a forward portion tiltable about an axis extending longitudinally of the vane and a rearward portion carried by said forward portion and tiltable relative thereto, manually controllable means for tilting the forward portions of said vanes and separate manually controllable means for tilting the rearward portions only of said vanes.

12. In an airplane, a wing including a broad forward portion having wing tips from which rearwardly trailing wing tip vortices extend when the airplane is in flight and a rearward portion merging with said wing tips and of gradually reducing width to the end of the wing, stabilizing means for said airplane comprising, a pair of airfoil vanes disposed one at each side of the longitudinal center line of said airplane rearwardly of the combined center of lift of said airplane and spaced substantially rearwardly of said wing tips and extending laterally a substantial distance beyond the axes of the respective wing tip vortices.

13. In an airplane having a wing of low aspect ratio from the tips of which rearwardly trailing wing tip vortices extend when the airplane is in flight, stabilizing means for said airplane comprising, a pair of airfoil vanes carried by said wing one at each side of the longitudinal center line of said airplane a substantial distance rearwardly of said wing tips and substantially in the medial plane of said wing and extending laterally a substantial distance beyond the axes of the respective wing tip vortices, said vanes being movable relative to said wing about axes extending generally lengthwise of the respective vanes.

14. In an airplane, a wing including forward and rearward portions forming a wing of low aspect ratio, said forward portion having a leading edge and also having its lateral extremities forming wing tips, and said rearward portion being of generally semi-circular plan form and merging in convex lines into said wing tips, laterally spaced propeller carrying projections on said leading edge forward of said wing tips, and stibilizing vanes having a greater span than said wing extending laterally from the sides of said rearward wing portion at locations remote from said wing tips.



15. In an airplane, a wing including forward and rearward portions forming a wing of low aspect ratio from which rearwardly trailing wing tip vortices extend when the airplane is in flight, said forward portion having a convex leading edge and also having its lateral extremities forming convex wing tips, and said rearward portion being of generally semi-circular plan form and merging in convex lines into said wing tips to form a convex trailing edge, laterally spaced propeller carrying projections on said leading edge forward of said wing tips, and stabilizing vanes oppositely extending from said rearward wing portion laterally outwardly beyond the axes of said wing tip vortices, said vanes comprising wing extensions and remaining fixed relative to said wing in flight.

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## Certificate of Correction

Patent No. 2,431,293. November 18, 1947.

CHARLES H. ZIMMERMAN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 6, line 72, and column 7, lines 1, 6, and 12, for the claim reference numeral "7" read *5*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of January, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
*Assistant Commissioner of Patents.*

Nov. 10, 1959 O. T. CARR 2,912,244

AMUSEMENT DEVICE

Filed Jan. 22, 1959 5 Sheets-Sheet 1

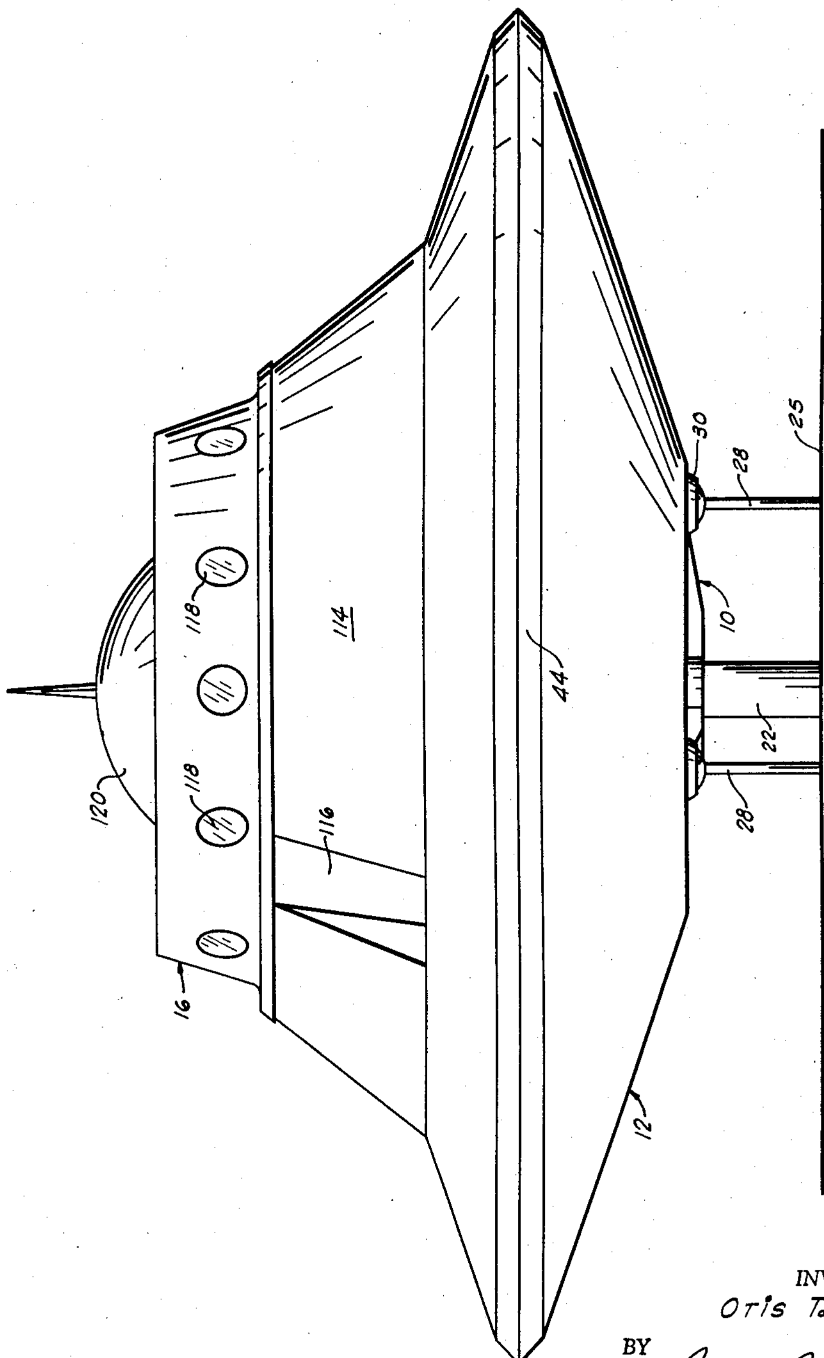


FIG. 1

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AMUSEMENT DEVICE

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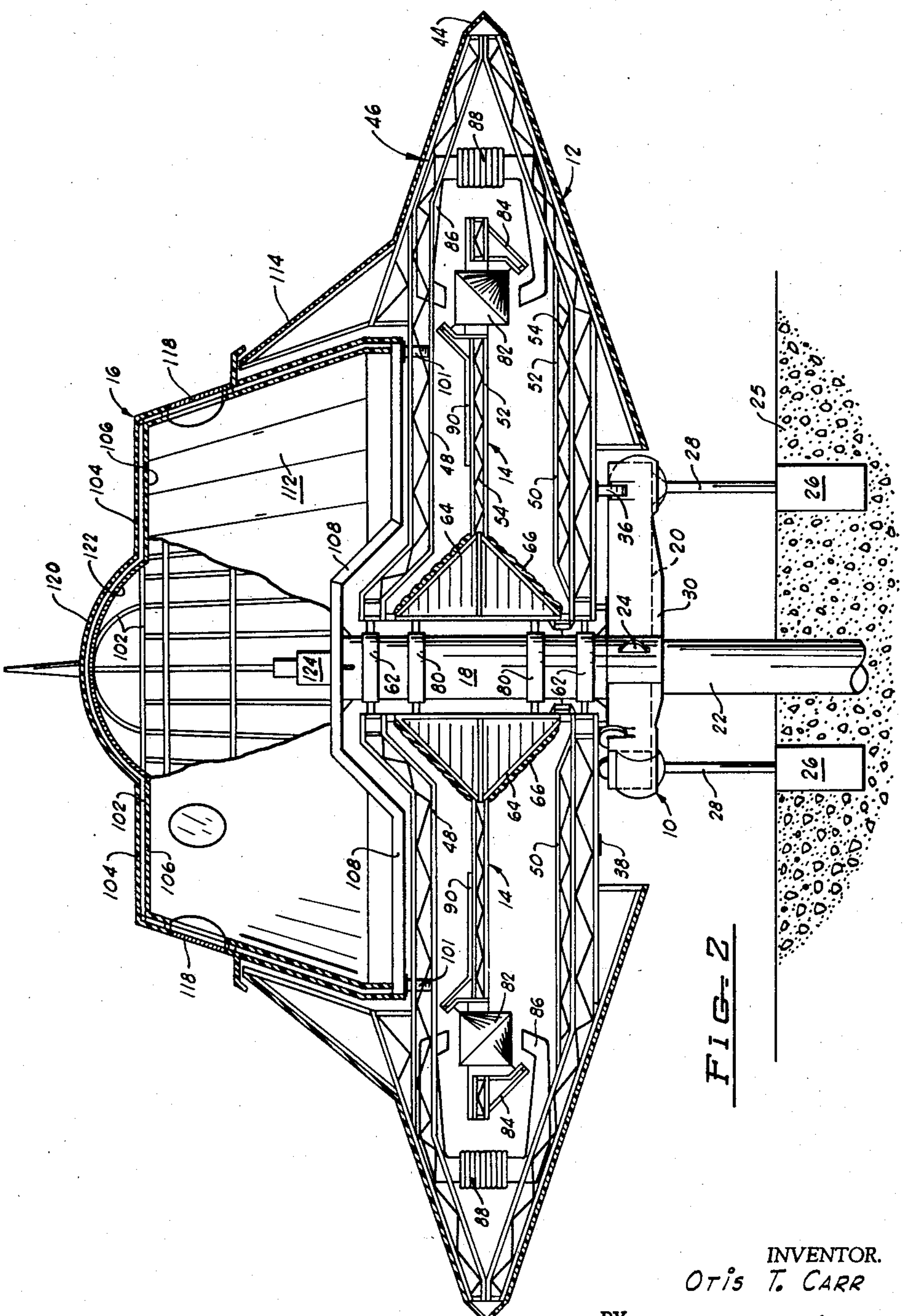

FIG-2

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AMUSEMENT DEVICE

Filed Jan. 22, 1959 5 Sheets-Sheet 3

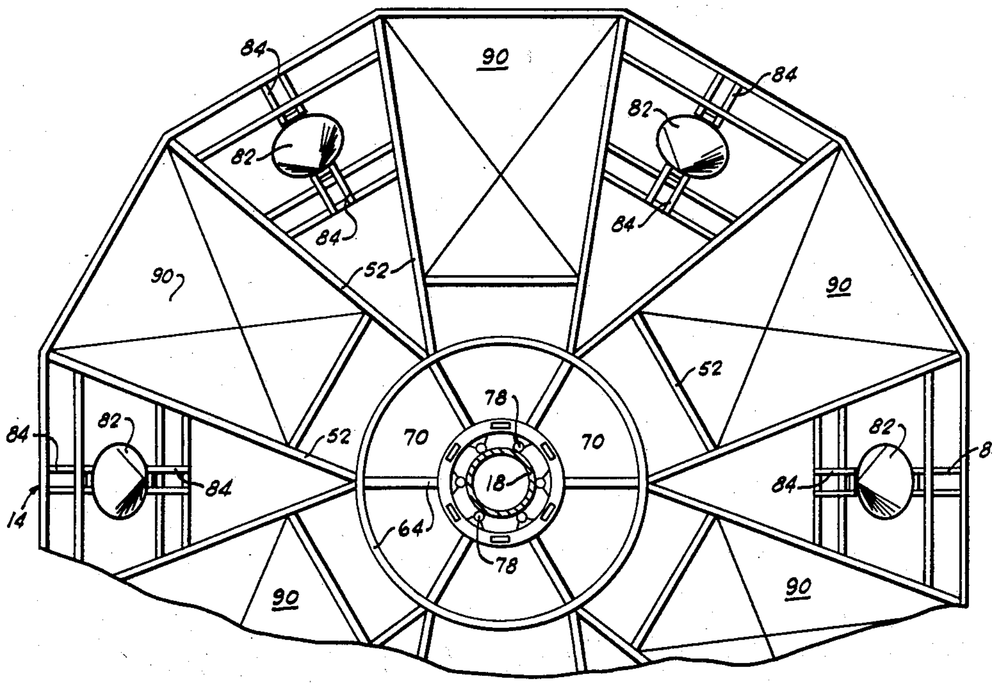


FIG. 5

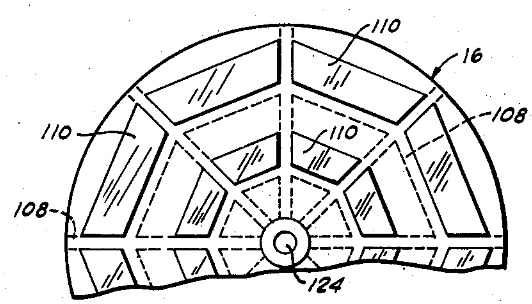


FIG. 7

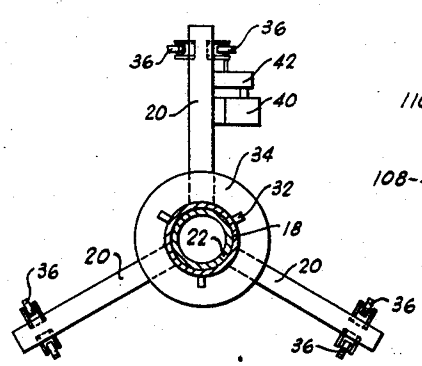


FIG. 3

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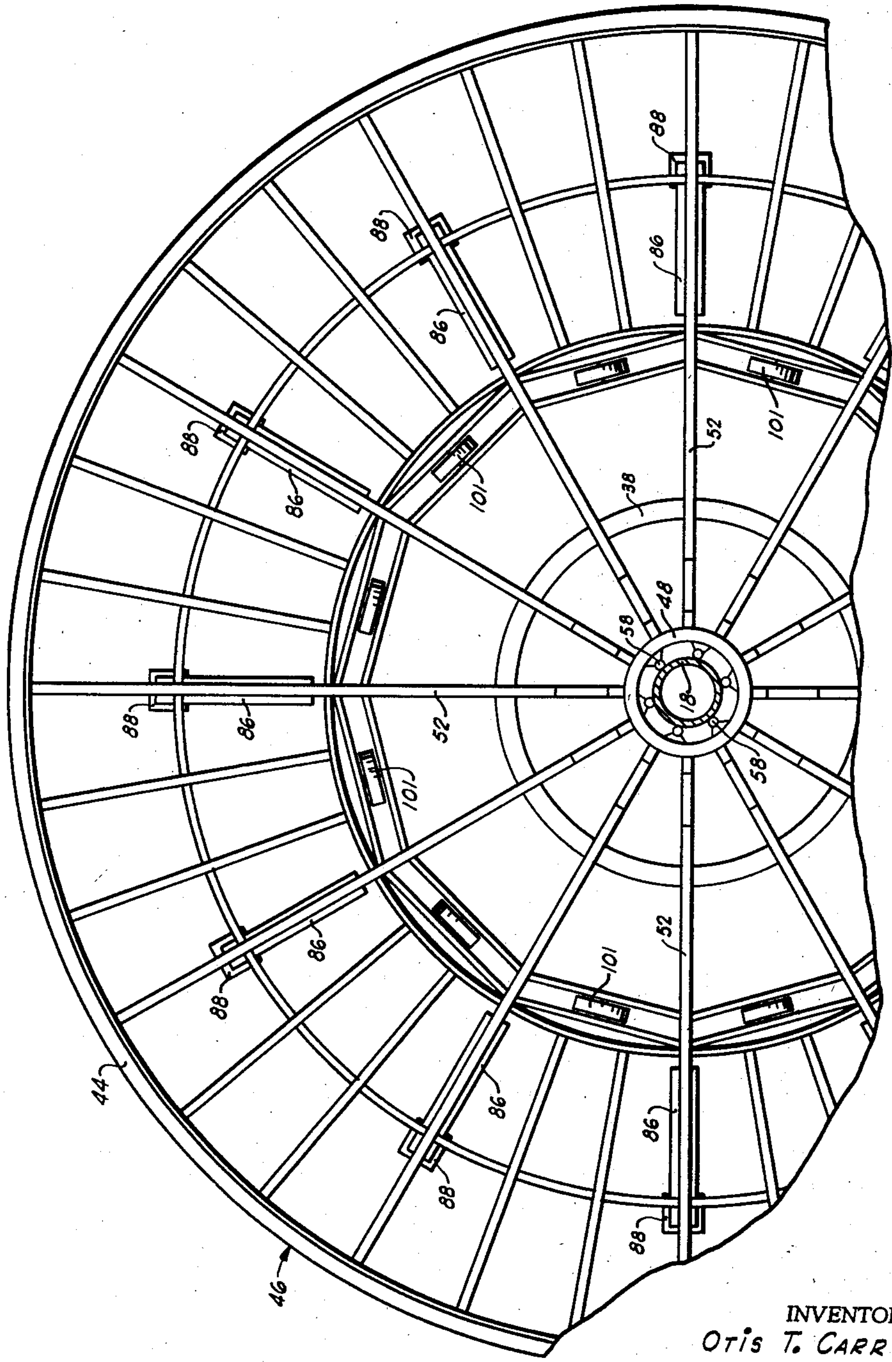


FIG. 4

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Nov. 10, 1959 O. T. CARR 2,912,244

AMUSEMENT DEVICE

Filed Jan. 22, 1959 5 Sheets-Sheet 5

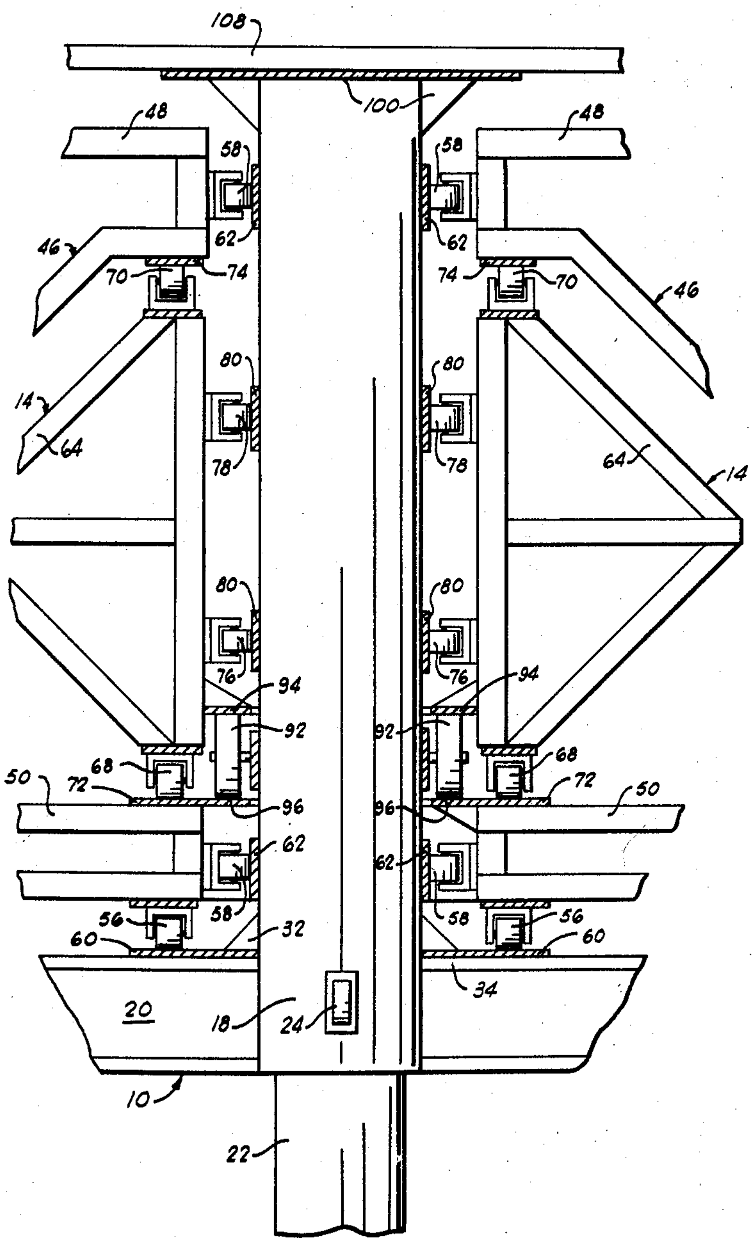


FIG. 6

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United States Patent Office

2,912,244

Patented Nov. 10, 1959



2,912,244

## AMUSEMENT DEVICE

Otis T. Carr, Baltimore, Md.

Application January 22, 1959, Serial No. 788,392

9 Claims. (Cl. 272—18)

This invention relates generally to improvements in amusement devices, and more particularly, to an improved amusement device of the type wherein the passengers will receive the impression of riding in an interplanetary space craft.

The present invention contemplates a novel amusement device having the overall configuration of a space craft and being formed in various sections, with portions of the sections being rotated in opposite directions to give the impression of movement to the passengers. It is also contemplated to move the craft up and down and display an animated movie of heavenly bodies above the passengers to give the passengers an impression of leaving the earth and approaching a distant planet or the like. This invention further contemplates the provision of electro-magnets, cones and the like carried by the oppositely rotating sections of the device, and windows through which the passengers may view these simulated objects to give the impression to the passengers that they are viewing the inner workings of an interplanetary space craft during flight of the craft. Finally, this invention contemplates the construction of the various portions of an amusement device simulating an interplanetary space craft in such a manner that the device may be easily transported in sections from one location to another and reassembled in a minimum of time.

An important object of this invention is to provide an amusement device wherein a passenger in the device receives the impression of flying in an interplanetary space craft.

Another object of this invention is to provide an amusement device having a general configuration of an interplanetary space craft and having oppositely rotating sections simulating the movement of various portions of such a space craft during flight.

A further object of this invention is to provide an amusement device simulating an interplanetary space craft and having a passenger cabin wherein the passengers may view various moving portions of the device to impress the passengers with flight in a space craft.

Another object of this invention is to provide an amusement device simulating an interplanetary space craft wherein the passengers will be physically moved a very minor distance and yet will receive the impression of flying in a space craft.

A further object of this invention is to provide a portable amusement device simulating an interplanetary space craft which may be easily disassembled and transported from one location to another.

A still further object of this invention is to provide an amusement device which is simple in construction, may be economically manufactured, and which will have a long service life.

Other objects and advantages of the invention will be evident from the following detailed description, when read in conjunction with the accompanying drawings which illustrate my invention.



In the drawings:

Figure 1 is an elevational view of an amusement device constructed in accordance with this invention.

Figure 2 is a vertical sectional view through the device illustrated in Fig. 1.

Figure 3 is a plan view of the landing gear for the amusement device, with the housing around the legs of the landing gear removed.

Figure 4 is a plan view of the supporting structure or frame work for the outer rotating shell of the amusement device shown in Figs. 1 and 2.

Figure 5 is a plan view of the central rotating assembly which rotates within the outer shell frame illustrated in Figs. 2 and 4.

Figure 6 is an enlarged sectional view illustrating the support and the drive between the inner rotating assembly and the outer rotating assembly.

Figure 7 is a plan view of the floor portion of the passenger cabin.

Referring to the drawings in detail, and particularly Figs. 1 and 2, a preferred embodiment of the present invention comprises, generally speaking, a supporting structure and landing gear **10**, an outer rotating shell **12**, an inner rotating assembly **14** (shown only in Fig. 2) and a passenger cabin **16** extending downwardly into the upper end portion of the outer shell **12**. The landing gear and supporting mechanism **10** comprises a vertically extending tubular member **18** around which the outer shell **12** and inner rotating assembly **14** are journaled, as will be hereinafter set forth, and a plurality of legs **20** extending radially outward in circumferentially spaced relation from the lower end of the tubular member **18**. The tubular member **18** is telescoped over a supporting stanchion **22** which may be in the form of a pipe, and the tubular member **18** is slidingly supported on the stanchion **22** by suitable wheels or rollers **24** to facilitate vertical movement of the member **18** on the stanchion **22**, as will be hereinafter set forth. The stanchion **22** is preferably supported in a suitable foundation **25** to provide adequate strength for the amusement device.

A suitable jack **26**, preferably a hydraulic jack, is anchored in the foundation **25** underneath the outer end portion of each of the landing gear legs **20** and is provided with an extension **28** extending upwardly into connection with the respective leg **20**. The jacks **26** are operated simultaneously to raise and lower the landing gear and supporting structure **10**, as will be described. A suitable shaped housing **30** is preferably secured around each of the landing gear legs **20** to provide a streamlined appearance. It may be noted that each of the legs **20** is preferably constructed out of a structurally strong member, such as an I-beam, and is secured to the lower end portion of the tubular member **18** by suitable braces **32** and plates **34** to assure a rigid and adequate connection of the legs **20** to the tubular member **18**.

A pair of rollers **36** (see also Fig. 3) are rotatably supported adjacent the outer end portion of each leg **20** of the landing gear and are arranged to engage a circular track **38** (Figs. 2 and 4) for partially supporting the outer shell **12** and inner rotating assembly **14** as will be described. Also, a suitable drive motor **40** (Fig. 3) is mounted on one of the legs **20** of the landing gear and is connected through a suitable gear box **42** to one of the rollers **36** to rotate the outer shell **12** with respect to the landing gear and supporting structure **10**. The roller **36** connected to the drive motor **40** may be suitably chained (not shown) to its companion roller **36** to assure an adequate drive connection between the drive motor **40** and the circular track **38**.

The shell **12** (Fig. 2) is tubular in configuration, with the diameter of the central portion thereof substantially larger than the diameter at the opposite ends thereof, and is supported in an upright position to give the general appearance of two saucers placed face-to-face. The outer edge portion 44 of the shell 12 is preferably formed of partially transparent material, such as Plexiglas, and is illuminated from within (not shown) to provide a band of light around the central portion of the shell 12. The remainder of the shell 12 is formed of any desired opaque and relative strong material, such as aluminum-laminated Masonite sheets.

The shell 12 is supported on a frame generally designated by reference character 46 and illustrated in Figs. 2 and 4. The frame 46 is circular in plan, as viewed in Fig. 4, and is substantially U-shaped in cross-section (as shown in Fig. 2) to provide an upper horizontally extending portion 48 and a lower horizontally extending portion 50 which extend from adjacent the support-member 18 outwardly to the central portion of the shell 12. The frame 46 may be easily formed with industrial square steel tubing 52 formed into a truss with bracing of steel rods 54. With this construction, the frame 46 may be easily fabricated in sections for convenient assembly, or the entire frame 46 may be lifted off of the supporting member 18 and transported to another location.

Support of the frame 46 and the outer shell 12 is provided by the track 38 (previously mentioned) which is secured on the lower face of the lower horizontally extending portion 50 of the frame 46 in a position to engage the rollers 36 carried by the landing gear legs 20. Additional support for the frame 46 is provided by rollers 56 (Fig. 6) secured around the inner edge of the lower portion 50 of the frame, and rollers 58 secured around the inner periphery of both portions 48 and 50 of the frame. The rollers 56 are arranged in circumferentially spaced relation around the inner periphery of the frame 46 and engage a circular track 60 supported by the legs 20 of the landing gear. The track 60 may be an extension of the upper plate 34 shown in Fig. 3. The rollers 58 engage tracks 62 extending circumferentially around the supporting member 18 to accommodate any radial forces imposed on the frame 46. It will be understood that any desired number of the rollers 58 may be provided around the inner periphery of the frame 46 to provide the necessary support. It will thus be apparent that when the drive motor 40 is placed in operation, the rollers or wheels 36 operated by the motor 40 will engage the track 38 to rotate the shell 12 in one direction around the longitudinal axis of the supporting member 18. The rollers 56 will engage the track 60, and the rollers 58 will engage the tracks 62 during such rotation of the outer shell 12 and frame 46.

The inner rotating assembly 14 is generally annular-shaped, as illustrated in Fig. 5, for movement around the supporting member 18 between the upper and lower horizontally extending portions 48 and 50 of the frame 46. The assembly 14 is also preferably constructed as a frame out of square steel tubing 52 formed into a truss with steel rods 54 for bracing, and is provided with a double conically-shaped framework 64 adjacent the supporting member 18. The framework 64 is provided to support a covering material 66 of any suitable type, such as laminated metal or plastic, to simulate a solid member in the central portion of the amusement device, which in turn simulates a portion of a space craft, such as the power unit for the craft. The covering material 66 may be corrugated if desired. The framework 64, as illustrated in Fig. 6, is also provided to support the rotating assembly 14 on the supporting member 18 and the frame 46. A plurality of rollers 68 are provided around the lower face of the framework 64, and a plurality of rollers 70 are provided around the upper face of the framework 64 to engage circular tracks 72 and 74, respectively, which are mounted on the frame 46. The rollers in each set of rollers 68 and 70 are provided in circumferentially spaced relation around the inner periphery of the rotating assembly 14 to accommodate vertical thrusts imposed on the rotating assembly 14. Additional rollers 76 and 78 are provided around the inner periphery of the framework 64 to engage tracks 80 extending circumferentially around the supporting member 18 to accommodate radial thrusts imposed on the central rotating assembly 14. It will be apparent that any desired number of rollers 76 and 78 may be provided around the inner periphery of the framework 64 to adequately support the rotating assembly 14.



I also prefer to support a plurality of conically-shaped members 82 in the outer edge portion of the central rotating assembly 14. Each conically-shaped member 82 may be easily formed out of a suitable sheet material, such as laminated aluminum or plastic, and is supported at its opposite ends by suitable trunnions 84 to extend through the truss comprising the frame of the central rotating assembly 14. The conically-shaped members 82 are preferably provided in circumferentially spaced relation around the assembly 14, as illustrated in Fig. 5, and are positioned to move through simulated electro-magnets 86 supported around the frame 46, as illustrated in Figs. 2 and 4. Each simulated electro-magnet 86 may be formed in horse shoe shape out of any suitable sheet material, and is provided with tubing or the like 88 around a portion thereof to simulate the winding of an electro-magnet. I further prefer to secure a plurality of plates 90 in spaced relation around the upper face of the rotating assembly 14 to simulate capacitor plates in a space craft. The plates 90 may be formed out of any suitable material, such as aluminum laminated Masonite, to provide a striking appearance.

The inner rotating assembly 14 is driven by a friction or dead wheel 92 pivotally supported on the tubular member 18, as illustrated in Fig. 6, engaging circular plate 94 and 96 carried by the inner rotating assembly 14 and the frame 46, respectively. The plates 94 and 96 are arranged in vertically spaced relation with sufficient distance therebetween to frictionally engage opposite portions of the wheel 92. It will therefore be apparent that when the frame 46 is turned in one direction, the plate 96 will engage the periphery of the wheel 92 to drive the wheel 92 and in turn drive the central rotating assembly 14 in an opposite direction by frictional engagement of the wheel 92 with the plate 94. Therefore, the various conically-shaped members 82 will be moved successively through the simulated electro-magnets 86 and give the appearance of the generation of electrical energy.

The cabin 16 is supported on the upper end of the tubular supporting member 18 and is rigidly secured to the member 18 by bracing 100 to move with the supporting member 18 and to be prevented from rotating with the shell 12 or rotating assembly 14. Additional support is provided by a plurality of rollers 101 carried by the frame 46 engaging a complementary track on the bottom of the cabin. The cabin 16 is constructed out of a suitable framework 102 covered by suitable sheet material 104, such as aluminum laminated with Masonite, on the outer surface of the framework and any other suitable material 106, such as Masonite, around the inner surface of the framework. It will be understood that substantially strong members 108 must be provided in the floor of the cabin 16 to adequately support passengers in the cabin. As illustrated in Fig. 7, a plurality of transparent windows 110 are provided adjacent the outer and inner peripheries of the floor of the cabin 16, through which passengers in the cabin may adequately view the inner rotating assembly 14 and the frame 46.

Passengers may either stand or sit in the cabin 16 and may gain entrance and exit from the cabin through suitable doors 112 as illustrated in Fig. 2. It will also be noted that the upper edge portion **114** of the outer shell **12** is extended upwardly to overlap the lower end portion of the cabin **16**. A portion of the upper edge **114** of the shell **12** is removed, as at **116** in Fig. 1, such that passengers may enter the cabin **16** through the doors **112**. Simulated port holes **118** are provided around the upper edge portion of the cabin **16** to further simulate an interplanetary space craft. It will be noted, however, that the port holes **118** are preferably covered with an opaque material on the inside of the cabin **16** to prevent the passengers from seeing familiar objects outside of the cabin **16**.

A dome **120** is preferably provided in the top central portion of the cabin **16** and the under surface thereof is covered with a suitable material **122**, such as cloth or the like, which will display a movie scene. A projector **124** is suitably mounted in the central portion of the floor of the cabin **16** to project an animated movie onto the screen **122** during operation of the amusement device. The movie displayed by the projector **124** is preferably an animated movie of heavenly bodies made in such a manner that the heavenly bodies displayed on the screen **122** will appear to come closer to and move away from the passengers during operation of the amusement device to give the impression of interplanetary flight.

In summarizing the operation of the preferred amusement device, the passengers are directed into the cabin **16** through the opening **116** in the upper edge portion of the shell **12** and through the doors **112**. The doors **112** are then securely fastened in closed positions and the passengers are thereafter prevented from viewing any object outside of the amusement device during the simulated flight. The drive motor **40** is then placed in operation to rotate the shell **12** and frame **46** in one direction, while the friction wheel **92** drives the inner rotating assembly **14** in an opposite direction. Passengers in the cabin **16** will then view the movement of the inner rotating assembly **14** and the frame **46** through the windows **110** to receive the impression of watching the inner workings of a space craft. Also, suitable lighting effects (not shown) are preferably provided in the shell **12** to illuminate the moving parts. Simultaneously with rotation of the shell **12** and the inner rotating assembly **14**, the jacks **26** are actuated to raise the supporting member **18** on the stanchion **22**. This upward movement of the supporting member **18** will be rather minor, but will be sufficient to give the sensation of rising to the passengers in the closed cabin **16**. It will be observed that when the supporting member **18** is raised, the shell **12** and inner rotating assembly **14** are simultaneously raised to retain the vertical relationship between the cabin **16** and the remainder of the apparatus viewed by passengers in the cabin. Also, simultaneously with rotation of the shell **12** and rotating assembly **14**, the movie is displayed by the projector **124** on the screen **122** on the dome of the cabin to give the passengers the impression of approaching one or more heavenly bodies. The jacks **26** are then operated in the opposite direction to lower the cabin **16** and the movie projected by the projector **124** may then provide an impression on the screen **122** that the passengers are returning to earth.

From the foregoing it will be apparent that the present invention provides an amusement device which will give the impression and sensation to patrons or passengers of the device that they are taking an interplanetary flight. The device includes counter-rotating sections simulating the inner workings of a space craft and these moving sections may be easily viewed by passengers in the device. Also, the passengers are slightly raised during operation of the device to simulate flight from the earth and a movie is simultaneously displayed to give the impression of approaching a heavenly body. It will also be apparent that the construction of the amusement device is such that the device may be easily disassembled and moved from one location to another. It will further be apparent that the present amusement device is simple in construction, may be economically manufactured and will have a long service life.



Changes may be made in the combination and arrangement of parts or elements as heretofore set forth in the specification and shown in the drawings, it being understood that changes may be made in the embodiment disclosed without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. In an amusement device simulating a space ride, the combination of: an outer tubular shell, the diameter of the central portion of said outer shell being substantially larger than the diameter at the opposite ends thereof, means for supporting the outer shell in an upright position with the largest diameter thereof extending horizontally, means for rotating the outer shell about its longitudinal axis, a plurality of simulated electro-magnets carried in circumferentially spaced relation in the outer shell, an annular-shaped frame rotatably supported concentrically in the outer shell, means for simultaneously turning said frame in a direction opposite to the rotation of the outer shell, conically-shaped members carried by said frame in positions for movement through the simulated electro-magnets in the outer shell, a passenger cabin having a floor therein, means for non-rotatably supporting the cabin above the outer shell with the floor of the cabin positioned within the upper end portion of the outer shell, and transparent windows in the floor of the cabin for viewing movement of the outer shell and said frame from the interior of the cabin.

2. An amusement device as defined in claim 1 wherein said means for supporting said outer shell comprises a tubular support member extending downwardly from the cabin through the outer shell and said frame, a base portion on the lower end of said tubular support member simulating a landing gear, cooperating rollers and tracks supporting the outer shell on the base portion, and means for raising and lowering said base portion during rotation of the outer shell and said frame.

3. In an amusement device simulating a space ride, the combination of: a vertically extending supporting member, a passenger cabin mounted on the upper end of the supporting member and having transparent windows in the floor thereof, an outer shell extending downwardly and outwardly from the lower end portion of the cabin and then inwardly and downwardly toward the supporting member, a first frame extending radially inward from the outer shell and having a generally U-shaped cross section with upper and lower horizontally extending portions, means rotatably supporting said first frame on the supporting member, a second frame rotatably supported on the supporting member for rotary movement horizontally between the upper and lower horizontally extending portions of the first frame, and means for rotating said first and second frames in opposite directions to simulate movement of the inner workings of a space craft as viewed from the cabin.

4. An amusement device as defined in claim 3 characterized further to include at least one jack connected to said supporting member for raising and lowering the cabin and first and second frames during rotary movement of said frames.

5. An amusement device as defined in claim 3 wherein said supporting member is a tube, and characterized further to include a fixed stanchion telescoped into the supporting member for holding the supporting member vertical, legs extending outwardly in circumferentially spaced relation from the supporting member below the lower horizontal portion of the first frame simulating a landing gear for the device, rollers carried by each leg, a circular track on the lower horizontal portion of the first frame arranged to ride on said rollers during rotation of the first frame, and a jack connected to each leg of the

landing gear for raising and lowering the supporting member on the stanchion during rotation of said frames.

6. An amusement device as defined in claim 5 wherein said means for rotatably supporting the first frame on the supporting member includes a track around the supporting member opposite each of the upper and lower horizontal portions of the first frame, and a plurality of rollers carried by each of the upper and lower horizontal portions of the first frame in circumferentially spaced relation in positions to engage the respective track.

7. An amusement device as defined in claim 5 wherein said means for rotatably supporting the second frame on the supporting member comprises a pair of vertically spaced tracks around the supporting member, two sets of circumferentially spaced rollers carried by the second frame in positions to engage said tracks on the supporting member, circular tracks on the upper and lower horizontal portions of the first frame, and circumferentially spaced rollers on the upper and lower faces of the second frame for engaging the last-mentioned circular tracks.

8. An amusement device as defined in claim 3 wherein



said means for rotating said frames in opposite directions comprises concentric annular plates secured around the first and second frames in vertically spaced relation adjacent the supporting member, a friction wheel carried by the supporting member in a position to engage said plates and drive the second frame in one direction upon rotation of the first frame in an opposite direction, and means for rotating the first frame.

9. An amusement device as defined in claim 3 characterized further to include a movie projector in the cabin arranged to project a movie of heavenly bodies on the interior of the cabin and provide passengers in the cabin with a sensation of interplanetary space flight.


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FLUID SUSTAINED AND FLUID PROPELLED AIRCRAFT

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FIG 1

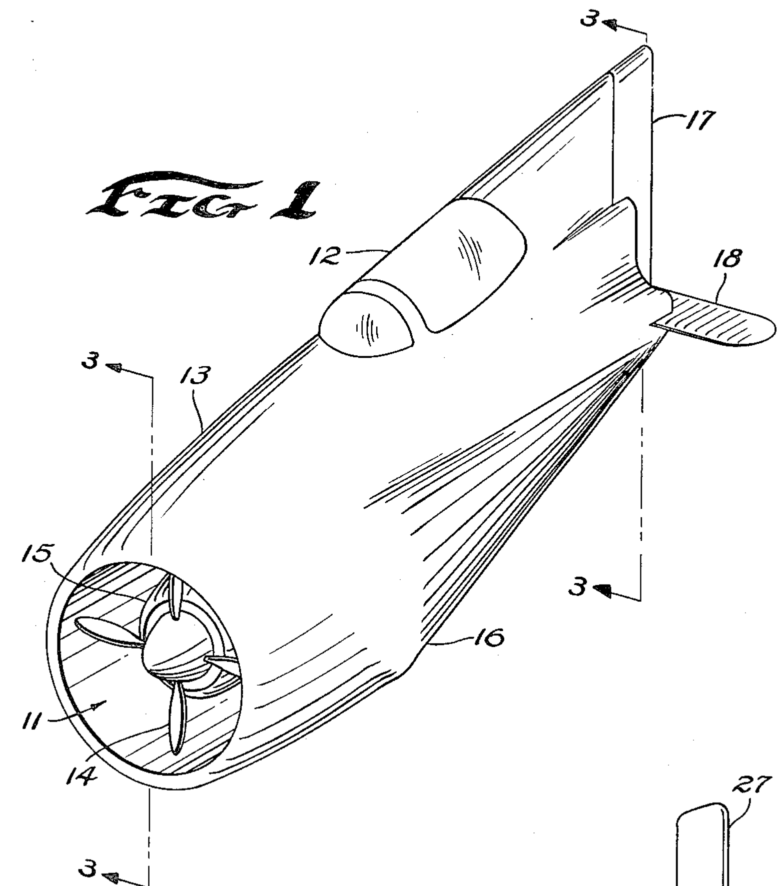
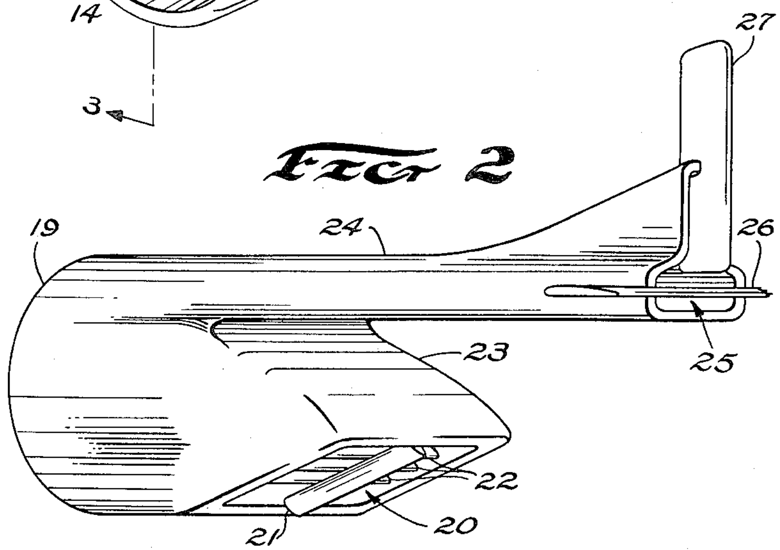



FIG 2

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FLUID SUSTAINED AND FLUID PROPELLED AIRCRAFT

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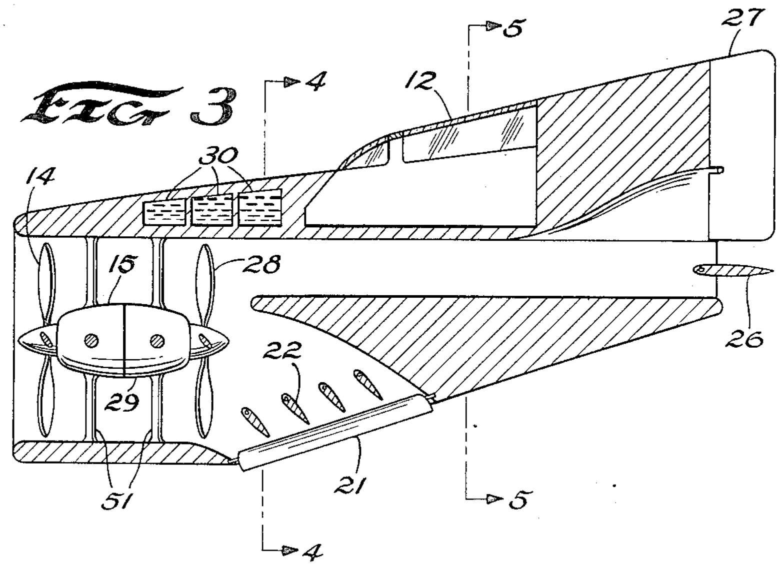



FIG 3

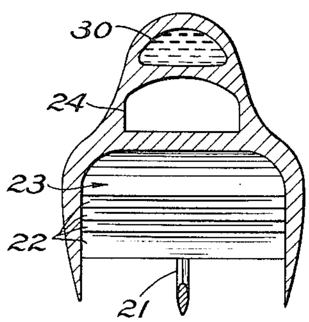
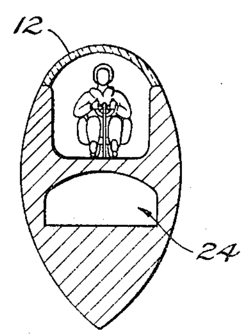



FIG 4

FIG 5

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FLUID SUSTAINED AND FLUID PROPELLED AIRCRAFT

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FIG 6

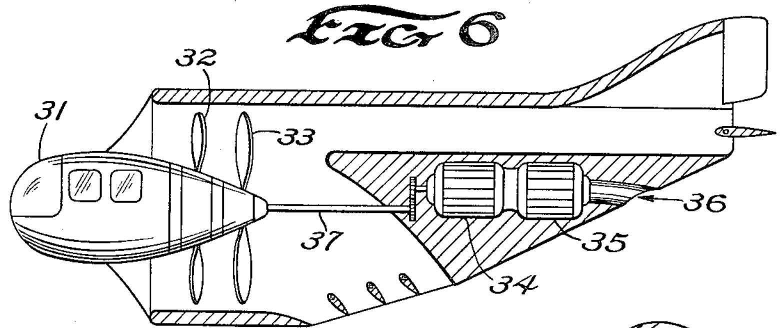
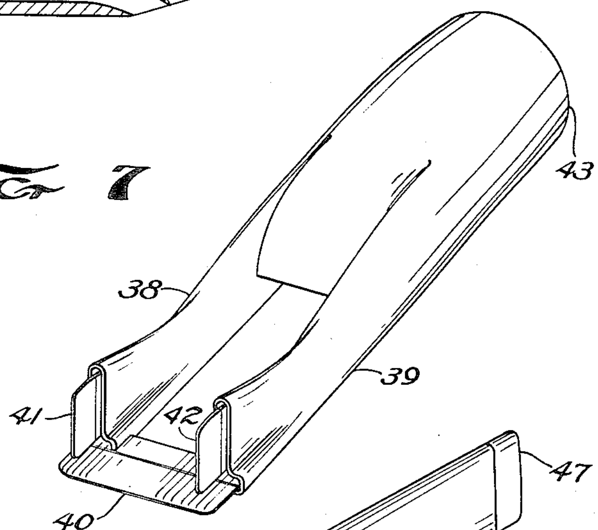



FIG 7



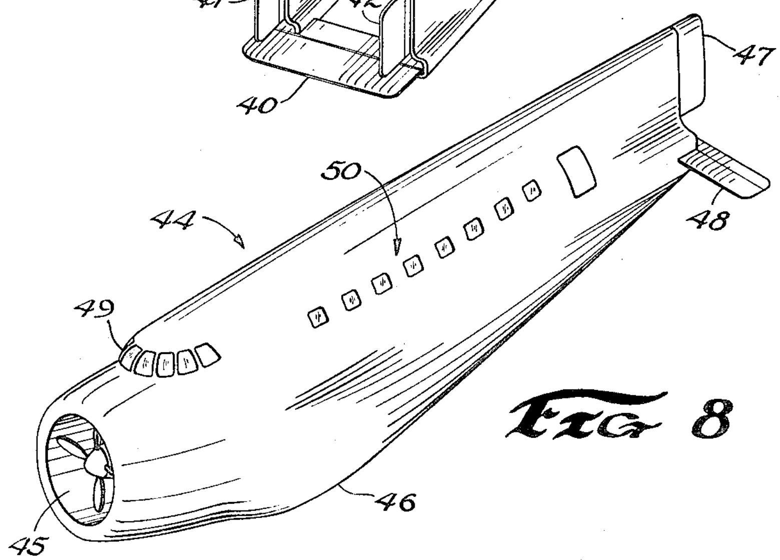




FIG 8

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2,918,230

FLUID SUSTAINED AND FLUID PROPELLED AIRCRAFT

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Application August 24, 1956, Serial No. 606,059

2 Claims. (Cl. 244—23)

The present invention pertains to wingless aircraft and particularly to aircraft with propellers enclosed within an air duct. The air duct and associate vanes direct an airstream as required for hovering, for vertical flight, or for forward flight.

Helicopters for air cargo and passenger service have been utilized in metropolitan areas. Helicopters are complicated by the gearing required at the hub of the propeller blades for changing pitch during their rotation. The speed of the helicopter is limited because when the forward velocity of the craft approaches the rotational velocity of the blade, the lift provided by the horizontal blade is reduced on one side of the aircraft. The size of the blade required on the helicopter is in itself a problem when helicopters are to be parked in a limited space; for example, on a roof heliport.

An object of the present invention is to provide simplified aircraft capable of vertical flight, hovering or horizontal flight.

Another object is to provide aircraft with shrouded propellers for obtaining increased efficiency.

Another object is to provide a single air propelling system in a bifurcated duct that directs two airstreams, one of the airstreams being directed downwardly and rearwardly to provide lift and propulsion at the center of gravity of the aircraft, and the other airstream being directed from the rear of the craft for readily changing attitude.

Another object is to provide in the aircraft air deflecting vanes at the outlets of the duct for providing control of the attitude of the aircraft through the use of conventional control means.

And still another object is to provide an arrangement in an aircraft in which the cockpit is ahead of the propellers so that wide angle visibility and a reduction of sound is obtained.

The objects and appended claims may be more readily understood by studying the following description with reference to the figures in which:

Figure 1 is a front oblique view of a small aircraft that utilizes the airflow system of this invention;

Figure 2 shows a rear oblique view of the air duct and its associated control services of this invention;

Figure 3 is a cross-sectional side view of the aircraft shown in Figure 1;

Figure 4 is a transverse cross-sectional view taken on plane 4—4 of Figure 3;

Figure 5 is a transverse cross-sectional view taken on plane 5—5 of Figure 3;

Figure 6 shows a side cross-sectional view of an aircraft that is partly cut away for showing modifications of the invention;

Figure 7 shows an oblique rear view of an air duct having a plurality of rear control portions; and

Figure 8 is a front oblique drawing of a passenger aircraft that uses the airflow system of this invention.

In general, each of the various aircraft of this invention utilizes an air duct for obtaining increased efficiency and

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for obtaining effective control of the aircraft. The front portion of the air duct may be cylindrical with an opening facing frontwardly. An air propelling system located within the cylindrical duct generates the required air stream for lifting, for forward thrust, and for control. The air duct is divided into a downwardly and rearwardly projecting portion near the center of gravity for providing lifting force and forward thrust, and one or more portions that extend to the rear of the aircraft for directing an air stream over the elevator and rudder. Deflection of the stream by the controllable elevator and rudder change the attitude of the aircraft as required. Although the aircraft in the accompanying drawings has been shown without landing gears, it is to be understood that conventional landing gears are used with the aircraft described herein.

A small aircraft that utilizes a bifurcated air duct is illustrated in Figure 1. The aircraft includes air duct 11, required power equipment, fuel tanks, and cockpit 12 all enclosed by outer skin 13. The forward portion of the air duct is a cylinder that is substantially horizontal or inclined slightly upward towards the front. A front opening of the duct faces frontwardly and preferably slightly upwardly. Propeller 14, propeller housing 15, and propeller driving means are mounted within the horizontal cylinder. As the air duct extends rearwardly, it is divided into two portions. The larger portion of the air duct is directed downwardly and rearwardly for forcing air out of an opening at the bottom of mid-section 16 of the aircraft. The smaller portion or the control portion of the air duct is directed rearwardly for discharging air on to rudder 17 and elevator 18.

In Figure 2 is shown the air duct and the control vanes of the aircraft that is illustrated in Figure 1. The air duct includes the forward cylindrical portion 19 that has its axis substantially parallel with the longitudinal axis of the aircraft. This cylindrical portion divides near the center of the aircraft to form a downwardly and rearwardly directed mid-section 23 that may have a rectangular opening, and a smaller horizontal portion 24 that extends to the rear and that has a rear opening 25 for directing an airstream over elevator 26 and rudder 27. The direction of flow of the airstream from the bottom opening 20 is controlled over wide angles by roll flap 21 and deflecting vanes 22. These vanes are controlled by usual control means employed in aircraft. For vertical or hovering flight the horizontal vanes are set for deflecting the airstream downwardly and for horizontal flight the vanes are set for directing the airstream at a slanted direction rearwardly and downwardly. Roll flap 21 may be controlled for deflecting the airstream sideways for controlling the roll of the aircraft. Control of the aircraft through use of the centrally located bottom opening alone would be difficult. In order to increase the torque about the center of gravity for readily changing the attitude of the aircraft, the rear portion 24 of the air duct is included for directing a stream of air over the rudder and elevator.

Operation of these rear control surfaces in the usual manner is very effective in changing attitude of the aircraft because of the high velocity of the airflow over the surfaces.

The air duct is clearly shown in the cross-sectional view of the aircraft shown in Figure 3. Counter-rotating propellers 14 and 28 are mounted within the front horizontal portion of the duct. Engines 15 and 29 for driving the propellers are mounted to the main frame of the aircraft by radial supporting bars 51. Gasoline tanks 30 are shown in a forward position above the air duct and cockpit 12 is shown behind the gasoline tanks and above the air duct.

In Figure 4 is shown a cross-sectional view of Figure

3 on plane **4—4**. This view shows the placement of gasoline tank **30** above the rear portion **24** of the duct and shows the larger portion **23** of the air duct.

In Figure 5 is shown a cross-sectional view taken of plane **5—5** of Figure 3. In this view the cockpit **12** is shown above rear portion **24** of the air duct.

A modification of the invention is illustrated in the partial cutaway side view shown in Figure 6. This modification includes the bifurcated air duct which provides effective control of the aircraft as described for the aircraft illustrated in Figure 1. In this modification, cockpit **31** has been located ahead of counter-rotating propellers **32** and **33**, and turboprop engines **34** and **35** have been located near the rear of the aircraft. By locating the engines near the rear of the aircraft, exhaust gases are conducted through a short duct **36** to the rear of the aircraft. Power from engines **34** and **35** is transmitted through shaft **37** to propellers **32** and **33**.

In addition to obtaining the efficiency and control features associated with a bifurcated air duct, the modification shown in Figure 6 provides cabin space ahead of the propellers in order that insulation from noise is very effective. Location of the engines in the rear of the aircraft permit gases to be exhausted readily and provides additional thrust that may be derived from the exhaust.

The air duct illustrated in Figure 7 utilizes two rearwardly extending portions for directing airstreams over the rear control surfaces. A duct having this configuration may be readily used in aircraft similar to those illustrated in Figures 1 and 6. In this example, air from rear ducts **38** and **39** is directed over elevator **40**. If desired, the outlets of the rear ducts may have the inverted **T** shape as shown in Figure 2 so that rudders **41** and **42** are in the airstream supplied from the ducts. As described in Figure 2, the cylindrical portion **43** has a front opening and joins with a downwardly and rearwardly mid-section.

An elongated streamlined passenger aircraft utilizing a bifurcated air duct is illustrated in Figure 8. Aircraft **44** has an air duct with a front opening **45**, downwardly and rearwardly facing opening at mid-section **46**, and an inverted **T** shaped opening for exhausting air over rudder **47** and elevator **48**. The rear portion of the air duct is inclined slightly upward for obtaining better pitch stability. Cockpit **49** and passenger cabin **50** are located near the top of the aircraft.

During take-off of the aircraft of this invention, the deflecting vanes located in the larger exhaust opening are positioned by conventional control means for deflecting an airstream downwardly. Also, the elevator and the roll flap are positioned as required for stabilizing the aircraft. The downwardly directed air stream causes the craft to rise vertically until desired altitude is attained before starting horizontal flight. Then conventional controls are operated for positioning the deflecting vanes in the larger air duct for directing the air stream rearwardly and downwardly. The downwardly vector provides lift as required for supporting the plane and the rearwardly vector provides thrust for propelling the aircraft forward.

In forward flight, the deflecting vanes correspond to trim tabs of the conventional wing-type aircraft. The deflecting vanes are set to provide required lift under average flight conditions so that horizontal flight is maintained readily. Small correction for determining the altitude of the plane is supplied by the roll flap at the exhaust opening of the larger air duct and by the rudder and elevator at the inverted **T** opening of the rear air duct. The flow of air from the rear air duct over the rudder



and elevator cause these control surfaces to be particularly effective in changing the attitude of the aircraft in response to the operation of conventional control systems.

Through the use of shrouded propellers, the aircraft of this invention provides greater lift and thrust per horsepower than is provided by aircraft using unshrouded propellers. The air duct in the arcraft of this invention provides two separate airstreams. The larger airstream emitted near the center of gravity of the aircraft provides most of the lift and propulsion; the smaller airstream emitted in the rear of the aircraft provides effective control and also aids in propulsion. The rear control air duct need not be parallel with the longitudinal axis of the arcraft. Good pitch stability may be provided by inclining the rear duct or control duct slightly upward toward the rear of the aircraft.

Flight speed of the aircraft of this invention is improved not only by increasing the efficiency of the propellers but also by reducing drag caused by large wing surfaces. Previous aircraft capable of landing at low speeds have had large wings or large horizontal propeller blades. In the present aircraft, the frontal profile has been greatly reduced by the absence of wings. The reduction of drag and increased thrust provided by shrouded propellers ensures a high rate of forward flight.

Although this invention has been described with respect to particular embodiments thereof, it is not to be so limited as changes and modifications may be made therein which are within the full intended scope of the invention as defined by the appended claims.

What is claimed is:

1. A wingless aircraft having an elongated fuselage that has a nose and an aft end, said fuselage encompassing an air duct, said air duct having a main portion extending rearwardly from a frontal inlet in said nose and dividing into a first branch that extends laterally to a side outlet and a second branch that extends longitudinally through the fuselage to an aft outlet, substantially all of the lateral cross-sectional area of said nose being the inlet of said main portion, said first branch being substantially larger than said second branch, air-propelling means mounted within said main portion, and controllable air-deflecting vanes mounted within said outlets.

2. A wingless aircraft comprising an elongated streamlined fuselage, the walls of said fuselage defining an air duct, said air duct having an inlet, a side outlet, and a plurality of aft outlets, said inlet facing forward at the front of said fuselage and being predominate in the frontal profile of said aircraft, said air duct having a main portion extending rearwardly from said inlet and dividing into a plurality of branches, one of said branches having substantial cross-sectional area and gradually curving laterally to terminate in said side outlet, the other of said branches having less combined cross-sectional area than said one branch and extending longitudinally through said fuselage to terminate in respective ones of said aft outlets, air-propelling means mounted within said main portion, and controllable air-deflecting vanes mounted in said outlets.

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TOROIDAL AIRCRAFT

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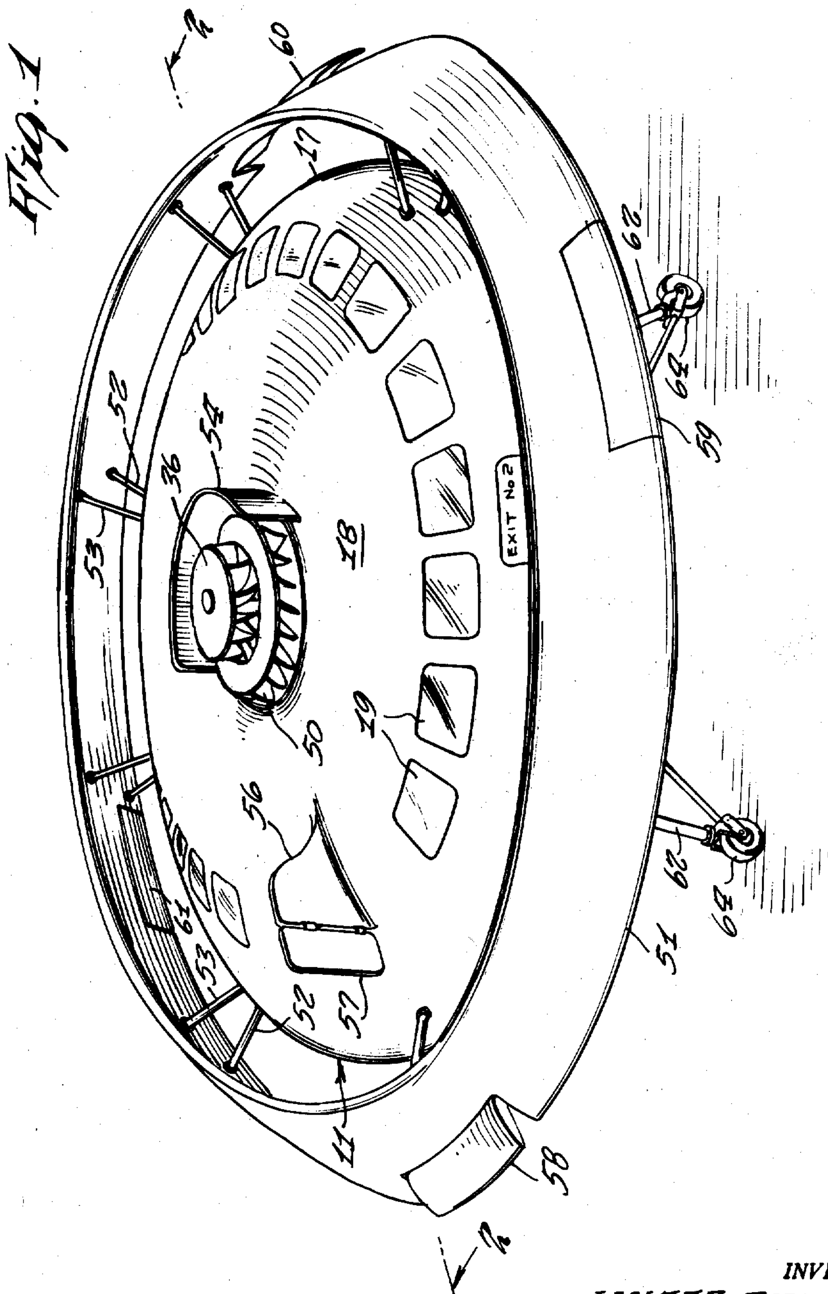


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TOROIDAL AIRCRAFT

Filed May 29, 1956 | 4 Sheets-Sheet 2

Fig. 2

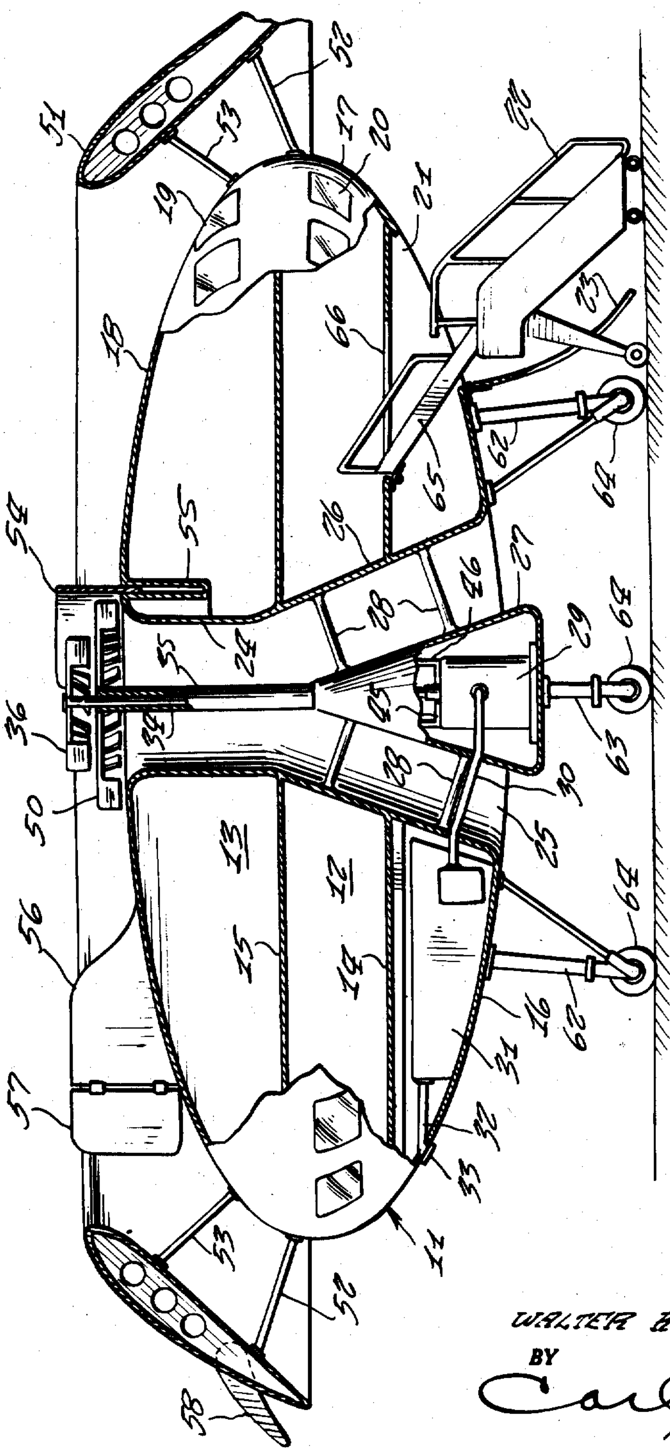

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Fig. 3

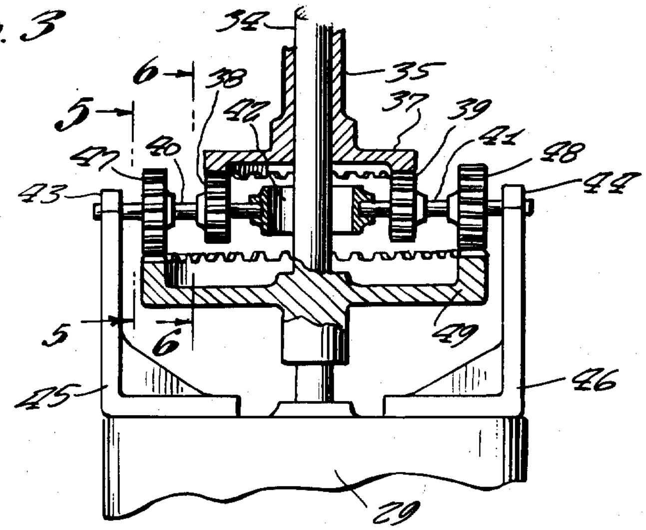



Fig. 4

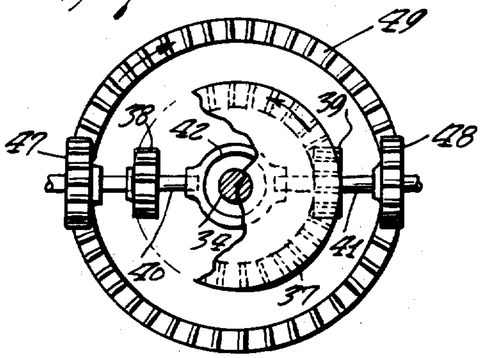



Fig. 7

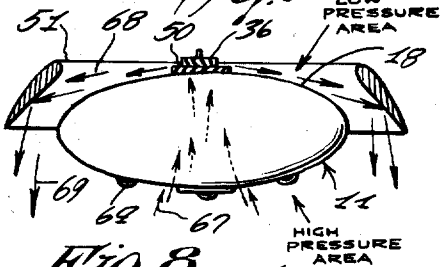



Fig. 5

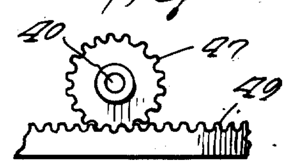



Fig. 8

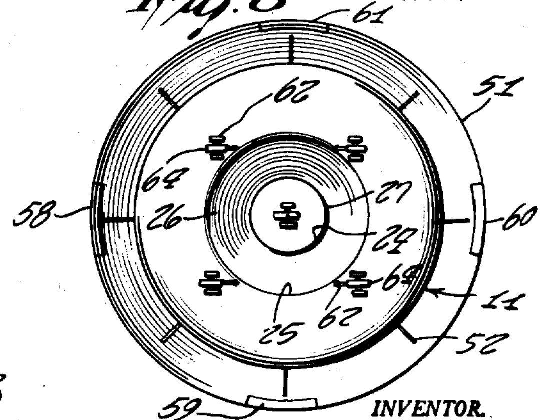
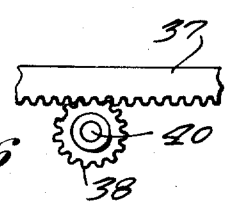



Fig. 6

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March 8, 1960 W. R. MELLEN 2,927,746

TOROIDAL AIRCRAFT

Filed May 29, 1956 4 Sheets-Sheet 4

Fig. 9

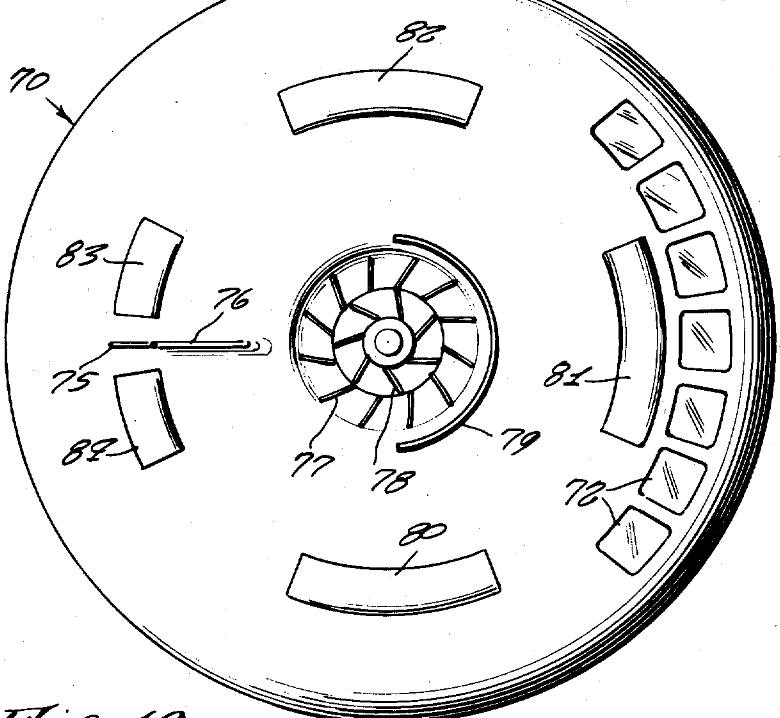
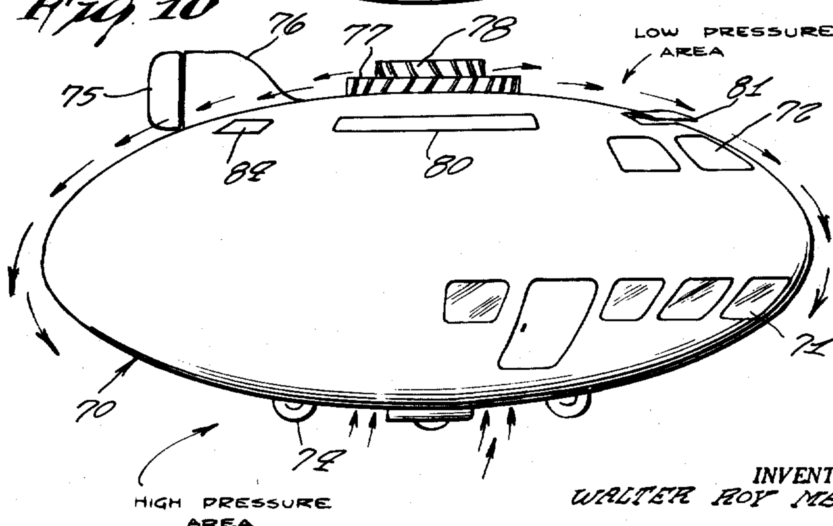



Fig. 10

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United States Patent Office 2,927,746
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2,927,746

# TOROIDAL AIRCRAFT

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Application May 29, 1956, Serial No. 588,045
2 Claims. (Cl. 244—12)

This invention relates to aircraft of the heavier than air type, and particularly to what I choose to term toroidal aircraft.

The main object of my invention is to produce a type of aircraft which is primarily built in the form of a toroid, and which therefore has several advantages lacking in conventional types of the airplanes and the like.

An ancillary object of my invention is to have a toroidal aircraft which requires a minimum of driving power to operate it in contrast with that required by other aircraft of similar types.

Another object of this invention is to have such an aircraft which by the very nature of its construction and form is free from dangerous exposure of operative parts as in rotating wing craft.

A further object of the invention is to have an aircraft as indicated which requires very small landing and take-off space.

Still another object of the invention is to have such aircraft which may safely be operated near other aircraft of the same type.

It is, of course, an important object of the invention to have a toroidal aircraft as mentioned which is simple in overall form and simple, yet effective to operate.

Other objects and advantages of my invention will appear in greater detail as the specification proceeds.

In order to facilitate ready comprehension of this invention for a proper appreciation of the salient features thereof, the invention is illustrated on the accompanying drawings forming part hereof, and in which:

Figure 1 is a perspective view of a toroid aircraft made according to my invention and embodying the same in a practical form;

Figure 2 is a vertical section of the same aircraft as taken on line 2—2 in Figure 1;

Figure 3 is a side elevation, partly in section of the rotor drive gearing of the aircraft of Figures 1 and 2;

Figure 4 is a top plan view of the same drive gearing as seen from above in Figure 3;

Figure 5 is a vertical section of the gearing as taken on line 5—5 in Figure 3;

Figure 6 is another vertical section thereof as taken on line 6—6 in the same Figure 3;

Figure 7 is a reduced diagram, partly sectional based on the aircraft of Figures 1 through 3 showing the nature of the air flow of the craft in active operation;

Figure 8 is a bottom view or plan of the same as seen from below in Figure 7;

Figure 9 is a top plan view of a modification of the aircraft; and

Figure 10 is a side elevation of the aircraft of Figure 9.

Throughout the views, the same reference numerals indicate the same or like parts and features.

In aeronautics, it is well known to have vanes and wings or blades upon propellers and rotors for lifting and propelling aircraft, and the type of vanes or wings often impart the name and nature of the craft to the type involved. In general, such craft have more or less exposed



moving wings and vanes or blades, and in this respect are very vulnerable to damage from many sources and therefore dangerous in their very nature. It has occurred to me that certain features of air rotors and the like should be capable of useful effect and operation when located in a more sheltered construction such as an actual saucer or toroid type of structure and the like to solve the problems of danger and lift. As a result, I have developed a toroid aircraft as already outlined, which will now be described in detail in the following, due reference being had to the accompanying drawing previously mentioned.

Hence, in the practice of my invention, a hollow toroid body generally indicated at **11** contains two superposed passenger chambers **12** and **13** having the individual floors **14** and **15** and outer walls, lower wall **16** peripheral rounded wall **17** and top or roof **18**. The peripheral wall **17** contains the upper and lower rows of windows **19** and **20** for the two chambers, while an opening **21** is accessible for entry of passengers by way of portable stairs **22** when the bottom door **23** is dropped open as shown. Upwardly through the axial center of the aircraft body **11** extends an air drive column **24** which is substantially cylindrical and tubular in its upper portion while flaring conically outward in the downward direction and forming a large air intake opening **25** at the lower end of the flaring portion **26**.

Within the central air column **24**, **26** and projecting down thru opening **25** is a conical motor housing **27** secured to the walls of the air column by radial rods **28**, **28** and containing a driving motor **29**, preferably of the fuel combustion type having a feed pipe **30** connected thereto and running from a fuel tank **31** having a filling pipe fixture **32** closed by a removable cap **33** exposed upon the lower body wall **16**. Manual controls and valves, throttles and the like are omitted for clarity in the drawing because such control means must be understood as they are well known and do not necessarily include any new features inherent in the invention as such.

Motor **29** has a drive shaft **34** extending upwardly through rotor tube **35**, through the upper end of motor housing **27** and at its upper end carrying a radial blower fan **36**. As best seen in Figures 3 to 6, inclusive, the tube **35** which is rotatable about shaft **34** has a crown gear **37** upon its lower end meshing with a pair of spur gears **38**, **39** mounted upon aligned shafts **40**, **41** extending rotatably at their inner ends into the central stationary ring-yoke **42** surrounding shaft **34** but out of contact therewith. The outer ends of these independent shafts **40**, **41** are rotatably supported in the upper bearing ends **43**, **44** of a pair of opposite brackets **45**, **46** fixed upon motor **29**. Within these bracket bearings **43**, **44** are fixed further spur gears **47**, **48** upon these shafts, which in turn mesh with a second larger crown gear **49** fixed upon vertical rotor shaft **34** a distance below the first mentioned crown gear **37** upon tube or sleeve **35**. These crown gears may well be bevel gears, if desired, but in any event, rotation of drive shaft **34** with its gear **49** naturally rotates spur gears **47** and **48** in opposite directions and thus also gears **38** and **39** with them, the latter gears in turn rotating gear **37** in the opposite direction to that of gear **49**. The sleeve **35** is thus rotated by gear **37** in the opposite direction to shaft **34** with its upper fan rotor **36**, and as sleeve **35** rotates in the opposite direction, this also holds for the second fan rotor **50** which surmounts the sleeve. The two fan rotors thus rotate in opposite directions and tend to sweep the air outwardly in radial directions off the rounded roof **18** of the aircraft body **11**.

As the mentioned aircraft body is formed with an airfoil profile, this creates a low pressure area upon the flat dome **18**, but the lifting effect is increased by disposing about the toroid body a circular wing **51** inclined outwardly downward in section and secured in position by a series of pairs of anchoring rods **52, 53**. This wing is located at the proper raised level to intercept the radial air currents set up by rotors **36** and **50**, and to give direction to the craft under such air drive. Three features are included in the structure, the first being a curved upright air shield **54** which may be raised from or lowered partly or fully into a curved recess **55** in the top of the craft. This shield normally cuts off the horizontal air drive from the rotors in the forward direction opposite to the rudder **56** with its movable rudder member **57** while freely allowing such driving air to strike the wing **51** about and rearwardly of the rudder structure that form the second feature. The third feature includes the four ailerons **58, 69, 60** and **61** that serve to tilt the whole craft in the direction of the particular aileron that is swung outward as in the case of rear aileron **58** in Figures 1 and 2. The controls for operating the rudder member **57** and the ailerons are omitted as well known and understood as included.

Beneath the craft are fixed a group of roller studs or legs **62, 62, 63** with ground rollers **64** for supporting the craft when on the ground at port. The door **23** in the bottom **16** allows the inside stair **65** to swing down through floor opening **66** to rest on the portable stairway **22** already referred to above. When the craft is to be raised into the air, the motor **29** is started, causing both drive fan rotors **36** and **50** to drive air away from the center out from the rounded top **18** of the body **11** against the inclined under surface of ring-shaped wing **51**, producing a double lift by means of low pressure over the curved top surface **18** and upward push beneath wing **51**. The shield **54** governs the amount of air allowed to reach more or less of the wing **51**, while the swingable rudder member **57** serves to steer the craft, and the ailerons **58** to **62** serve to tilt the whole as desired and give rising angle to the craft. The action may be followed diagrammatically in Figures 7 and 8, in which arrows **67** indicate how the air rises through the central air column to fan drive rotors **36** and **50** and how the latter drive the air radially outward as per arrows **68** to impinge on the inner surface of wing **51**, and rebound downward as per arrows **69**. The roller studs are withdrawn so as to avoid projecting to any great extent, while the windows are omitted for simplicity in these diagrammatic views. As the air drive rotors rotate in opposite directions, they eliminate any tendency of spinning the craft about a vertical axis and allow easy steering by the rudder.

In Figures 9 and 10 are shown a modification of the aircraft in which the toroid hollow body indicated at **70** has the same general outline as the body **11**, with the lower and upper windows **71** and **72** for the passenger chambers and the lower door **73**, as well as the landing gear **74** resembling the gear **62, 63, 64** described before. A dirigible rudder **75** hinged to stationary rudder **76** serves to steer the craft while the fan rotors **77, 78** are similar to rotors **36, 50**. There is in this case no spaced circular wing deflector, although it has the upper front curved air shield **79**. Instead of the four ailerons on the circular wing deflector **51**, this form of aircraft has at least as many upper deflectors **80, 81, 82** and the rear pair **83, 84**, which are operated by raising them individually as deflector **81**. The motor drive with shaft and sleeve and gears are as described, and the central air column drawing up air to the fan rotors is also as previously described in connection with Figures 1 to 8. Deflection of the air downward around body **70** is obtained partly by the tendency an air stream has to follow a curved surface and partly by boundary layer control obtained from the air being drawn in under the lower surface of the body **70**.

Manifestly, variations may be resorted to, and parts and features may be modified or used without others within the scope of the appended claims.

Having now fully described my invention, I claim:

1. A toroidal aircraft including the combination of a hollow toroid body circularly developed about an upright central axis, the toroid body having an upwardly convex top and a downwardly convex bottom with passenger compartments located within and windows for the compartments exposed upon the exterior of said body, landing gear with roller studs secured beneath the latter, a stationary rudder mounted upon the top and provided with a hinged rudder member connected thereto, a circular baffle surrounding the toroid body in uniformly spaced apart relation, said baffle being downwardly and outwardly inclined and located with its upper inner edge or periphery located at a distance above the top of said body and the lower outer edge or periphery disposed substantially at the level of the widest diameter of said body with means for securing said baffle rigidly thereto, means for directing air inwardly beneath the bottom and upwardly axially through said body and then outwardly from the center upon the top to alter the air pressure beneath said bottom and inversely alter the air pressure upon said top, said means comprising a central vertical passage means extending axially upward through said body and having the lower portion thereof conical in form so as to flare downwardly, and means for forcibly drawing the air upwardly through said vertical passage means including an upwardly tapering motor housing in the flaring portion of said passage having a prime mover with a driven shaft extending upwardly through said passage with fan rotor means mounted upon the upper end thereof for rotation by said shaft immediately above the level of said top, said top having an arcuate recess extending a short distance downwardly thereinto with a correspondingly arcuate air shield curved about the central axis of the toroid body equipped to be raised upwardly from and lowered down into said recess to varying extent in a position diametrically opposite said rudder.

2. A toroidal aircraft according to claim 1, wherein the prime mover has plural shaft means extending upwardly through the vertical air passage and the fan rotor means comprising a pair of oppositely driven fan rotors upon the upper ends of the plural shaft means for driving air radially outward over said top, and the baffle has a plurality of aileron flaps forming movable control members upon a plurality of spaced positions on the baffle for modifying the flight of the aircraft at will.

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ROTATING JET AIRCRAFT WITH LIFTING DISC WING AND CENTRIFUGING TANKS

Filed March 28, 1955 — 2 Sheets-Sheet 1

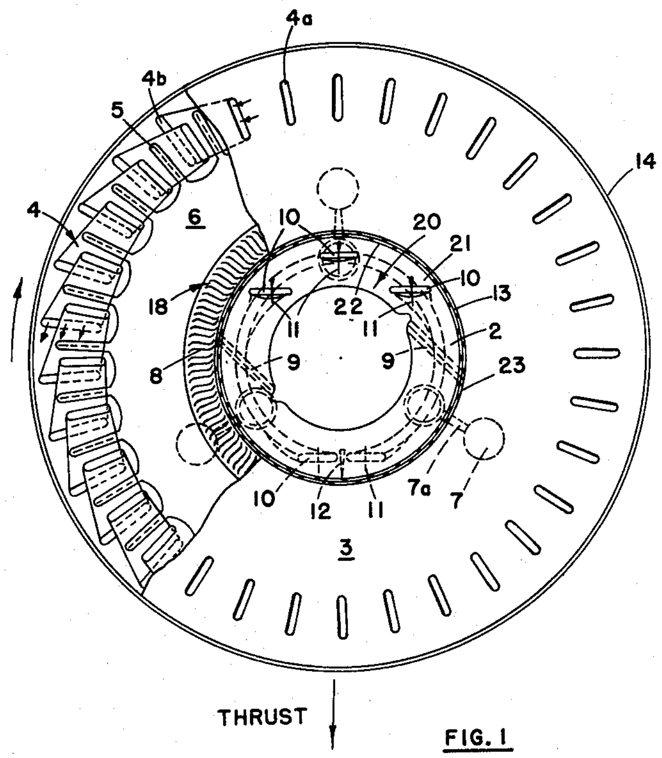


FIG. 1

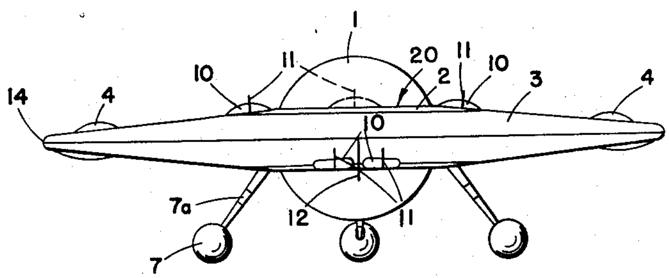


FIG. 2

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ROTATING JET AIRCRAFT WITH LIFTING DISC WING AND CENTRIFUGING TANKS

Filed March 28, 1955 2 Sheets-Sheet 2

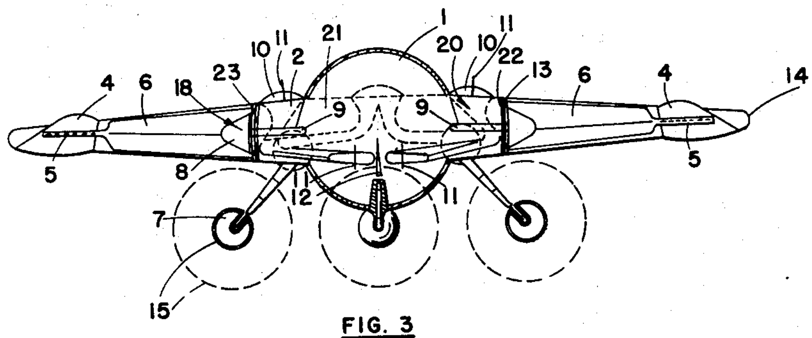


FIG. 3

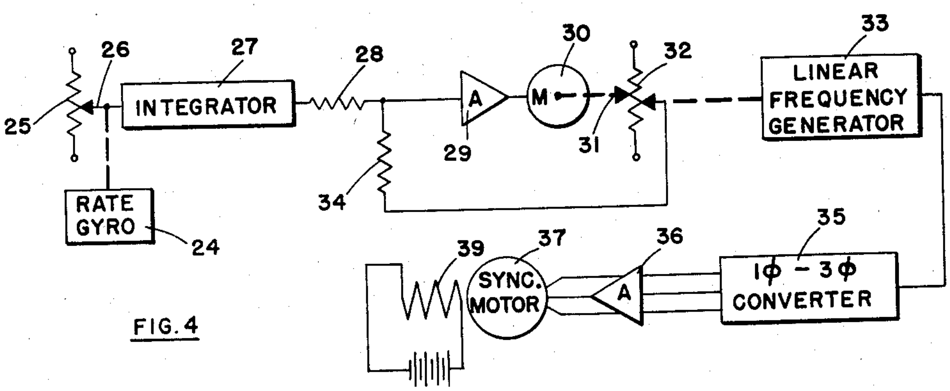


FIG. 4

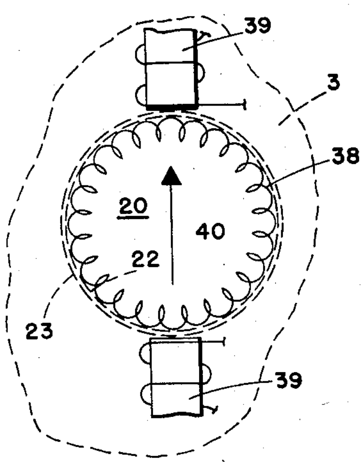


FIG. 5

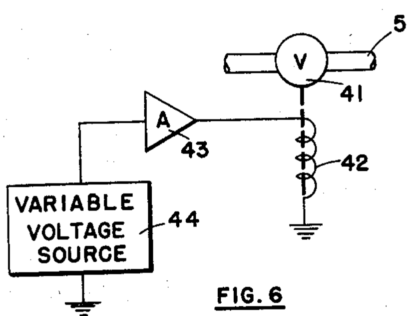


FIG. 6

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United States Patent Office 2,939,648 Patented June 7, 1960



2,939,648

# ROTATING JET AIRCRAFT WITH LIFTING DISC WING AND CENTRIFUGING TANKS

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Filed Mar. 28, 1955, Ser. No. 497,299

Claims priority, application Germany Mar. 27, 1954

9 Claims. (Cl. 244—12)

This invention relates to a jet powered aircraft having the configuration of a double convex-shaped disc with a spheroidal central body, and more particularly to a jet powered aircraft in which the driving jets are spaced adjacent to and around the circumference of a double convex-shaped disc which rotates around a central body which does not rotate.

In the present known airplanes which move forward with great speed so as to exceed the speed of sound, a backward thrust is created which not only affects human being adversely but also creates construction material fatigue of a high degree. This evidently is one of the greatest causes of accidents.

This aircraft has been created as a safe, very fast and highly economical flying device. It takes off from and lands vertically on any suitable ground or water surface and has the ability to remain in suspension at any point at any desired altitude regardless of weather conditions. Great maneuverability is possible and for example, an acute angle change of course can be executed. Acute angle turning is made possible by the fact that all the turning devices are in proximity to the center of the aircraft and further, the center body is the only portion that is turned in that the wing, extending outwardly therefrom, is continuously rotating and is not affected by the turning of the central body. When landing, even though jet channels or nozzles are shut off, the device has excellent balance resulting from the rotation of the disc wing.

Extremely effective use of jet fuel is achieved by employment of a relatively large number of small jet channels or nozzles which are supplied with fuel by injectors having numerous small orifices or apertures.

The all-view cabin in the non-rotating body can contain, in addition to the service and personnel rooms, any required equipment, such as air-conditioning and pressure devices, radar, steering and speed controls, and instruments.

This device has great climbing capacity in high altitudes. Its trajectory of flight is easily regulated at all times and thus eliminates all jolting movements that can be injurious to human health.

Therefore, an object of this invention is to provide an aircraft different from the conventional design by creating a disc-like rotating flying device having a lifting wing disc and a non-rotating central body comprising a spheroidal-shaped, all-view cabin which at its midsection is horizontally broadened into a truncated, tapered disc.

A principal object of this invention is to provide an improved jet powered aircraft having flight properties that do not adversely affect human being or materials.

A further object of this invention is to provide an improved jet powered aircraft which is safe, capable of high speed and very economical in operation.

A still further object of this invention is to provide a disc wing jet aircraft which is capable of taking off and landing vertically on land and water.



An object of this invention is to provide a disc wing aircraft which has the ability to remain in suspension at any point at any desired altitude regardless of weather conditions.

Another object of this invention is to provide a disc wing aircraft with great and easy maneuverability to that it can make acute angle course changes.

Other objects of invention will become apparent from the following description taken in connection with the accompanying drawings, in which

Fig. 1 is a plan view of the aircraft having a portion cut away to show some of the interior and lower portions;

Fig. 2 is an elevation view of the disc wing aircraft looking from the rear.

Fig. 3 is a partially cross-sectioned view of the wing disc with the forward portion thereof cutaway;

Fig. 4 is a schematic drawing of rate gyroscope system which maintains body **20** irrotational;

Fig. 5 shows the synchronous motor **30** of Fig. 4 in detail; and

Fig. 6 shows the solenoid valve circuit for controlling flow of fuel into fuel injector **5**.

Referring to Figs. 1–3, truncated disc-shaped platform **2** extends horizontally and radially outward from the spheroidal-shaped, multi-view cabin **1**. Platform **2** extends from the approximate horizontal midsection of cabin **1** and they together form body **20** within double convex or V-shaped tapered disc wing **3**. Wing disc **3** has its greatest thickness adjacent platform **2** and tapers symmetrically, radially outward from its hollow central portion **21** in which body **20** is situated. The circumference formed in disc **3** around hollow central portion **21** is concentric with disc **3**, as is the circumference of body **20** formed around truncated disc-shaped platform **2**. Disc wing **3** is surrounded by metal rim **14**. A bearing surface area **13** is formed between circumference **22** of body **20** around platform **2** and circumference **23** formed around hollow central portion **21** of disc **3**. Bearing surface area **13** can be provided by multiple double ball or roller bearings.

In platform **2** of body **20** are rotation-starting rockets **9**. They are spaced and directed to fire away from body **20** and into bucket vanes **8** of starting turbine **18** located around and open to inner circumference **23** of disc **3** formed around hollow central portion **21**. Rockets **9** are placed in position substantially tangent to cabin **1**. They are fired from within cabin **1** through openings in circumference **22** to start the rotation of disc **3** by their thrusting forces and continue to be fired until sufficient rotating speed is achieved to allow jet channels or nozzles **4** to be activated.

As the starting rockets are fired for only a short period of time, the disposition of their exhaust may be easily handled in the turbine blading and the surrounding space. As may be seen in Fig. 1, there is considerable space between and around the blades of turbine **18** for the expansion of the rocket gases. Further, the rockets may fire into the turbine at only two points and after the blades move away from these points, there is a considerable period during which the gases may be expanded and leak out along the inner circumference of the casing or through some other opening or openings which may be made in the turbine casing.

Immediately outboard of vanes **8** are fuel tanks **6** which rotate with disc **3** and this rotation develops a centrifuging action to feed fuel into fuel injectors **5**. Fuel flows into injectors **5** from tanks **6** and amounts can be varied to individual injectors by electromagnetic means, such as variable solenoid valves (not shown in Figs. 1–3) operated in cabin **1** and shown in Fig. 6. Fuel injectors **5** extend into jet channels **4** in a substantially horizontal, radially outward direction and are tube-shaped, having a number of small openings or apertures to allow for an even and economical distribution of fuel. The type of openings in injectors 5 depend upon the kind of fuel used, which can be liquid, dust, powder, gas or solid. Ignitors, not shown, can be employed in injectors 5, if necessary, depending upon the fuel used. They can be pyrotechnics or electrically operated types.

Jet channels 4 are spaced evenly around the outer circumference of disc 3 and they are shown to have the cross-section of an elongated slot having two sides substantially parallel but can be of other design configurations. They extend through disc 3 from top to bottom and are sloped away from the vertical, with the top toward the direction of rotation. They are open to the top and bottom external surfaces of disc **3** and are closed to the interior of disc 3 except for their connection with fuel tanks 6 by injectors 5. Channels or nozzles 4 have similar cross-section from top to bottom, except that the cross-section is progressively elongated on the way down from the top so that the bottom is considerably longer than the top. When disc 3 starts to rotate, the upper slots *4a* of channels 4, being toward the direction of rotation and the lower slots *4b* being sloped away from it, the former act as intake suctions and through the latter, after burning of the fuel, a thrusting force is exerted downward and in the direction of rotation. This thrust action gives the disc wing its vertical uplift.

Jets of the configurations shown when rotated at high speeds cause a sufficient amount of air to enter them so that they will function efficiently as ram jets. The fact that the inlets are open toward the direction of rotation and that the discharges are in the opposite direction effects, in itself, a scooping action to cause considerable air to be forced into the inlets. Additional scooping action occurs because the openings of the jets extend above the main surface of the wing 3, as may be seen in Figs. 2 and 3. The inlets, as shown in Fig. 1, may appear somewhat out of proportion in size to the remainder of the drawing. Their exact size is a matter of design to be determined in the practice of the invention.

The level horizontal flight of the aircraft is made possible by means of a plurality of air-flow ducts **10** which, in body **20**, are arranged to extend from the front top side to the rear bottom side at the midportion. Air enters openings in ducts **10** external of and at the front of body **20** and is discharged external of and at the rear of body **20**. Main steering control rudder or vane **12** is located on the rearward bottom of body **20** midway between the discharge openings of ducts **10**. Further steering is made possible by means such as vanes **11** within ducts **10** or directly external of their discharge openings.

Non-rotation of body during flight is achieved by electromagnetic fields which can be imposed upon disc 3 and body **20** in various ways so as to counteract the direction of rotation of the disc wing. As shown in Fig. 4, one system which would give the desired result employs rate gyroscope **24** which is attached to nonrotating body **20** with its sensitive axis parallel to the azimuth axis of the body. Rate gyroscope **24** generates a torque about its output axis which is proportional to the angular velocity about its input axis. This torque is customarily measured by a spring (not shown). The motion of rate gyroscope **24** about its output axis against the spring is customarily measured by means of an electrical device, such s a synchro or potentiometer. As shown in this figure, potentiometer **25** is used and has its wiper arm **26** mechanically driven by rate gyroscope **24**.

An electrical voltage source (not shown) is connected against the stationary terminals of potentiometer **25**. The electrical voltage generated upon wiper arm **26** of potentiometer **25** is therefore proportional to the angular velocity measured by rate gyroscope **24**. Wiper arm **26** is connected to the input of integrator **27** where the signal is integrated. The output of integrator **27** is connected through impedance matching resistor **28** to the input of servo amplifier **29** which is connected by its output to drive motor **30**. Motor **30** is is mechanically connected to drive the wiper arm **31** of potentiometer **32** and to drive the frequency controller of frequency generator **33**. Wiper arm **31** of potentiometer **32** is connected through impedance matching resistor **34** to form a feedback loop to the input of servo amplifier **29**. The shaft rotation of motor **30** therefore, in accordance with servo art, has a rotation proportional to the voltage output of integrator **27**. Frequency generator **33** is a linear frequency generator which has an electrical output whose frequency is proportional to the shaft rotation of motor **30**. Frequency generator **33** generates a single phase voltage which is connected to the input of converter **35** which changes the single phase voltage to a three phase voltage. A three phase voltage output of converter **35** is then connected through three phase amplifier **36** to the A.C. winding of synchronous motor **37**. Synchronous motor **37** has its A.C. winding **38** preferably around the periphery of body **20**, as shown in Fig. 5. The A.C. winding of synchronous motor **37** may be, for example, of the ring type or of the salient pole type. The D.C. field windings **39** of synchronous motor **37** are upon rotating disc **3**. Vector **40** is the resultant of the fields in winding **38** and is shown in position to prevent rotation of body **20**.

The electro-mechanical device which maintains body **20** irrotational operates as follows:

When rate gyroscope **24** detects an angular velocity, regardless of how the angular velocity is caused, it generates a signal which is integrated by integrator **27** to increase the frequency of the voltage applied to A.C. windings **38**, to thereby cause the electrical field which is generated to rotate synchronously with the external disc **3**.

Referring to Fig. 6, showing an electrical circuit for the operation of solenoid valves **41** in injector **5**, a variable voltage source **44** is connected through amplifier **43** to solenoid coil **42**. Valves **41** can be opened to any certain position by varying the voltage in cabin **1**.

The hydraulically operated retractable landing gear has three legs *7a*, one end of each being directed downward and the other end of each being secured in body **20**. On the lower ends of the legs are ball-like pneumatically inflatable buffers **7** which provide an elastic, cushioned touching of the ground when landing. For landing and taking off from water, elastic expandable outer skins **15** are provided to cover ball-like buffers **7** and are pneumatically inflated from cabin **1**.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

I claim:

1. A disc wing jet aircraft comprising a double convex-shaped disc having a radially outward directed taper from its center, said disc having an open central portion about its geometrical center, said open portion being concentric with the circumference of said disc, a circular body within said central portion and concentric to said disc, said disc and said body having a common vertical axis, said disc mounted to rotate on said body in a plane perpendicular to their common axis, rocket means within said body directed to exhaust away from said body and toward said disc, bucket vanes in said disc adjacent to said body in position to receive said exhaust from said rockets, fuel tanks outward of said vanes in said disc, jet channels in said disc adjacent the circumference thereof and outward of said tanks; fuel injectors outward of said tanks and connected thereto, extending into said jet channels; air-flow ducts within said body for achieving hori-

zontal flight of said aircraft, steering means, and electromagnetic means within said body and said disc to prevent the rotation of said body.

2. A disc wing aircraft comprising a double convex-shaped disc having a radially outward directed taper from its center, said disc having an open central portion about its geometrical center, said open central portion being circular and concentric with the circumference of said disc, a circular body within said central portion and concentric to said disc, said disc and said body having a common vertical axis, said disc mounted to rotate on said body on said common axis, a plurality of rockets within said body directed to exhaust away from said body and toward said disc, bucket vanes in said disc adjacent to and surrounding said body in position to receive the thrust from said rockets, fuel tanks outward of said vanes in said disc, a plurality of fan-shaped jet channels in said disc adjacent to the circumference thereof and outward of said tanks; fuel injectors outward of said tanks and connected thereto, extending into said jet channels; a plurality of air-flow ducts extending through said body in a generally forward to aft direction, said ducts being open adjacent and to the forward surface of said body to allow entry of air and said ducts being open adjacent and to the after surface of said body to allow discharge of said air, steering vanes external of and adjacent to said ducts, and electromagnetic means within said body and said disc to prevent the rotation of said body.

3. A disc wing aircraft according to claim 2 wherein said body comprises a central, all-view spheroidal-shaped cabin having a tapered truncated disc-shaped platform extending generally horizontally and radially outward therefrom at its approximate vertical midsection, said platform extending to the circumference of said body and said taper being substantially the same as that of said disc, said body and said disc having bearing surfaces therebetween on which said disc rotates about said body.

4. A disc wing aircraft according to claim 2 wherein said body comprises a central, all-view spheroidal-shaped cabin having a tapered truncated disc-shaped platform ex-extending generally horizontally and radially outward therefrom at its approximate vertical midsection, said platform extending to the circumference of said body and said taper being substantially the same as that of said disc, said body and said disc having bearing surfaces therebetween on which said disc rotates about said body, said rockets being open in said circumference of said body and extending in said body in directions substantially tangent to said spheroidal-shaped cabin.

5. A disc wing aircraft according to claim 2 in which said jet channels are spaced within and around said circumference of said disc, each of said channels extending from the top of said disc in a sloping direction away from the vertical to the bottom of said disc, each of said channels being open to the exterior of said disc at the top and bottom thereof, said opening at said top being an elongated slot, said opening at said bottom being an elongated slot of greater length than said first-mentioned slot, and said fuel injectors extending in a substantially horizontal direction from said tanks into said channels, a plurality of openings in said injectors to evenly distribute fuel from said tanks into said channels, electromagnetic means to regulate the quantity of fuel flowing from said tanks to said elements.

6. A disc wing aircraft according to claim 2 further comprising a retractable landing gear having three legs with one end of each directed downward from said body when said gear is extended, each of said legs having its other end secured in said body, said one end of each leg having a ball-shaped buffer secured thereon, and each of said buffers having a pneumatically expandable skin surrounding said buffer.

7. A disc wing aircraft comprising double convex-shaped disc having a radially outward directed taper from its center, said disc having an open central portion about its geometrical center, said open central portion being circular and concentric with the circumference of said disc, a circular body within said central portion and concentric to said disc, said disc and said body having a common vertical axis, said disc mounted to rotate about said body on said axis, said body having a central, all-view, spheroidal-shaped cabin having a tapered truncated disc-shaped platform extending generally horizontally and radially outward therefrom at its approximate vertical midsection, said platform extending to the circumference of said body and said taper being substantially the same as that of said disc, said body and said disc having bearing surfaces therebetween on which said disc rotates about said body, a plurality of rockets within said body directed to exhaust away from said body and toward said disc, said rockets being open in said circumference of said body, bucket vanes in said disc adjacent to and surrounding said body in position to receive the thrust from said rockets, tapered fuel tanks outward of said vanes in said disc, a plurality of fan-shaped jet channels in said disc adjacent to the circumference thereof and outward of said tanks; said jet channels being spaced within and around said circumference of said disc, each of said channels extending from the top of said disc in a sloping direction away from the vertical to the bottom of said disc, each of said channels being open to the exterior of said disc at said top and bottom thereof, said opening at said top being an elongated slot, said opening at said bottom being an elongated slot of greater length than said first-mentioned slot; fuel injectors outward of said tanks and connected thereto, extending into said jet channels; said injectors extending in a substantially horizontal direction from said tanks into said channels, a plurality of openings in said injectors to evenly distribute fuel from said tanks into said channels, a plurality of air-flow ducts extending through said body in a generally forward to aft direction, said ducts being open adjacent and to the forward surface of said body to allow entry of air and said ducts being open adjacent and to the after surface of said body to allow discharge of said air, steering vanes external of and adjacent said ducts, electromagnetic means within said body and said disc to prevent the rotation of said body, electromagnetic means to regulate the quantity of fuel flowing from said tanks to said elements, a retractable landing gear having three legs with one end of each directed downward from said body when said gear is extended, each of said legs having its other end secured in said body, said one end of each leg having a ball-shaped buffer secured thereon, and each of said buffers having a pneumatically expandable skin surrounding said buffer.

8. A disc wing jet aircraft comprising a double convex-shaped disc having a hollow central portion concentric to and within said disc, said disc tapering radially outward from said central portion, a body within said central portion and concentric to said disc, said disc and said body having the same vertical axis, said disc mounted to rotate on said body on said axis, means within said body to actuate means within said disc to cause said disc to start rotating about said body, means within said body to lift said body and said disc, means within said body to achieve horizontal flight for said aircraft, means on said body to steer said body and said disc, and means within said body and said disc to prevent the rotation of said body when said disc is rotating.

9. A disc wing jet aircraft comprising a disc having an open central portion concentric thereto, a body within said central portion and concentric to said disc, said disc and said body having a common vertical axis, said disc mounted to rotate about said body on said axis, means

within said body to actuate means within said disc to cause said disc to start rotating about said body, means within said disc to lift and drive said body and said disc, means on said body to steer said body and said disc, and means within said body and said disc to prevent the rotation of said body when said disc is rotating.

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AIRCRAFT WITH DUCTED LIFTING FAN

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Fig-1

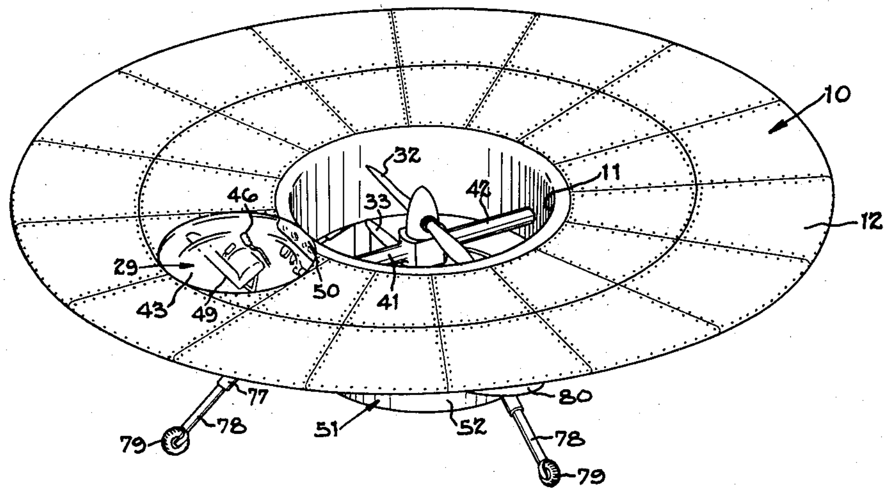
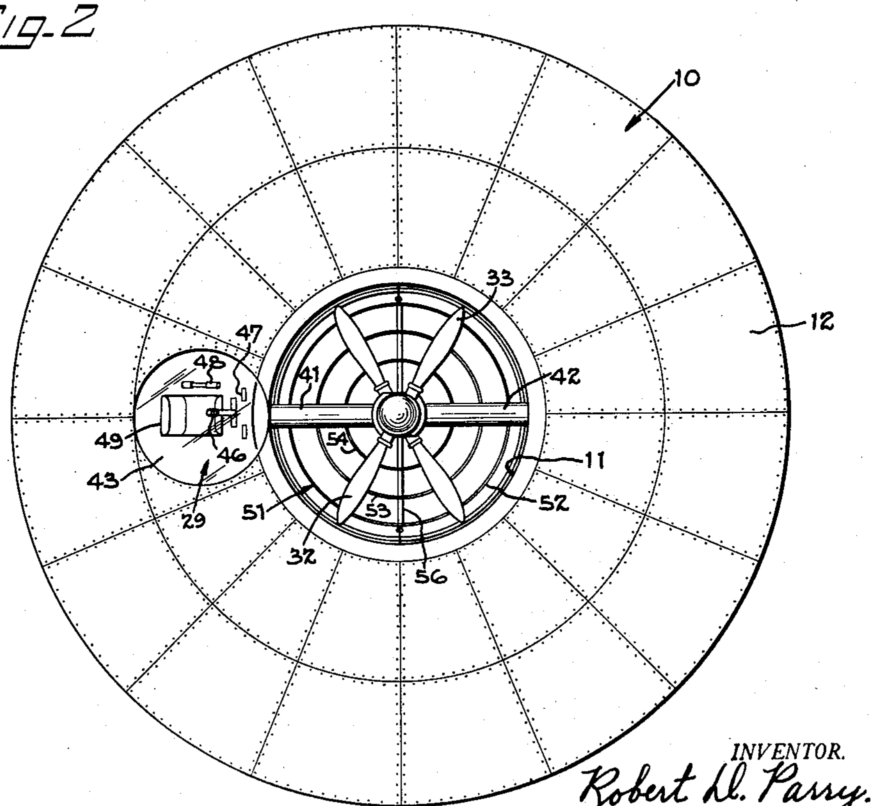



Fig-2

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AIRCRAFT WITH DUCTED LIFTING FAN

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Fig-3

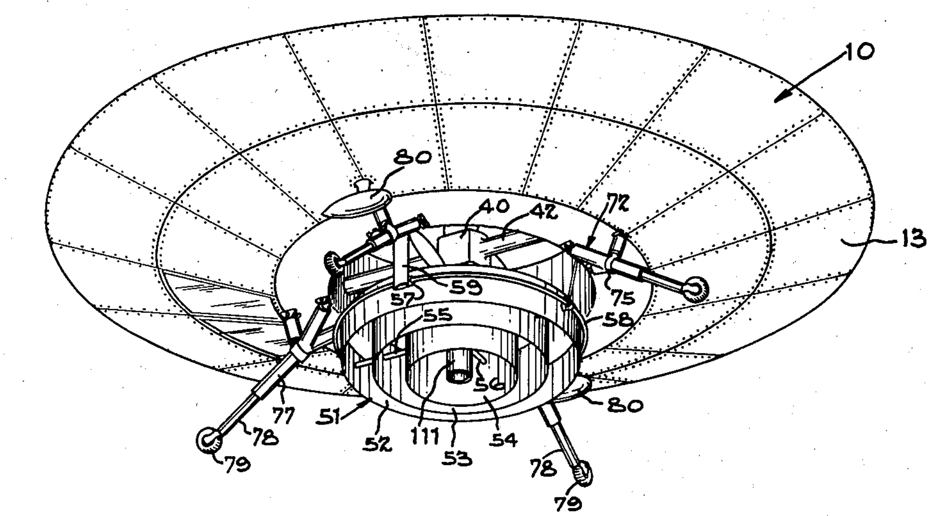
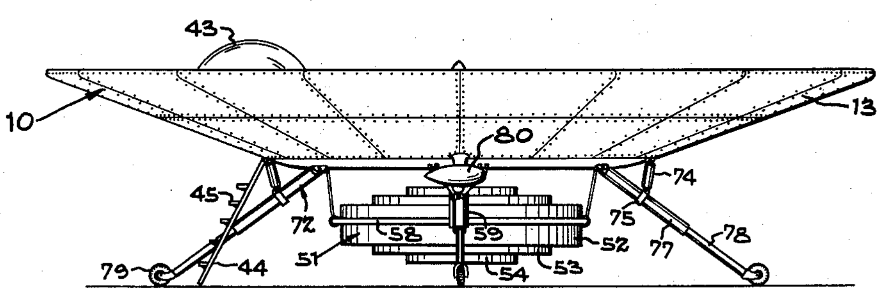



Fig-4

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AIRCRAFT WITH DUCTED LIFTING FAN

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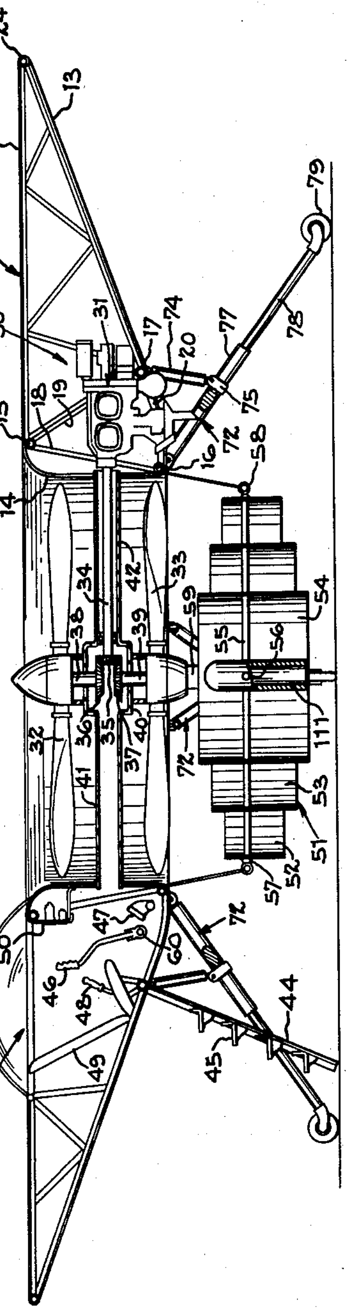


FIG-5

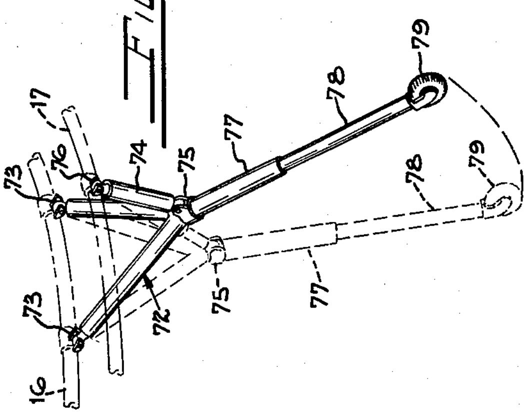


FIG-7

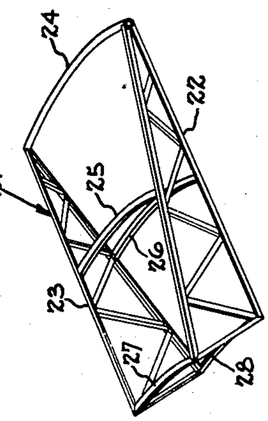


FIG-6

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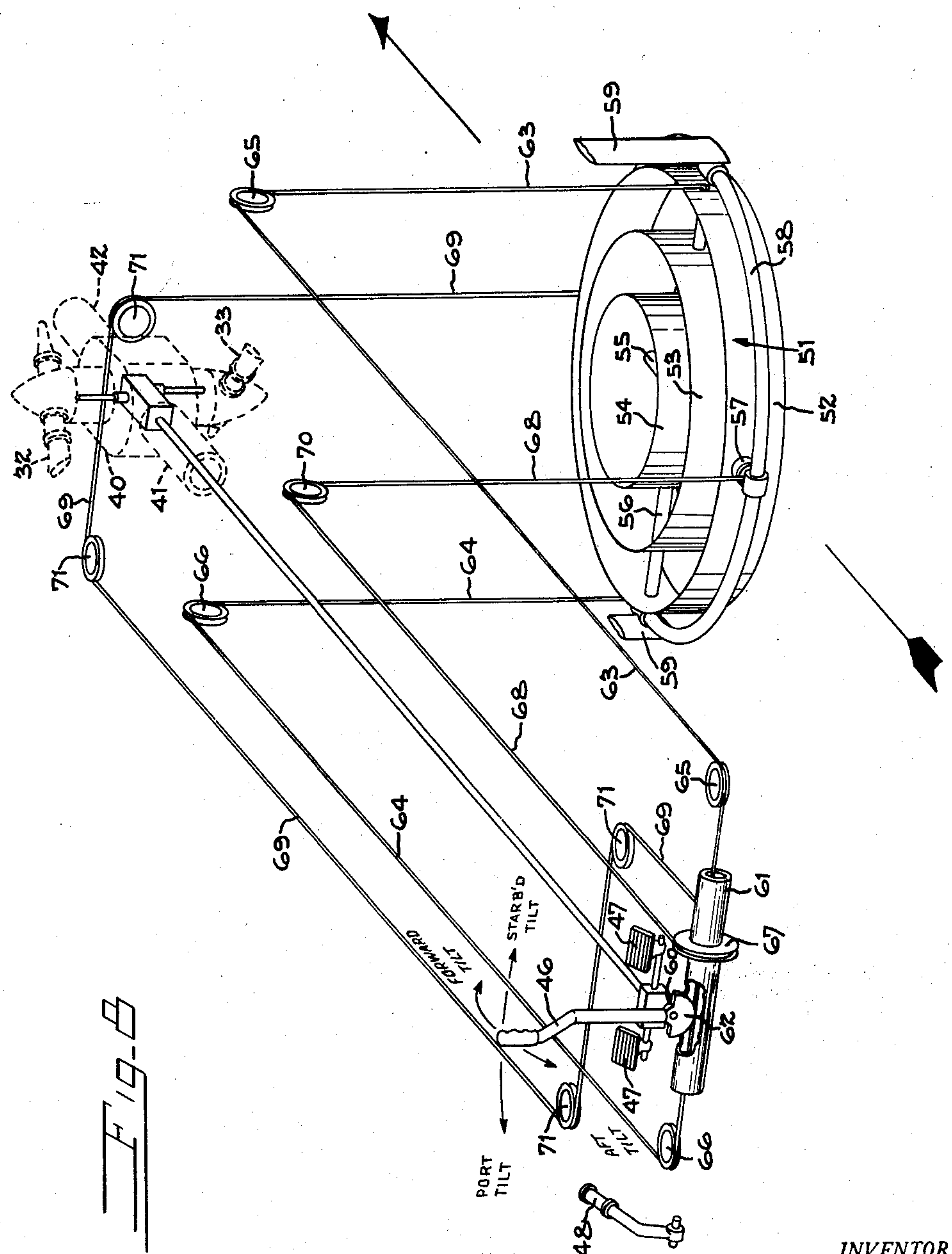


Fig. 8

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Fig. 9

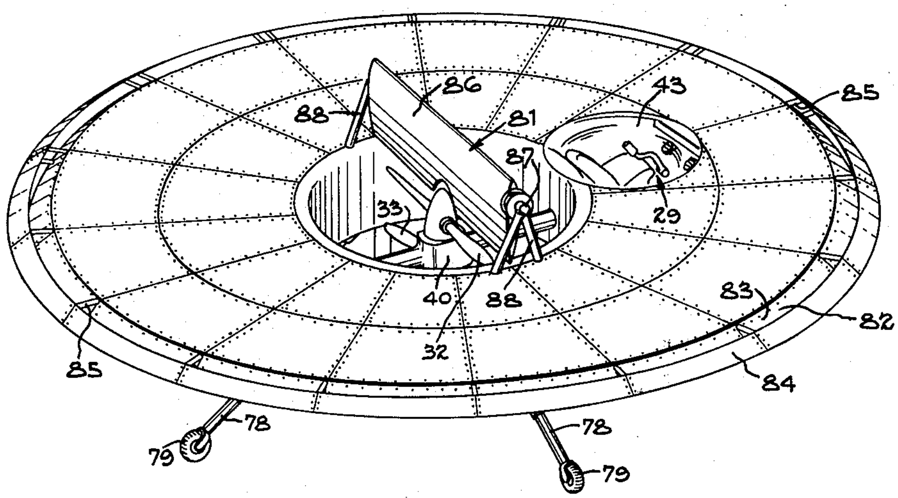
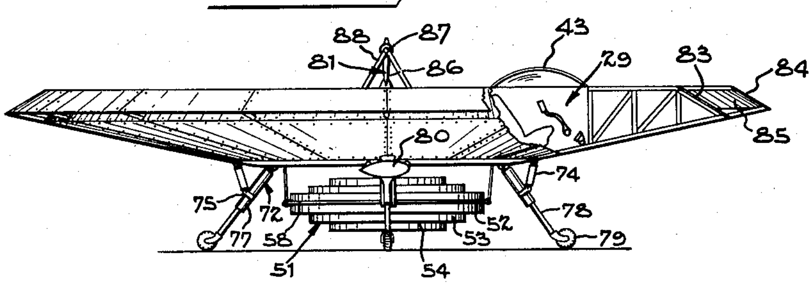



Fig. 10

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AIRCRAFT WITH DUCTED LIFTING FAN

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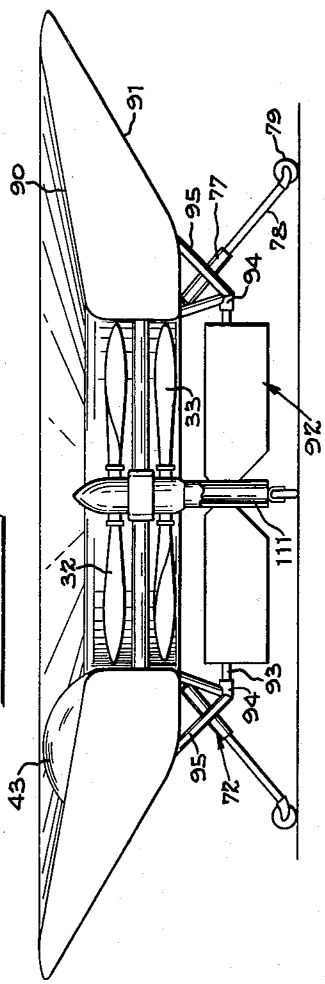


Fig. 11

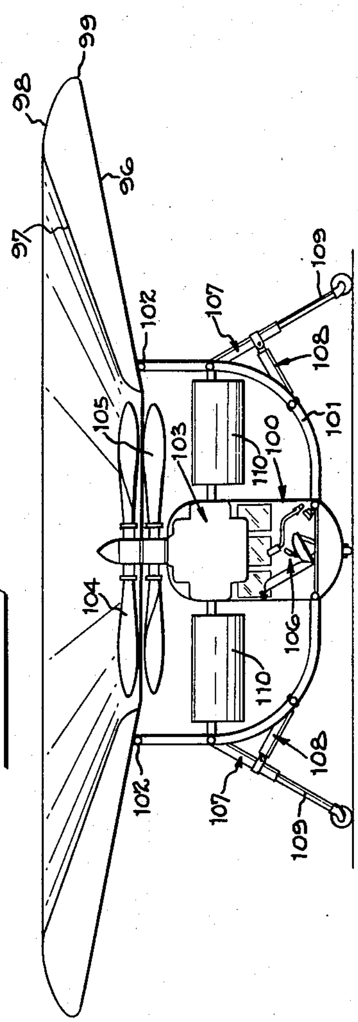


Fig. 12

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AIRCRAFT WITH DUCTED LIFTING FAN

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Fig-14

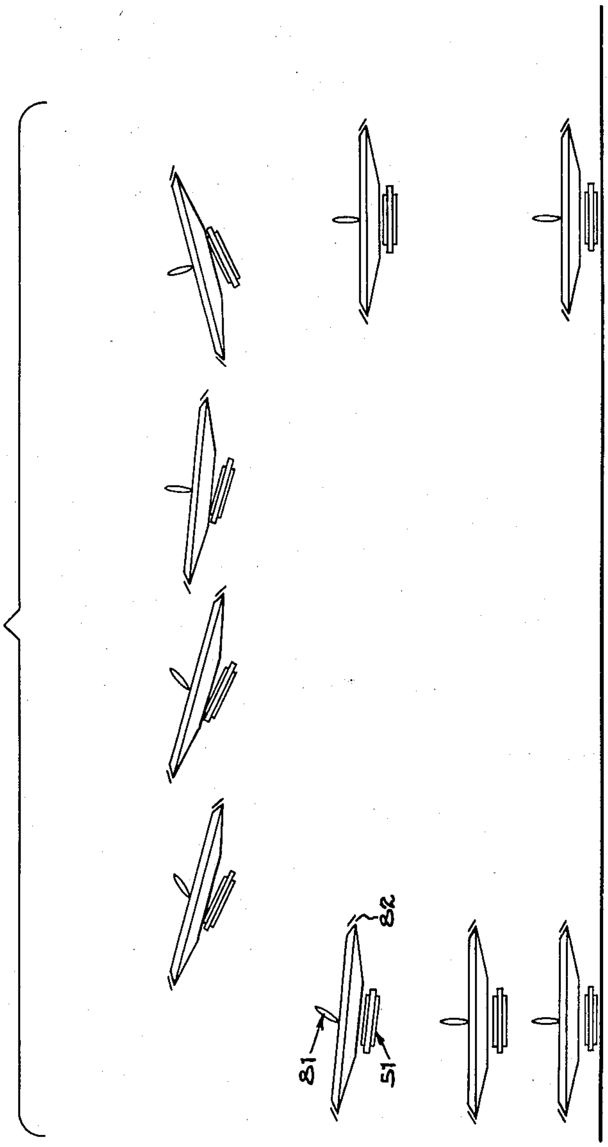
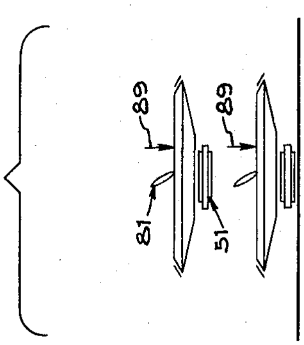



Fig-13

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United States Patent Office

2,953,320

Patented Sept. 20, 1960

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2,953,320

# AIRCRAFT WITH DUCTED LIFTING FAN

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Filed July 18, 1955, Ser. No. 522,583

9 Claims. (Cl. 244—12)

This invention relates to aircraft, and it is the primary objective of the invention to provide an aircraft to fulfill the need for a low cost, safe, easily operated aircraft which does not require conventional airport facilities to take off and to land.

The present aircraft has many of the desirable performance characteristics of a helicopter in that it can take off vertically from a position of rest upon the ground and in that it is capable of flight in any direction. But, unlike a helicopter, it does not depend upon rotating elements such as the rotor vanes of a helicopter to make a safe descent in the event of a power failure. Also unlike a helicopter, directional control is not obtained through the manipulation of rotating members such as rotor vanes. In addition, unlike a helicopter the present aircraft can be taxied, that is, moved under power, while it is upon the ground.

Essentially, the novel features of the aircraft reside in the shape of the body or airframe, which is both a fuselage and, in a sense, an airfoil; the disposition of the thrust producing device which is used to lift and sustain the aircraft in flight; and, in the controls which are provided for directing the aircraft when it is in flight.

The body or airframe is circular as seen from above. Preferably, the upper surface of the body is planar. The under surface of the body, on the other hand, is in the shape of the frustum of an inverted, shallow cone. The central area of the body is open to define a large, cylindrical throat which extends through the aircraft from top to bottom. In the preferred embodiment, thrust is produced by a pair of counter-rotating propellers which are mounted within the cylindrical throat to rotate about the vertical central axis of the aircraft and thus to produce thrust along this axis. The rotating propellers pull air through the throat, discharging it at the underside of the aircraft as a high speed stream of air. Hence, a major portion of the lift obtained is a direct result of the propellers reaction upon the air which they contact upon rotation. The remainder of the lift, and a significant part of it, is that which is obtained from air moving across the upper surface of the body of the aircraft toward the throat, being pulled into the throat by the rotating propellers.

In its simplest form, the aircraft is controlled both in flight and while being taxied on the ground by movable control surfaces which may take several forms. These control surfaces are mounted directly below the exit of the throat where they are in the path of the high speed blast of air driven downwardly by the rotating propellers. Essentially, the aircraft when in flight moves in the direction in which it is tilted. Such tilting is initiated by canting or angulating the control surfaces with respect to the direction of the stream of air driven downwardly by the propellers.

Due to the symmetrical, circular shape of the body or airframe of the aircraft, the words "pitch" and "roll," as these terms are applied to the conventional winged airplane, are synonymous as applied to attitudes of this aircraft. The word "tilting" is more apt and is used herein to describe any deviation of the central axis of the aircraft away from the vertical; and the control surfaces which are located in the high speed column of air below the aircraft control such "tilting." Turning the aircraft about its vertical central axis or "yawing," as this term is employed to describe the attitude of a conventional aircraft, may also be controlled by control surfaces in the propeller stream, but it is preferred that this control be obtained when counter-rotating propellers are employed by increasing or decreasing the torque of one or the other of the two propellers. The reaction to this difference in torque causes the plane to yaw about the axis of rotation of the propellers which coincides with the central axis of the aircraft.

Except that for safety sake the aircraft should always travel in the direction in which the pilot is facing, there is actually no need to turn or yaw the aircraft in changing the direction of flight. That is, a simple turn is possible by simply tilting the vertical axis of the aircraft in the direction in which it is desired to turn. However, because of the desirability of having a fixed fore and aft relationship for the convenience of the pilot, the latter control which turns the aircraft is provided.

The controls which are employed, including a throttle for the engine, a "stick" or wheel for tilting the aircraft and means such as pedals to turn the aircraft, may be arranged in the pilot's compartment in the same way that the controls are arranged in a conventional airplane. Thus, the transition from a conventional airplane to the present aircraft is an easily mastered one. This is a distinct advantage over the control system employed in a helicopter, wherein the controls are entirely foreign to anyone making the transition.

One of the most outstanding features of this aircraft is that it has a terminal velocity, under normal load conditions, in a free fall, such as might occur in the event of a complete power failure, which is sufficiently low that it can be absorbed safely upon impact with the ground by landing gear. The conical under surface stabilizes the aircraft so that it automatically seeks and descends in a horizontal position. In this free fall the windmilling of the propellers has an appreciable braking effect, but the main reason for the low terminal velocity is the shape of the body of the aircraft. The fall is not a completely uncontrolled one. By cross-controlling the control surfaces which are on the underside of the aircraft it may be guided or slipped to a degree such that the pilot has some control in the selection of a landing place. It is not suggested that a landing without power will be a gentle one. It is contemplated, however, that the shock of striking the earth from a free fall shall be safely absorbed in the landing gear structure without serious injury either to the occupants or to the aircraft structure.

This aircraft is an inexpensive one to manufacture in comparison with current types. The symmetrical body or airframe may be divided into a series of wedge-shaped segments substantially all of which may be of identical construction. These individual segments may be trussed following conventional airframe manufacturing techniques. Preferably the annular portion of the body surrounding the cylindrical throat is manufactured as a unit and the wedge-shaped segments may be fastened to this unit and to one another to provide the circular shape. In the preferred embodiment of the invention, one of the segments is modified to provide a pilot's compartment. Preferably, the pilot is seated in the compartment so that he faces away from the center of the aircraft toward the edge of the airframe. In this way his visibility is not hindered by the thrust producing device and the controls which are located adjacent to the throat in which the thrust producing device is mounted.

It is also preferred that the segment of the airframe diametrically opposite the pilot's compartment be modified to mount an engine to drive the counter-rotating propellers which are used in the preferred embodiment. In the larger forms of the aircraft, the annular area surrounding the throat may be modified to seat passengers or to carry other types of pay loads. It will be appreciated, therefore, that a major portion at least of the segments of which the airframe is comprised may be identical. This is in contrast to a conventional airplane in which substantially all parts are of different sizes and shapes. Obviously there is no need for the expensive fabrication of such individual components as an empennage, right and left hand wings, or for tapering fuselage sections.

In order to take off the pilot opens the throttle gradually to lift the aircraft from the ground and he then tilts it in the direction he wishes to fly. The tilting is accomplished by changing the attitude of the control surfaces which are within the high speed stream of air issuing from the bottom of the throat. To descend, the pilot simply levels off over the spot he wishes to land upon and the engine is throttled back to reduce lift, which causes the aircraft to settle. Maneuvering in flight is accomplished as in a conventional airplane. For example, to make a simple turn a conventional airplane is rolled and turned, and the pitch then changed to elevate the nose. In the present instance, however, since pitch and roll are accomplished by simply tilting the aircraft, these two changes in attitude are combined and the pilot just changes the direction of the tilt while turning. Climbing or descending, unlike in a conventional aircraft, are primarily the result of changing the amount of thrust produced, and this may be done without altering the attitude of the aircraft since it can move in these directions while in a horizontal position. It will be seen, therefore, that the combination of throttling the engine, and tilting and turning the body makes it possible to fly the aircraft in any direction, to bring it to a stop in mid air, to hover, and to climb and descend vertically.

In the drawings, several modifications including a preferred embodiment of an aircraft embodying the principles of the invention are shown. Additional objectives of the invention and advantages of the aircraft will be readily apparent to those skilled in the art from the following detailed description of these various modifications. In the drawings:

Figure 1 is a perspective view of an aircraft embodying the principles of the present invention as seen from a point above and to one side.

Figure 2 is a top plan view of the aircraft shown in Figure 1.

Figure 3 is a perspective view looking up toward the underside of the aircraft from a side thereof.

Figure 4 is a side elevational view.

Figure 5 is a lateral cross sectional view through the aircraft taken on a plane which passes through the pilot's compartment and the engine compartment.

Figure 6 is a perspective view showing a part of the framework of the aircraft.

Figure 7 is a diagrammatic perspective view showing the preferred form of landing gear for the aircraft.

Figure 8 is a schematic layout showing the control system for the aircraft.

Figure 9 is a perspective view from one side and above of a modified form of the aircraft.

Figure 10 is a side elevational view of the modified form of aircraft shown in Figure 9.

Figure 11 is a diagrammatic cross sectional view showing an additional modification.

Figure 12 is a view similar to Figure 11 showing another modified form.

Figure 13 is a diagrammatic view illustrating the operation of the controls of the aircraft shown in Figure 9.

Figure 14 is a diagrammatic view showing the various attitudes of the aircraft of Figure 9 from take-off, through a flight and to a landing.

In the drawings, the numeral **10** is used to designate generally the body or airframe of an aircraft embodying the principles of the present invention. The body of the aircraft is circular as viewed from above and a central opening is provided in it which defines a substantially cylindrical throat **11** extending vertically through the aircraft. The diameter of the throat may be approximately one-third of the diameter of the body, however, this relationship may be varied depending upon factors which will be explained below. As may be seen in Figures 1 through 5, it is preferred that the upper surface **12** of the body of the aircraft be flat or planar. The underside **13** on the other hand is substantially in the shape of a frustum of a cone, slanting upwardly and outwardly symmetrically from the annular area immediately surrounding the lower end of throat **11**. The angle of the slant of the undersurface relative to the horizontal in this case is approximately 20°. It is also preferred that the aircraft body comprise a central, annular section, which is a structural unit, plus a plurality of wedge-shaped segments which are affixed to the central annular section and to one another surrounding the center part.

Essentially the framework for the central part of the aircraft includes a sheet metal, cylindrical shell **14** which constitutes the wall of throat **11**. This shell may be made of stainless steel if desired. The upper edge of shell **14** may be flared outwardly on a radius at the entrance to the throat as shown; it is preferred, however, that the lower edge of the throat meet the underside of the aircraft at substantially a right angle. The upper rim of the shell is affixed, by means such as welding or riveting, to a circular, tubular frame member **15** which lies in a horizontal plane surrounding the entrance to the throat. The lower rim of the shell is fastened in a similar manner to a circular, tubular frame member **16** which is slightly smaller in diameter than the upper tubular frame member **15**. A third tubular frame member **17** is provided which is substantially greater in diameter and which extends around the shell in spaced relationship to it and at a level above the frame member **16**. These three frame members are secured to one another by sets of truss members **18**, **19** and **20** each set of which is arranged in the form of a triangle, the sets of truss members being disposed at spaced points surrounding the shell. The central part of the aircraft thus comprises the shell plus the three tubular frame members and the trussing, which provides a light and structurally strong unit.

A body segment **21** is shown in skeletal form in Figure 6. A plurality of these segments is secured to the two tubular frame members **15** and **17** surrounding the unitary central part of the aircraft. These segments may be made following recognized aircraft frame manufacturing techniques. As shown in Figure 6, each segment may comprise a pair of trussed spars **22** and **23**, which, in the assembled aircraft, extend radially outwardly from the central unit to an arcuately formed tubular brace **24**, which brace is formed on the curvature corresponding to the circular shape of the periphery of the aircraft. Upper and lower sets of ribs **25** and **26** are provided to strengthen the mid-portion of each segment, and the inner ends of the two spars may be joined by ribs such as those indicated **27** and **28**. Preferably, the latter two sets of ribs are formed on an arc which is concentric to the circular shape of the aircraft. In one embodiment of the invention all but two of the segments are identical. In this embodiment one of the segments is modified to provide a pilot's compartment indicated generally at **29**, and the second segment is modified to provide an engine compartment indicated generally at **30**. The segments are secured to one another following recognized airframe manufacturing techniques and the framework of the aircraft body thus provided is covered by a light weight, metal skin in which panels of sheet metal are riveted to the structural members of the frame; of, if it is desired, fabric or other materials may be used as a covering for the framework.

In the instance shown in Figure 5, a gasoline engine **31** is employed to power the aircraft. The engine may be of conventional design of the type now employed to power light aircraft. The engine **31** is mounted upon the two inner and outer circular tubular frame members **16** and **17** which are at the underside of the aircraft. To balance the aircraft the engine is located in the segment which is diametrically opposite to the pilot's compartment. In the instance shown in Figure 5, the pilot faces the engine across the throat. For convenience in describing the location of various parts of the aircraft, they are related to the vertical plane which passes through the engine and the pilot's compartment; this plane being designated the "fore and aft" plane, and a horizontal axis in this plane being designated the "fore and aft" axis, with "fore" designating that side of the aircraft toward which the pilot faces. In addition, the terms "left" and "right" are used to designate parts which are located to one side or the other of the fore and aft axis relative to the direction in which the pilot faces.

Preferably two counter-rotating propellers **32** and **33** are employed to create the thrust for lifting and sustaining the aircraft in flight. These propellers are mounted for rotation about a common vertical axis, one above the other, the axis of rotation being in alignment with the vertical central axis of the throat **11** and of the aircraft body. The propellers exert an upward thrust, and because of their location, one above the other, the pitch of the upper propeller **32** is slightly less than the pitch of the lower propeller **33** so as to equalize the torque resulting from their being rotated. The propellers are driven by a shaft **34** which extends from engine **31** toward the center of the throat **11**. The inner end of shaft **34** has a bevel gear **35** keyed to it which is meshed with a bevel gear **36** at the upper side, and meshed with a bevel gear **37** at the lower side. The respective upper and lower bevel gears **36** and **37** are keyed respectively to propeller shafts **38** and **39** to drive the two propellers in opposite directions. The two propeller shafts are journalled in a housing **40** which also encloses the three bevel gears **35**, **36** and **37**. The housing is supported from the sides of throat **11** by means of a pair of tubes **41** and **42** which are aligned with one another diametrically of the throat with tube **42** serving as an enclosure and, through bearings, as a journal for the drive shaft **34** which connects the engine to the propeller assembly.

Although not shown in detail here, it will be appreciated that the tube **41** provides a convenient means for obtaining access to the inside of housing **40** and to the propellers for controls in the event variable pitch propellers are employed. The reason for using propellers of this type will be discussed in detail at a later point.

The primary purpose of the power plant employed in the present aircraft is to exert an upward thrust. Balanced counter-rotating propellers of the type illustrated do this without exerting a turning force upon the aircraft. It will be appreciated, therefore, that the same end may be achieved either directly or indirectly through the use of a gas turbine engine or other thrust producing device. Thus it is not intended that the invention be limited to a power plant of the specific type illustrated in the drawings.

As previously indicated, in order to balance the weight of the aircraft around the central vertical axis of the aircraft, it is preferred that the pilot's compartment or cockpit be located at a point directly opposite to the engine, as is shown in Figure 5. The cockpit may be housed within a segment **21** which is modified to omit the ribs and other cross bracing so that this area is open and as free as possible of all protuberances. In addition, it is recommended that the pilot's compartment be enclosed at the top by means of a plastic "bubble" canopy such as the one shown at **43**. In order to provide access into a pilot's compartment, the underside of the aircraft includes a hinged panel or door **44** which is arranged to swing down into the position shown in Figure 5. This panel has steps **45** mounted upon it so that the pilot may climb up the panel and through the opening provided in the underside of the aircraft by lowering the panel and get into the cockpit.

It is recommended that the controls of the present aircraft conform as nearly as possible to the controls of a conventional airplane as shown so that transition to this aircraft is an easily mastered one for a pilot. Hence, the cockpit includes a conventionally mounted stick **46**, a pair of "rudder" pedals **47** and a throttle **48**. Inasmuch as the present aircraft has no rudder, as such, the term "rudder" as used in describing the pedals suggests the comparative change of attitude in the present aircraft which is caused by operation of the pedals—referring to the effect which manipulation of the rudder pedals of a conventional airplane has on that type of ship. The stick and "rudder" pedals are located directly in front of a pilot's seat **49**, whereas the throttle is located at the left side of the seat. Movement of the stick controls the tilting of the aircraft, movement of the "rudder" pedals controls the yawing or turning movement of the aircraft, and the throttle controls the r.p.m. of the engine. It is preferred that the throttle open to increase r.p.m. by swinging the throttle handle upwardly, inasmuch as this arrangement appears to be the most natural movement for lifting the aircraft. Flight instruments may be mounted in a panel **50** which is directly in front of the pilot where they may be seen readily.

In general, the attitude of the aircraft when in flight is changed in two ways. The pedals **47** may be connected to devices for changing the pitch of one of the propellers relative to the other. Varying pitch, of course, changes the torque exerted by one of the propellers, which torque exerts a turning force on the aircraft tending to revolve it about the vertical central axis of rotation of the propellers. This change "yaws" or turns the aircraft. The other change in attitude is brought about by the reaction of the moving column of air below the propellers upon control surfaces or vane devices which are connected to the stick. Essentially, the connection from the control surfaces to the stick is arranged so that the aircraft tilts in the direction toward which the top of the stick is moved. More specifically, in the embodiment shown in Figures 1–5 of the drawings, the control surfaces are in the shape of a series of cylinders which are mounted concentrically around the vertical axis of the ship directly below the throat. These cylinders collectively form a "directional nozzle" which is designated generally by the numeral **51**. In the instance shown, the directional nozzle comprises three thin-walled cylinders designated **52**, **53** and **54** respectively. The cylinders are graduated in height with the central one **54** being the tallest one of the three. This arrangement is preferred so that the adequate clearance is provided between the outer cylinder and the underside of the aircraft when the nozzle is tilted severely. The three cylinders are attached to one another by a pair of cross rods **55** and **56** which extend through the various cylinders at right angles to one another. The cross rod **55** which extends fore and aft has its opposite ends pivotally journalled in bearings **57—57** which are mounted respectively upon diametrically opposite sides of a tubular gimbal ring **58**. See Figure 8. The ring, in turn, is pivotally journalled for rotation about an axis at right angles to the axis of the two journals **57—57** at the lower end of struts **59—59** which depend from the underside of the aircraft at opposite sides of the throat **11**. In this way the directional nozzle may be tilted, within the limits of the mount, in any direction around the point at which the two cross rods **55** and **56** meet, which is a point on the vertical central axis of the aircraft.

Referring now to the schematic layout of the control system shown in Figure 8, it will be noted that four cables are employed to tilt the directional nozzle and that all four of these cables are attached to the control stick **46** which is in the pilot's compartment. More specifically, the lower end of the stick is pivotally mounted upon a bracket **60** which is affixed to a control tube **61**. The lower end of the stick is journalled to the bracket for rotation about an axis which extends generally fore and aft of the ship, whereas the tube is mounted for rotative movement around an axis which extends transversely of the aircraft. The underside of the stick below the axis upon which it is mounted constitutes an arcuate quadrant **62**. Attached to the lower end of the quadrant are two cables designated **63** and **64** which extend from opposite sides of the quadrant through the longitudinal axis of the control tube **61**. Cable **63** extends around a pair of pulleys **65—65** forwardly and then downwardly and it is attached at its lower end to the end of cross rod **56** which is at the right side of the aircraft. The other cable **64** passes around two pulleys **66—66** in a like manner and is attached at its lower end to the opposite end of cross rod **56**. Thus, swinging the top of the stick to the left pulls cable **64** to elevate the left side of the directional nozzle, and the downward blast of air from the propellers impinging upon the angulated nozzle causes the aircraft to tip toward the left. Movement of the top of the stick in the opposite direction pulls cable **63** to tilt the directional nozzle in the opposite direction which has the effect of tilting the aircraft toward the right. The control tube **61** has a pulley **67** affixed to it, and this pulley also has two cables attached to it, designated **68** and **69** respectively, which extend respectively forwardly from the top and bottom sides of the pulley. The top cable **68** extends straight ahead around a single pulley **70** and then down to the gimbal ring where it is attached to the ring adjacent to the rear bearing **57** in the conventional manner. The cable **69**, on the other hand, passes around four pulleys, each of which is indicated by the numeral **71**, extending to the left of the central opening in the aircraft, and then downwardly to a point of attachment on the gimbal ring which is diametrically opposite to the point of attachment of cable **68**. By attaching the two cables **68** and **69** in this way, movement of the top of the stick toward the rear of the aircraft causes the control tube to rotate for tightening cable **68**. This elevates the rear of the directional nozzle to cause the aircraft to tilt upwardly at the front. Rocking the stick forward tightens cable **69** which raises the front part of the directional nozzle, having the effect of tilting the forward part of the aircraft downwardly. It will be apparent that movement of the stick to both swing quadrant **62** and to rotate pulley **67** will tilt the directional nozzle about both the axes of the gimbal ring mount, thereby permitting any desired direction of tilt for the aircraft.

The two "rudder" pedals **47—47** may be connected mechanically, electrically or hydraulically by any of the known means to the variable pitch mechanisms for one or both of the two propellers for increasing or decreasing the torque of one propeller relative to the other in order to turn the aircraft. In the instance shown in Figure 8, the two pedals are shown diagrammatically as being connected hydraulically to variable pitch mechanism at the upper one only of the two propellers so that its pitch may be varied with respect to the pitch of the lower propeller. In this case the pitch of the lower propeller is fixed. It will be obvious that various combinations of controls are possible for the two propellers including a differential type of gearing so that one propeller shaft may be slowed down by a braking device or other means relative to the other in order to cause a change in torque for turning purposes.

The throttle lever **48** may be connected to the engine **31** by any of the known means for increasing or decreasing the amount of thrust produced by the propellers. In the preferred embodiment the throttle lever is situated to the left of the pilot's seat so that he may place his right hand on the stick, or wheel if one is used, while holding the throttle with his left hand. It is preferred that the throttle lever be a substantially long one and connected to the engine so that the lever has a long arc of swing over the speed range of the engine. In this way the control is a sensitive one so that slight changes in r.p.m. may be made easily.

The landing gear employed consists of three or more shock absorbing, wheeled struts which are attached to the two inner and outer tubular frame members **16** and **17** at the underside of the aircraft. The landing gear provided has a substantial amount of movement and it is arranged so that its resistance to upward movement progressively increases. Thus the gear decelerates the downward movement of the aircraft upon landing which is in contrast to the usual type of gear in which the resistance to upward movement is substantially constant over its range of movement. In the instance shown, each strut of the landing gear comprises a Y-shaped upper portion **72**, the upper ends of which are pivotally connected by means such as brackets **73—73** to the tubular frame member at spaced points. Just below the points where the two arms of the Y join one another, a decelerating oleo strut **74** is pivotally attached to the leg of the Y-shaped yoke by means such as the brackets disclosed at **75**. The upper end of the decelerating oleo strut is pivotally attached to tubular frame member **17** by means of a bracket **76**. Thus the Y-shaped yoke is secured to the body of the aircraft at three spaced points for stability. The lower end of the leg designated **77** of the Y-shaped yoke extends downwardly and outwardly from the suspension points and mounts a tubular strut **78** which carries at its lower end a caster type of wheel **79**. Inasmuch as the impact of the present aircraft with the ground under conditions where it falls freely without power may be quite severe, the parts employed in the gear should be structurally strong ones and the range of swinging movement of the gear as shown in Figure 7 should be over a substantial vertical distance. Furthermore, if desired, the two arms of the Y-shaped yoke may be constructed so as to provide shock absorption upon impact with the ground.

Caster mounted wheels are suggested because the aircraft can be taxied while upon the ground in any direction by "revving" up the engine and tilting the directional nozzle to direct the blast of air at an angle against the ground. In such movement, the aircraft is elevated slightly with respect to the ground, but the pivotally mounted landing gear remains in contact with the ground.

Although it is not shown here, it will be appreciated that a circular pontoon may be substituted for the under carriage illustrated in the drawings in the event it is desired to have the aircraft operate off water.

Gasoline for the engine may be carried in a conventional tank mounted inside of the body of the aircraft if desired. It is preferred for safety's sake, however, to provide jettisonable gas tanks of the type shown at **80**, these tanks being streamlined in the direction fore and aft of the aircraft. Two such tanks may be used and the tanks located at opposite sides of the aircraft at points spaced equally from the center. In addition the system for delivering gasoline from the tanks to the engine preferably is arranged so that gasoline is drawn equally from both tanks so as to maintain a state of balance of the aircraft as the supply is used.

Operation of the aircraft shown in Figures 1 through 5 in a typical flight is as follows. With the aircraft resting upon the ground and with the controls in neutral, the pilot accelerates the engine by raising the throttle lever **48**. When sufficient thrust is developed by the counter-rotating propellers the aircraft lifts, rising straight up off of the ground. The pilot then may tilt the aircraft in the direction in which he wishes to fly while at the same time turning the aircraft so that he faces in that direction. The tilting is accomplished as previously described by changing the angulation of the direction nozzle with respect to the vertical axis of the ship. The turning is a matter of changing the torque exerted by the upper one of the two propellers for yawing the aircraft in the direction desired.

If the pilot wishes to continue to climb in the direction in which the aircraft is tilting he merely increases the throttle setting. To change the direction of flight the stick and "rudder" pedals are manipulated in unison to both tilt and turn the aircraft. The aircraft can be brought to a halt while in flight by raising the leading edge. The tendency for the aircraft to at first climb (as a result of the leading edge being elevated and the aircraft still in forward motion) may be overcome by decreasing the throttle setting. Then by manipulating the throttle and the degree of tilt of the aircraft it can be brought to a halt so that it literally hangs upon the thrust produced by the propellers and the lift produced by the air moving across the upper surface of the body toward the throat. To descend, the pilot merely decreases the r.p.m. of the engine while guiding the aircraft to a point directly above the spot on the ground he wishes to land. The aircraft may be brought to a slow halt over this spot and the throttle then slowly closed to lower the aircraft until the landing gear touches the ground.

The operation and construction of the modified form of the aircraft which is shown in Figures 9 and 10 is slightly different from the one previously described. In this instance, the basic construction is identical to the one previously described in that the directional nozzle, the landing gear, the engine compartment and the general configuration of the body of the aircraft, including the throat are substantially the same, the major changes being in the provision of an additional control vane **81** and the provision of a slotted edge **82** which extends around the periphery of the "wing" or body of the aircraft. In addition, it will be noted from Figure 9 that the pilot is turned around so that he faces away from the throat of the aircraft. This same arrangement for the pilot may be used in the modification previously described and is actually preferred because it increases his visibility, since he does not have to look over the throat and the added distance of the body of the aircraft beyond the throat. More specifically, the frusto-conical underside of this modification of the aircraft is slanted with respect to the horizontal a lesser amount than the aircraft previously described. In this instance the slant is approximately 12°; whereas, in the previously described aircraft the slant is approximately 20°. The outer edge of the upper surface is slanted downwardly with respect to the planar top of the aircraft at approximately 30° as shown at **83**. A narrow, frusto-conical cowling **84**, which is also slanted at 30° surrounds the periphery of the aircraft in spaced relationship to it. The cowling is secured to the aircraft by a plurality of webs **85** which extend radially outwardly from the body of the aircraft and which may be continuations of the spars **22** and **23** which are at the respective sides of the segments **21**. Preferably, if continuation spars are used to form the webs the opposite sides are covered by sheet metal or other covering material to streamline them. The cowling itself may be made of stressed skin construction following known aircraft manufacturing techniques.

The slotted edge **82** thus provided is found to stabilize the aircraft to a great extent in that the slots damp out tendencies for the aircraft to oscillate during changes in attitude while in flight. The slots are also found to slow down considerably the terminal velocity of the aircraft in a power off free fall as will be explained at a later point in the specification. The directional nozzle may be connected to the control stick by cables as previously described. However, in this instance due to the reversed position of the pilot, the cables extend from the stick toward the rear of the ship. This difference is not illustrated inasmuch as the change will be readily apparent to anyone skilled in the art. The same is true of the connection between the "rudder" pedals and the variable pitch mechanism in the upper one of the two propellers.

The additional control vane **81** consists of a symmetrically shaped airfoil section **86** which, when in the neutral position, extends in a vertical plane diametrically across the top of the throat, transversely of the aircraft and immediately above the upper propeller. The opposite ends of the vane are mounted in journals designated generally **87** for rotation about an axis which extends longitudinally of the vane diametrically across the throat. The bearings at the two ends of the vane may be supported by streamlined struts such as those shown at **88**, which extend upwardly from the body of the aircraft at opposite sides of the throat. The vane may be connected, following the techniques employed in providing adjustability to trim tabs on conventional aircraft, to a wheel, a crank, or an equivalent adjusting device which is located in the pilot's compartment.

The adjustable control vane **81** has two functions. For one thing it may be used to trim up the ship in the fore and aft direction in the event an unbalanced condition is present—which may occur frequently, if the aircraft is flown by different pilots whose weights vary considerably. An unbalanced condition of this sort is illustrated in Figure 13. In this case a small arrow designated **89** is used to represent an unbalanced downward force which is ahead of the vane **81**. Obviously, if the aircraft is going to be taken off vertically, as soon as the aircraft is free of the ground the unbalanced weight is going to tend to tip the aircraft toward the displaced center of gravity. Such unbalance could be overcome by changing the angulation of the directional nozzle. In a severe unbalanced condition, however, this would limit considerably the directional control obtainable at the nozzle. It is found that the off center weight can be compensated for by angulating the vane **81** such that it slants upwardly away from the side at which the overload occurs. Under these circumstances, the stream of air being pulled downwardly by the rotating propellers strikes against the angulated vane (much in the same way that air strikes against an angulated rudder or aileron in a conventional aircraft) to exert a tilting moment on the aircraft. Thus, in Figure 13 the tilting moment is counter-clockwise which balances the downward force represented by the arrow **89**. In its use as a means of trimming the aircraft the vane **81** has its greatest utility on take-off and landing when the aircraft is near to the ground. For the sake of safety the aircraft should be maintained in a horizontal position during these times.

The control vane **81** also may be used to alter the attitude of the aircraft in conjunction with the directional control nozzle while in flight. A typical flight from take-off to landing is illustrated in the series of small views comprising Figure 14. Assuming a substantially balanced condition, the aircraft is first taken off vertically with the vane streamlined to the column of air being pulled into the throat by the propellers. To change the attitude of the ship for moving off toward the right as viewed in Figure 4, the control vane may be angulated so that its top is toward the right. The downwardly moving stream of air acting upon the vane then exerts a tilting moment which tends to lower the front of the aircraft which is toward the right in these views. As soon as the aircraft starts to move off in the flight path toward the right, the directional control nozzle may be shifted to angulate the direction of the blast of air issuing from the throat. The aircraft is held in tilted condition while maintaining horizontal flight by the combination of the tilting moments exerted by the directional nozzle and by the vane. To bring the aircraft into the horizontal position for hovering over the spot upon which the landing is to be made, the control vane 81 may be turned so that it is straight up and down, which increases its drag to tilt the aircraft as shown. In this change of attitude, the directional nozzle may also be shifted as illustrated. Then, to decend from the hovering position the control vane remains in the neutral position, the directional nozzle is moved to neutral and the engine slowly decelerated to lower the aircraft slowly toward the earth.

In the modification of the aircraft which is disclosed in Figure 11 of the drawings the body is of slightly modified shape and a different type of control vane system is employed in place of the directional nozzle 51. In this case, the upper surface 90 of the aircraft body is slightly dish-shaped instead of being flat. The frusto-conical shape is retained at the underside 91, but the degree of slope is increased. The body shape shown, although not as stable insofar as oscillations are concerned as the modification of Figures 1 to 10 has the advantage that a slightly greater amount of lift is derived from air being pulled across the top of the body surface and into the throat by the rotating propellers. In this instance, directional control is obtained through the use of four rudder-like control vanes which are indicated generally at 92. These control vanes are mounted in pairs for turning movement about two horizontal axes which are disposed at right angles to one another. As shown in Figure 11 two of the vanes are mounted upon a rod 93 which is journalled at its opposite ends in brackets 94—94, the respective brackets being mounted upon the lower ends of struts 95—95 which depend from the underside of the aircraft. An additional pair of vanes is mounted in a similar manner upon a rod which extends at right angles to the rod 93 transversely of the aircraft. The four vanes are connected to the controls inside of the pilot's compartment by cables so as to have substantially the same effect upon changes in the attitude of the aircraft obtainable by angulating the directional nozzle 51. The vanes of each set may be operated simultaneously or, if desired, they may be arranged so that they may be operated independently of one another, the vanes of each set being movable in opposite directions relative to one another in order to turn the aircraft about its vertical axis. Substantially the same type of vane control system is employed in the modification of the invention which is disclosed in Figure 12. In this instance, the body of the aircraft, although circular and having a central opening or throat in it, in cross section, is more in the shape of a conventional airfoil. The underside, designated 96, retains the frusto-conical shape. The upper side 97, however, is also in the shape of a frustum of an inverted cone having an even greater slant than the conical surface of the underside. In the annular area, designated 98, adjacent to the periphery, the body curves outwardly and downwardly, meeting the undersurface at a radius 99 so that in cross section (as may be seen from Figure 12) the appearance of the body or "wing" is very much like an airfoil. This is done to increase the lift obtainable from air moving across the top of the aircraft toward the throat.

Due to the comparative thinness of the "wing" of this modification the pilot's compartment is disposed in a pod 100 which is located underneath the wing on the vertical central axis of the aircraft. The pod is attached to the "wing" by means of a series of arcuate struts 101 which are attached to the pod and which extend radially outwardly from it and up to attachment brackets such as those shown at 102—102 which are secured to the underside of the "wing." The pod in this instance also mounts an engine 103 for driving counter-rotating propellers 104—105. Like in the previously discussed modifications, the two propellers are mounted for rotation about the vertical central axis of the aircraft and they exert an upward thrust. The lower part of the pod, in which the pilot's seat and controls, indicated generally at 106, are located, may be enclosed in clear plastic so that the pilot has 360 degrees of visibility. The landing gear in this modification is attached to the struts 101 and consists of a pair of oleo struts 107—108 which are disposed at right angles to one another, and which are pivotally secured to the struts 101 at spaced points such that the lower end 109 of each component of the landing gear, which carries the caster wheel, may both telescope upwardly and swing radially in order to absorb landing shocks.

The directional control vanes in this case are designated 110—110. Actually four such vanes are provided, being located in pairs on the two major axes of the aircraft (like in the instance shown in Figure 11) below the counter-rotating propellers where they may be angulated with respect to one another for controlling the attitude of the aircraft.

All of the modifications which have been discussed have in common a frusto-conical undersurface plus the central opening or throat. The degree of slant of the undersurface of the different modifications vary, the two extremes being shown in Figure 11 (where the undersurface is on a slant approximately 30 degrees) and in Figure 10 where the slant of the underside is approximately 12 degrees. These specific degrees of slant are intended to be representative of a general range and are not set forth in a limiting way.

The shallower slant, which may be even less than 12 degrees, is preferred when used in combination with the cowling structure which is shown in Figure 10. The undersurface actually may approach or conform to a spherical surface, particularly in the instance of the modification shown in Figures 9 and 10, wherein the cowling serves to stabilize the oscillations of the aircraft when its attitude is changed in flight. Generally speaking the steeper the cone the more stable the aircraft is. However, the steeper slant makes the aircraft more sluggish in forward flight, the shallow slant being best suited for aircraft designed for speed.

Regardless of the degree of slant of the underside of the aircraft, the purpose in each case is the same—to provide stability in flight and particularly in a descent with or without power. The conical shape is found to stabilize the aircraft even in a fall from an inverted position, damping out oscillations so that the aircraft descends with its central axis vertical to land in an upright position.

Furthermore, the preferred modifications of the aircraft which are shown in Figures 1 through 10 and Figures 13 and 14 have the planar upper surface. Actually when the present aircraft is flying in any direction except vertically the planar upper surface is at a negative angle of attack relative to the oncoming air. Hence, in flight the aircraft "planes" against the oncoming air; but in the reverse fashion compared to the conventional aircraft which has a positive angle of attack. The drag of the planing action of the negative angle of attack is overcome by the upward component of the thrust. It may be said, therefore, that the present aircraft "planes against upward thrust," whereas the conventional aircraft "planes against the downward force of gravity."

As has been suggested previously, aircraft of the frusto-conical body design shown, under normal load conditions, have a surprisingly low speed terminal velocity in a power off free fall. This is particularly true of the preferred modification of Figures 9 and 10, wherein the slotted periphery of the body of the aircraft serves both as a stabilizing factor and as an airbrake. In such free fall the rotating propellers windmill which also slows the rate of descent. The directional nozzle or directing vanes may be used in free fall to guide the path of descent to an appreciable extent so that the pilot may have some choice of a landing spot, the latitude of his choice being dependent upon the altitude of the aircraft. It is not contemplated that the landing in a power off free fall would be an easy one. However, the landing gear provided is capable of absorbing a considerable amount of force over a relatively great vertical distance in comparison with conventional gear and the pilot is further cushioned by his seat so that the deceleration of the pilot upon impact with the ground is not a sudden one. Furthermore, in the event that the pilot loses complete control of the aircraft, and there is a power failure, he is protected in all of the embodiments of the invention, except that shown in Figure 12, by the wing or body section surrounding him which must be crushed before the pilot is exposed to injury. Hence, a power off descent over rough country or into trees should not be a disastrous one for the pilot under any circumstances.

As a further safety precaution, and for use in a free fall descent under overloaded conditions only, the aircraft of this invention may be fitted with a rocket tube of the type shown at **111**. The rocket tube is directed downwardly on the central axis of the aircraft, being open at the bottom. The tube may contain a proximity fused fired rocket which will fire at a predetermined elevation above the ground during free fall to decelerate the aircraft to a safe rate of descent by the time the landing gear is ready to strike the ground.

It will be seen, therefore, that I have fulfilled the objectives set forth in providing an aircraft which is circular in shape, and therefore, economical to manufacture; one which has all of the desirable characteristics of a helicopter in that it is capable of vertical take-off and landing, which may be flown in any direction and which may hover in the air, thus not being dependent upon conventional airport facilities; an aircraft which is unusually stable in flight; and one which will literally safely land itself without any effort upon the part of the pilot.

Having described my invention, I claim:

1. An aircraft comprising a body which is circular as viewed from above, the central portion of said body being thicker than the rim thereof with the underside tapering outwardly and upwardly symmetrically from a centrally located annular area which is concentric to the rim of said body, the central portion of said body being open inwardly of said annular area to provide a cylindrical throat of substantial size which passes through the center of the body from top to bottom, a pair of counter-rotating propellers mounted within said cylindrical throat for rotation about an axis which is common to the vertical central axis of said aircraft, means to rotate said propellers for directing a high velocity stream of air downwardly through said throat, gimbal ring means mounting a plurality of concentrically arranged thin-walled cylinders beneath said throat, said cylinders normally arranged with their common vertical axis in alignment with the vertical axis of said body, and means to tilt said cylinders relative to the vertical central axis of the aircraft in any direction, whereby the reaction of the high velocity stream of air on the tilted cylinders causes said aircraft to tilt.

2. An aircraft comprising a circular body as viewed from above, the under surface of said body being in the shape of a frustum of an inverted, shallow cone, the central portion of said body being open to provide a substantial cylindrical throat which passes vertically through the center of said body, means to produce a high velocity stream of air which is directed downwardly through said cylindrical throat, a plurality of concentrically disposed, unitarily arranged thin-walled cylinders, gimbal ring means mounting said cylinders upon said body immediately below said throat for simultaneous tilting movement, said cylinders normally being disposed with their common axis aligned vertically with the central axis of said body, and means to tilt said thin-walled cylinders, whereby said high velocity stream of air reacts against said cylinders to cause the aircraft to tilt.

3. In an aircraft, an airfoil which is circular as viewed from above, said airfoil having a substantially large opening in the center thereof which extends through it from the top to the bottom, the undersurface of said body surrounding said central opening being in the shape of the frustum of an inverted shallow cone, and a cowling affixed to and surrounding the periphery of said circular body in spaced relationship therewith, said cowling being angulated outwardly and downwardly and defining with the adjacent outer peripheral edge of the aircraft a slotted area surrounding said body.

4. An aircraft comprising a body which is generally circular as seen from above, said body having a substantially large opening in the center thereof to define a throat which extends through the body concentric to the vertical central axis of said body, the upper surface of said body surrounding said throat being substantially planar, the undersurface thereof being frusto-conical in shape, a thrust producing device mounted within said throat and arranged to direct a stream of air downwardly through said throat for lifting and sustaining said aircraft in flight, and a cowling affixed to and extending around the periphery of said body in spaced relation therewith and defining with said body a slotted annular area to stabilize said aircraft in flight.

5. An aircraft comprising a body which is circular as viewed from above, the central portion of said body having a substantially large opening in the center thereof which extends through it from the top to the bottom to define a cylindrical throat, a thrust producing device mounted in said throat, said thrust producing device adapted to project a high velocity stream of air downwardly through said throat, at least one control surface which is mounted on the body of the aircraft and which is disposed below said throat within said stream of air, means to angulate said control surface with respect to said stream of air to cause said body to tilt with respect to the horizontal, and a cowling affixed to and surrounding the periphery of said circular body in spaced relationship therewith, said cowling being angulated downwardly and defining with the adjacent outer peripheral edge of the aircraft a slotted area surrounding said body.

6. An aircraft comprising a substantially circular body as seen from above, the undersurface of said body being in the shape of the frustum of an inverted shallow cone, the central portion of said body being open to define a cylindrical throat which passes vertically through the center of said body, a thrust producing device mounted within said throat to lift and sustain said aircraft in flight by directing a stream of air vertically downwardly through said throat, a cowling affixed to and extending around the outer periphery of said circular body in spaced relationship therewith, said cowling slanting downwardly and outwardly to serve as an air brake in the event of a power-off free fall descent of the aircraft, and a vane extending diametrically across the upper end of said throat, said vane adapted to be angulated with respect to a stream of air pulled downwardly through said throat by the thrust producing device while in power flight for changing the attitude of said aircraft, and said vane adapted to be angulated with respect to a stream of air moving upwardly through said throat to change the attitude of said aircraft in the event of a power-off, free fall.

7. An aircraft comprising a substantially circular body as seen from above, the undersurface of said body being in the shape of the frustum of an inverted shallow cone, the central portion of said body being open to define a cylindrical throat which passes vertically through the center of said body, a thrust producing device mounted within said throat to lift and sustain said aircraft in flight by projecting a stream of air vertically downwardly through said throat, a cowling affixed to and extending around the outer periphery of said circular body in spaced relationship therewith, said cowling slanting downwardly and outwardly to serve as an air brake in the event of a power off, free fall descent of said aircraft, and one or more control surfaces pivotally mounted upon said body and disposed below said throat, said control surfaces adapted to be angulated with respect to the stream of air

projected downwardly through said throat by the thrust producing device while the aircraft is in power flight for changing the attitude of said aircraft, and said control surfaces adapted to be angulated with respect to a stream of air moving upwardly through said throat to change the attitude of said aircraft in the event of a power off, free fall.

8. An aircraft comprising a circular body as viewed from above, the upper surface of said body being planar, the undersurface of said body being in the shape of the frustum of a shallow inverted cone, the central portion of said body being open to define a cylindrical throat which passes vertically through the center of said body, a pair of counter-rotating propellers mounted within said throat for rotation about the vertical central axis of said body to produce an upward thrust, control surfaces, means to manipulate said surfaces to tilt said body in any direction with respect to the horizontal to cause said aircraft to move in flight in the direction of the tilt, and a cowling affixed to and surrounding the periphery of said body in spaced relationship therewith, said cowling slanting downwardly and outwardly to provide a slotted, annular area completely surrounding the outer periphery of the aircraft to stabilize the aircraft in any direction of flight.

9. In an aircraft, a body which is circular as seen from above, the upper surface of said body being substantially planar, the undersurface of said body being in the shape of the frustum of an inverted shallow cone, the central portion of said body being open to define a cylindrical throat extending vertically through said body, the annular portion of said aircraft body immediately surrounding said throat being a structural unit and consisting of a substantially cylindrical member defining said throat, upper and lower cylindrical tubular frame members attached to the respective upper and lower ends of said cylindrical member, a third circular tubular frame member surrounding said cylindrical member in spaced concentric relationship therewith, a plurality of sets of trussing members connecting the respective tubular frame members, the truss members of each set being arranged in triangular form and in a plane which extends radially outwardly from the vertical central axis of said cylinder, and a plurality of tapering segments connected to one another and to the central structural unit, said segments forming a continuous, annular body surrounding the central structural unit.



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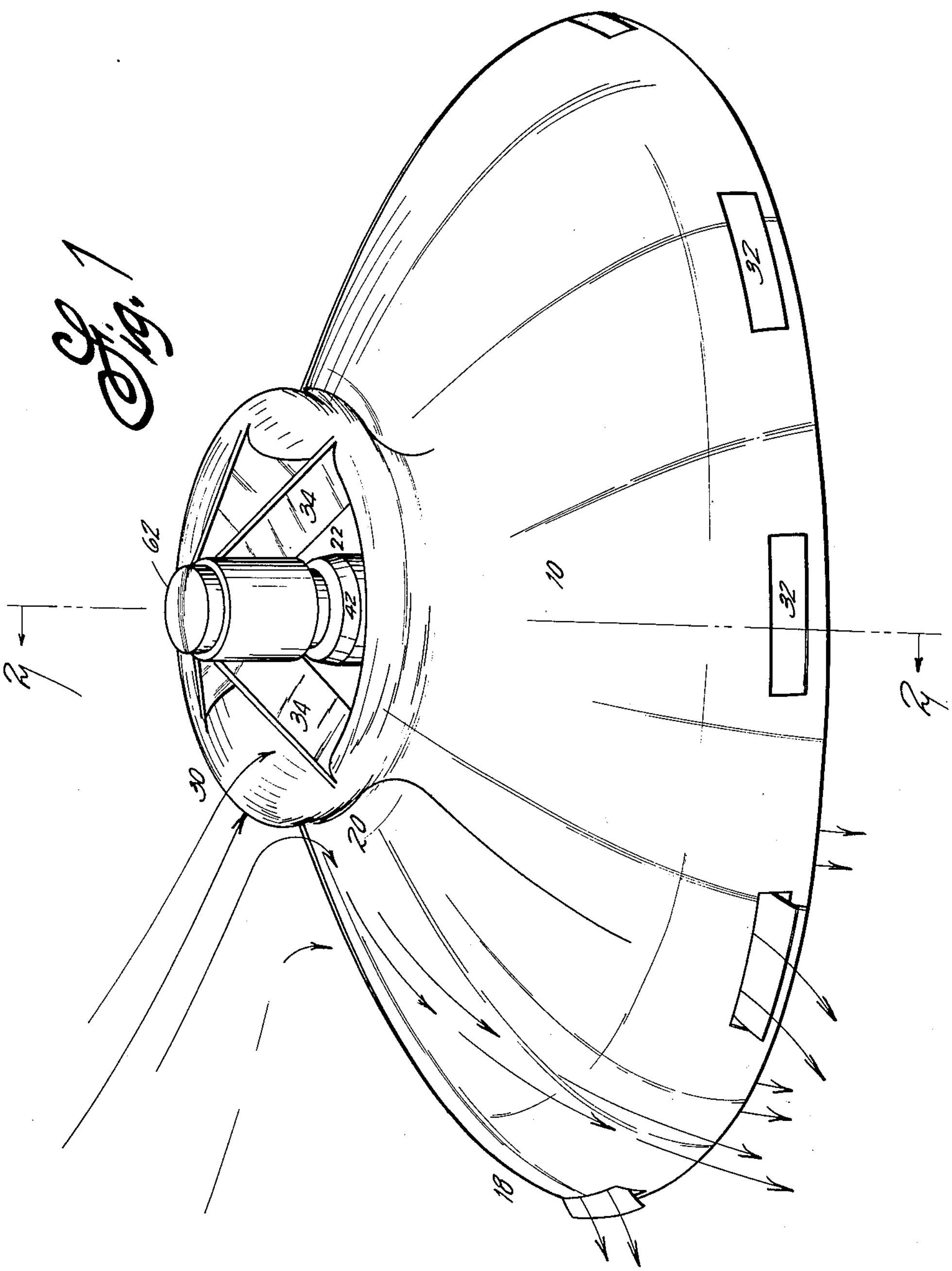
Aug. 22, 1961 T. P. MULGRAVE ET AL 2,997,254

GYRO STABILIZED VERTICAL RISING VEHICLE (DISCOID)

Filed Oct. 30, 1959 2 Sheets-Sheet 1

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GYRO STABILIZED VERTICAL RISING VEHICLE (DISCOID)

Filed Oct. 30, 1959 2 Sheets-Sheet 2

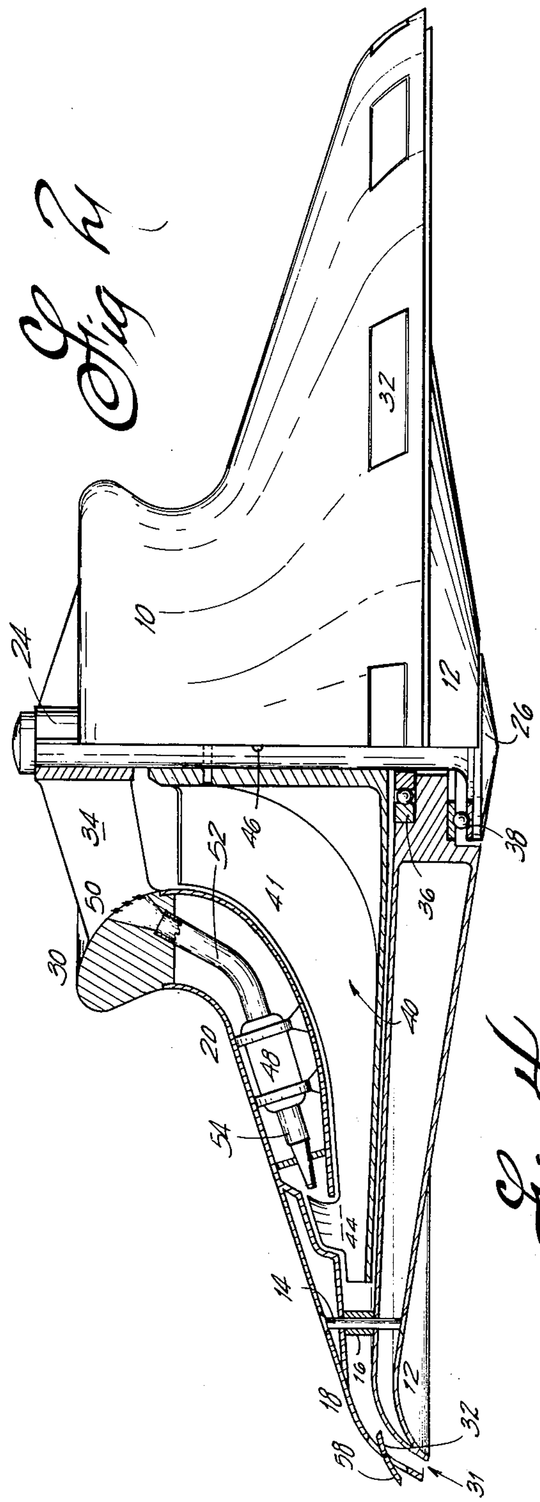


Fig 2

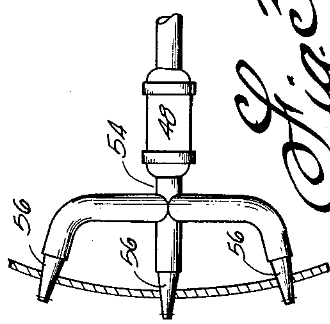


Fig 3

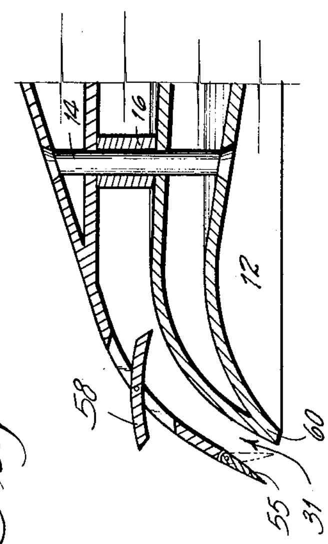


Fig 4

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2,997,254

# GYRO STABILIZED VERTICAL RISING VEHICLE (DISCOID)

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Filed Oct. 30, 1959, Ser. No. 849,998
4 Claims. (Cl. 244—12)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties therein or therefor.

This invention relates to a flying device and more particularly to that type of device wherein the wing, tail and fuselage are embodied in a compact integral structure having a configuration and fluid impelling apparatus that derives sufficient lift to provide vertical take-offs and landings.

It is an object of this invention to provide a device with low drag in horizontal flight.

Another object is to provide a flying device wherein its configuration and fluid impelling structure provide lifting effects due to the aerodynamic flow pattern of the fluid passing over and through the device.

Yet another object of this invention is to provide a flying device of greater strength, stability, security, compactness and simplicity of construction, which concomitantly eliminate elevator airfoils, ailerons, outside rudders or other factors of empennage and parasite drag.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description which is considered in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of the device embodying my invention.

FIG. 2 is a partial cross-section taken along line 2—2 of FIG. 1.

FIG. 3 is an enlarged view of the nozzle portion of the gas generator of FIG. 2 better illustrating the position of the nozzles.

FIG. 4 is an enlarged view of the lip portion along the outer periphery of the device of FIG. 2 better illustrating the flow control means and the shape of the lower edge of the lip around this outer periphery.

Referring in particular to FIGS. 1 and 2 of the drawings, the exterior surface or contour of the device is defined by the two sections 10 and 12. The section 10 is generally bell-shaped with its outer surface sloping upwardly and inwardly between the points 18 and 20 and then flaring outwardly again at 20 to form the crown or lip portion 30. The central circular opening 22 is formed in the top or crown of the plate. The contour of the top section 10 between points 20 and 30 as shown in FIG. 2 is S or ogee-shaped. This produces a lip configuration around the periphery of the opening 22.

Section 12 is also generally bell-shaped though somewhat more flattened than section 10. Section 10 and 12 are fixedly positioned one to the other with their outwardly flaring extremities juxtaposed and spaced a predetermined distance apart by means of the peripherally positioned studs 14 and spacing sleeves 16. With the plates secured in this manner, an annular cavity is defined in the area therebetween. This cavity, when seen in cross-section (FIG. 2) tapers, that is, it narrows from the opening 22 toward the peripheral extremity 32.

Section 10 is journaled on the shaft 24 by means of the spaced rib elements 34. Section 12 is similarly journaled on the shaft 24 by the radial thrust bearing 36 which allows rotation of sections 10 and 12 on the shaft. The



vertical thrust bearing 38 is affixed to the flanged extremity 26 of the shaft 24 for withstanding the vertical thrust of the housing formed by sections 10 and 12.

The impeller assembly 40 which is fixedly mounted on shaft 24 by means of one or more pins 46 includes a plurality of impeller blades 41. These blade elements are in balanced relationship around the shaft and extend radially from the shaft into the cavity between sections 10 and 12. The taper of blades 40 follow the taper of the cavity formed by sections 10 and 12 so as to partition the interior of the cavity into separate multiple passageways which terminate at the relatively narrow extremities 32. Vanes 44 are secured to the extremities of blades 41.

A plurality of gas generators 48 are provided with air inlet conduits 50 connected to the opening 22 in section 10. Propulsion nozzles 56 (FIG. 3) connected to the exhaust end of gas chamber 48 through plenum chamber 54, directs the combusted air and gases upon the vanes 44 of blades 41. The preferred embodiment consists of four such generators balanced around the periphery of the opening 22.

The louver 55, disposed at the extremity of section 10 (FIG. 4) and individually operable by the pilot in a manner not shown in the drawing determines the area of the exhaust openings. The louver 58 varies the resultant vector of the exhaust thrust of air.

In operation the gas generator 48 is ignited, air is drawn from the opening 22 through the vertical inlet 50, and directed by the conduit 52 into the generator 48. The air is then heated and expelled by the propulsion nozzles 56 onto the vanes 44 causing the impeller assembly 40 to rotate.

Rotation of the blades 41 of the impeller assembly 40 draws air from the outer surface 20 of section 10 up and over the lip 30 into the opening 22. Due to the configuration of the lip 30, the velocity of the air increases substantially as it passes over the lip without separating from the boundary layer surface. In addition the velocity of the air inside the shell also increases because of the tapering of the passageways. The ultimate velocity of the air can be controlled to some degree by varying the areas of the outlets 32 through rotation of the louver 55.

The high velocity of the air over the lip 30 without separation from the boundary causes a lifting force upon the device.

The contour of the peripheral lip of section 12 defines a cusp configuration at 60. This cusped configuration at 60 permits the formation of a vortex in the cusp cavity under the plate 12 which remains in equilibrium due to the design characteristics of the cusp and performs a dual function. First, it increases the flow velocity at point 18 of the wing. Second, it acts as a roller bearing for the flow in directing the airstream from the annular opening 31 at the trailing edge of the wing thereby eliminating possibility of boundary layer separation on the trailing edge of the surface 10 of the wing.

The rush of air down through the passages created in the internal cavity by the vanes 40 causes the wing to rotate around the shaft 24 producing a gyroscopic stability and the attainment of high angular momentum which reduces friction. The stationary collar 62 and the flanged extremity 26 prevent the wing from rotating off of the shaft.

The above description of the operation whereby high lifting forces are produced on the surface of the wing permit a vertical take-off and landing of this aircraft. In the event that it is desired to change from vertical to transitional flight the louvers 58 are operated to change the direction of the thrust of air passing through the cavity in the interior of the wing.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A flying device comprising an airfoil structure having a central circular opening therein; said structure having a top section being generally bell-shaped, and substantially ogee or S-shaped around the periphery of said opening; a bottom section also being generally bell-shaped, spaced a predetermined distance from the top section so as to form a chamber therebetween which opens into said opening in the top section, said chamber having its sides progressively tapering inwardly to provide a relatively narrow opening around the outer periphery of the two sections; the outer extremity of the lower section being contoured to a curvilinear wall surface including a cusp so as to facilitate stabilization of a fluid vortex behind the cusp; a shaft vertically disposed in said opening; means for rotatably mounting the structure upon the shaft so that the structure may rotate independently of the shaft; a plurality of blades secured to the shaft, extending radially in balanced relationship from the shaft into the said chamber and partitioning the interior of said chamber into separate multiple passages; power means for rotating said blades whereby fluid is drawn radially inwardly across the top section of said structure over the top of the lip and downwardly through the opening over the cusp whereby a lifting thrust is effected at various points along the surface of the structure.

2. A device according to claim 1 including a plurality of louvers located at the peripheral extremity of the top section for controlling the velocity of the fluid drawn into the chamber.

3. A device according to claim 2 further including a second plurality of louvers located on the periphery of the top section for changing the direction of the fluid discharged at the periphery of the structure.

4. A flying device comprising a circular airfoil structure having a central circular opening therein; said structure being defined by two sections, a top section and a bottom section, spaced a predetermined distance apart and being substantially symmetrical about a vertical axis through said opening wherein the peripheral surface of the top section adjacent the periphery of the opening is substantially ogee or S-shaped, whereby the air will be sucked over the top of the said lip so as to create a lifting effect therein; a shaft vertically disposed in said opening; means for rotatably mounting the structure upon the shaft so that the structure may rotate independently of the shaft; a plurality of blades secured to the shaft, extending radially in balance relationship from the shaft; a plurality of gas generators located in the upper section of said structure in balanced relationship about the shaft; conduit means for leading air from the said opening in the structure through the gas generators; means for heating the air; a plurality of nozzle means to expell the heated air from the gas generators to cause rotation of said blades whereby air is drawn radially inwardly across the top section of said airfoil structure and downwardly through the opening; means for expelling the air through the bottom of the opening to produce a lifting thrust.

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Jan. 23, 1962 J. C. M. FROST ETAL 3,018,068

DISC AIRCRAFT WITH MULTIPLE RADIALLY DISPOSED GAS TURBINE ENGINES

Filed May 9, 1955 5 Sheets-Sheet 1

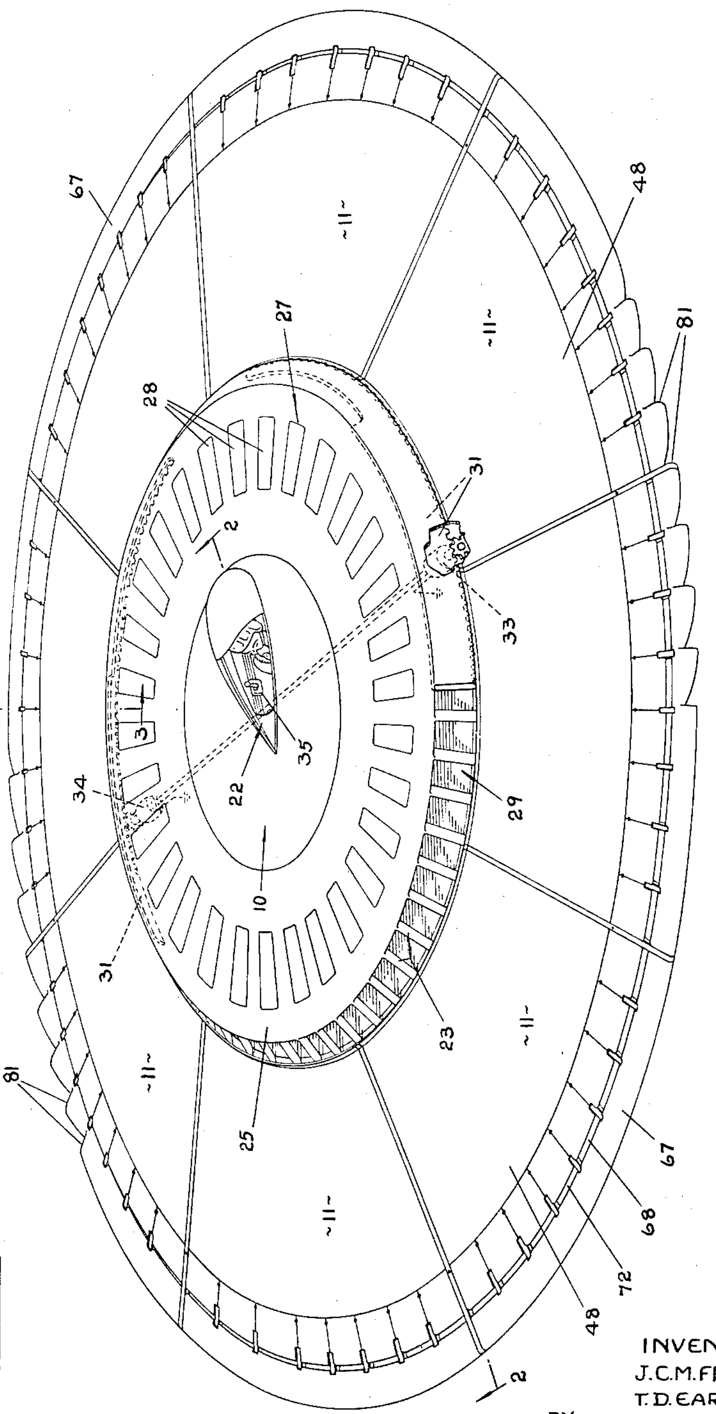


FIG. 1

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DISC AIRCRAFT WITH MULTIPLE RADIALLY DISPOSED GAS TURBINE ENGINES

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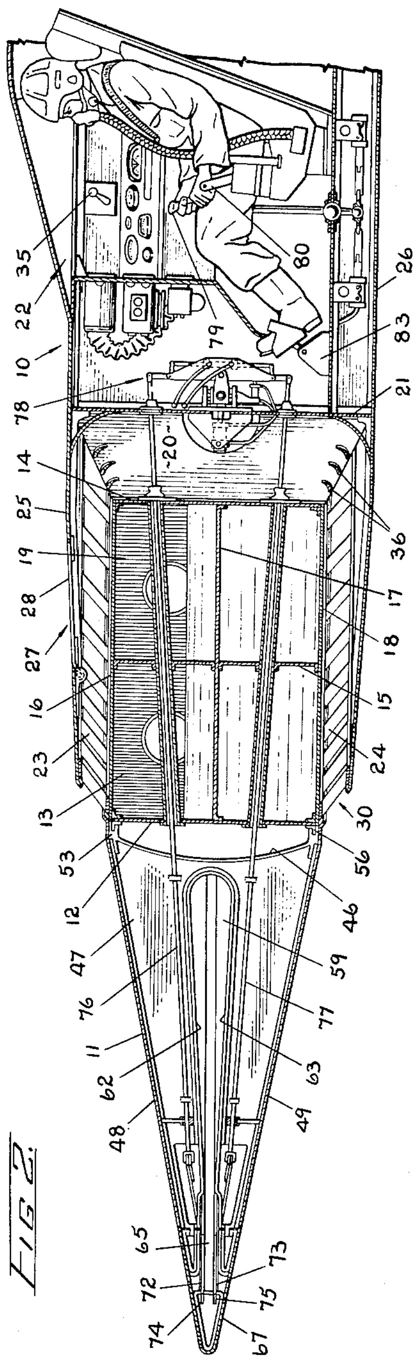

FIG. 2.

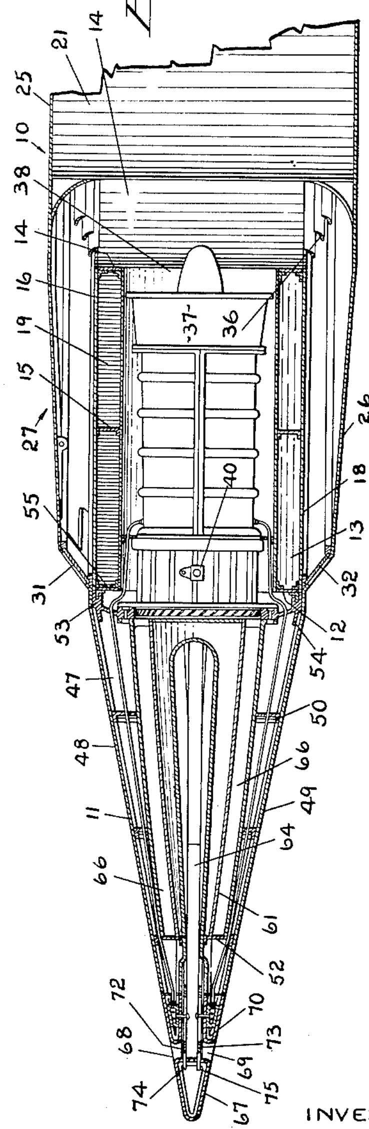

FIG. 3.

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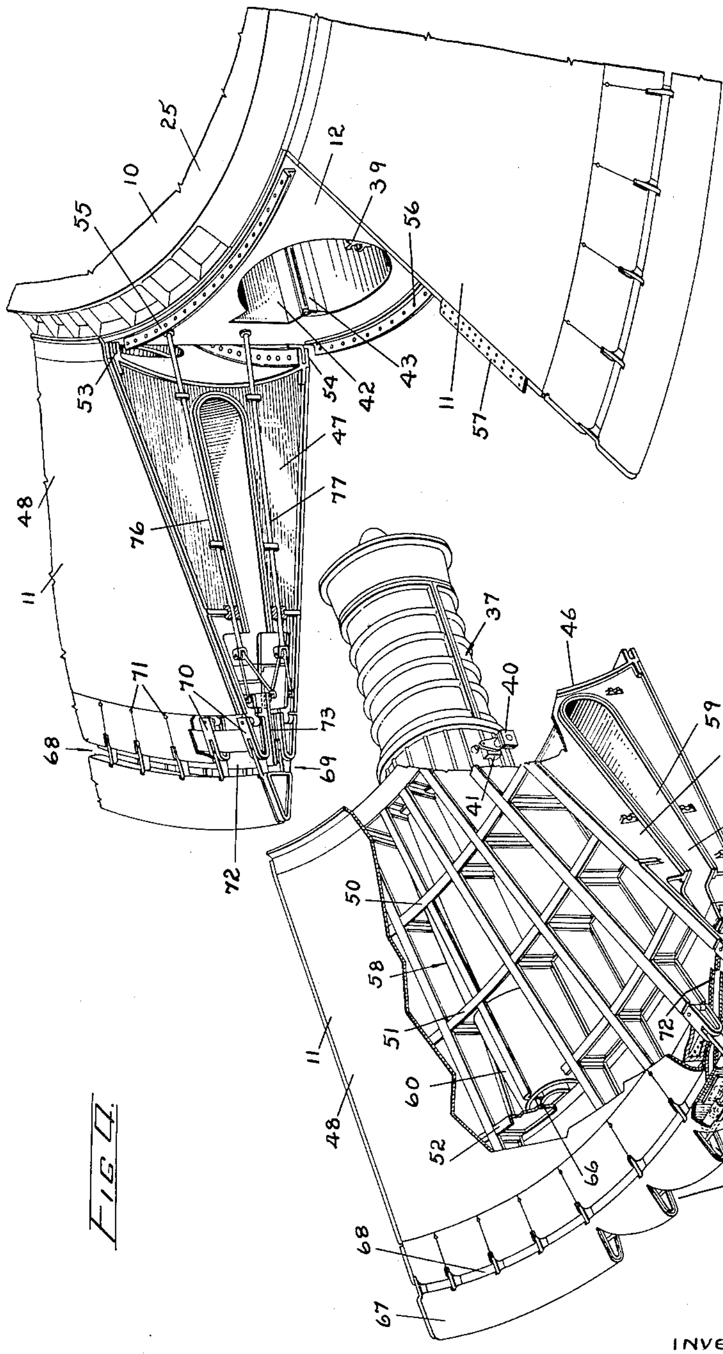

FIG. 4.

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FIG. 7.

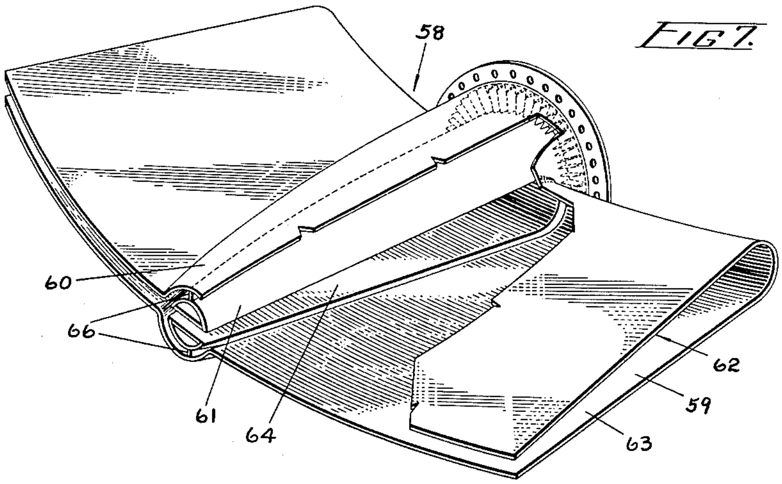
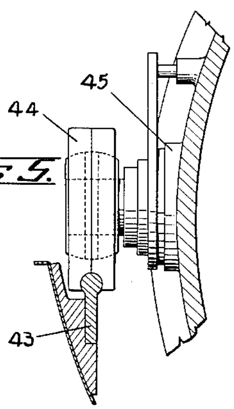



FIG. 5.



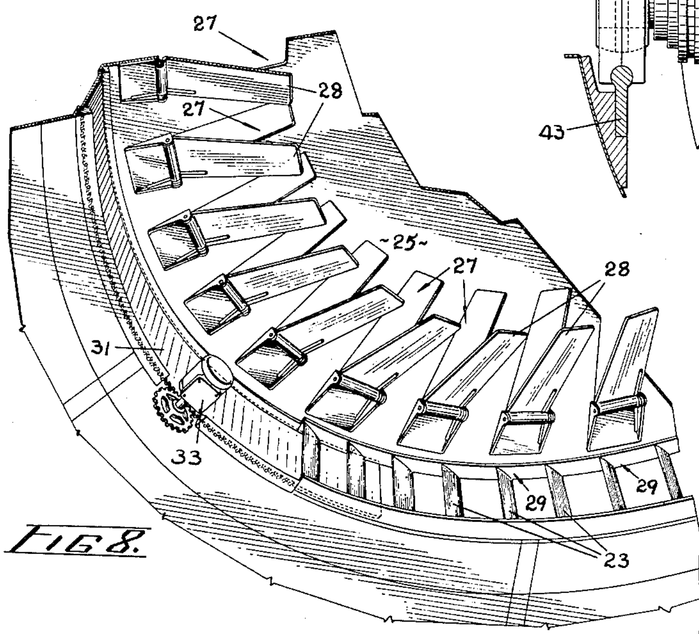




FIG. 8.

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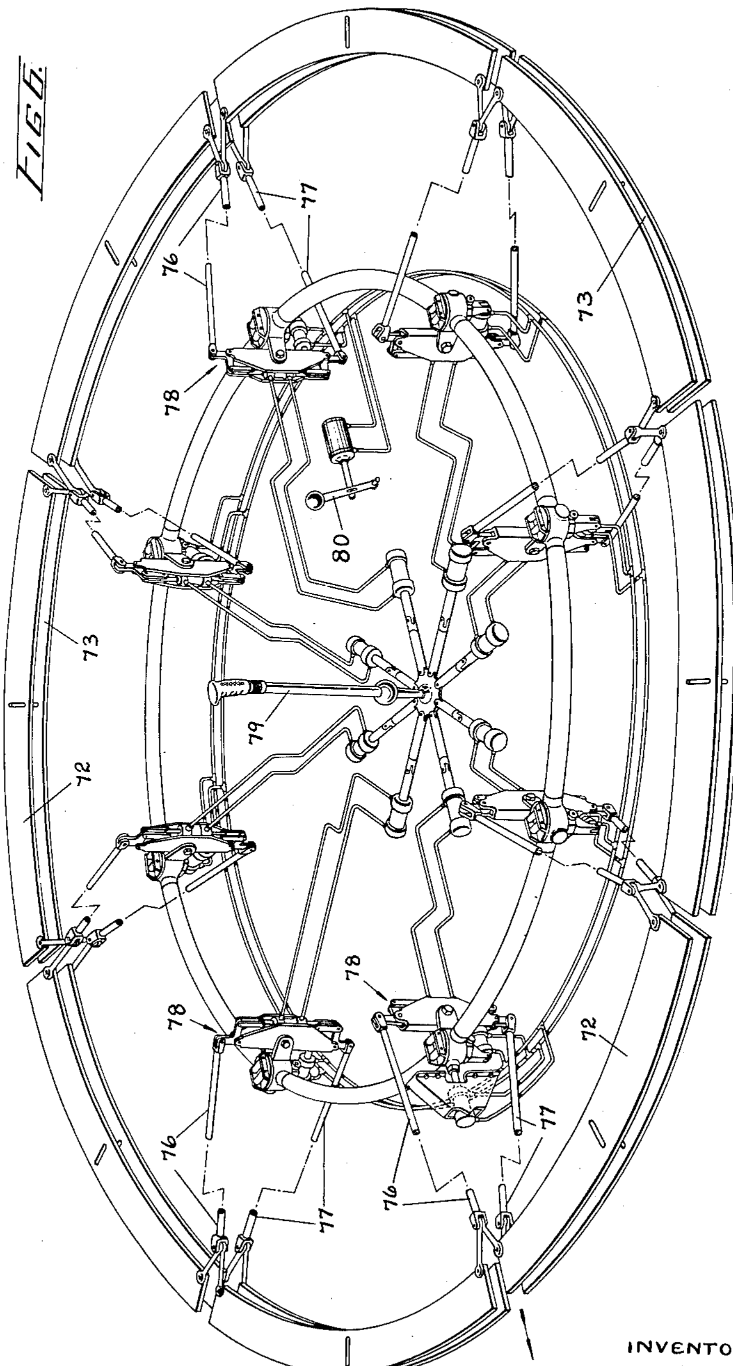
FIG. 6.

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United States Patent Office — 3,018,068 — Patented Jan. 23, 1962



3,018,068

# DISC AIRCRAFT WITH MULTIPLE RADIALLY DISPOSED GAS TURBINE ENGINES

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Filed May 9, 1955, Ser. No. 507,100
Claims priority, application Great Britain May 11, 1954
12 Claims. (Cl. 244—15)

This invention relates to aircraft and more particularly to disc-type or circular aircraft deriving a propulsive thrust from a stream of high-speed gases flowing within the aircraft in generally radial directions and discharged from the periphery thereof. An aircraft of this type is disclosed in the co-pending patent application of John Dubbery, John Carver Meadows Frost and Thomas Desmond Earl, Serial No. 684,615 filed on September 17, 1957.

The aforementioned co-pending application describes an aircraft which comprises a generally lentiform structure sheathed by opposed aerofoil surfaces converging towards each other in an outboard direction from their central inboard portions to their perimetrical edges, and a radial flow gas turbine engine disposed between the said aerofoil surfaces and having a disc-like rotor the plane of rotation of which is approximately parallel to the medial plane between the said opposed surfaces. Air enters an inlet provided in the upper aerofoil surface, then after passing through plenum chambers it flows radially outboardly through a double-sided multi-stage radial flow compressor of a gas turbine engine, then into an annularly arranged combustion chamber of the engine where it supports the combustion of the fuel and from which the products of combustion or gases expand through a radial flow turbine of the engine into a peripheral passage, whence they flow radially outboardly through a perimetrical orifice which includes selectively variable means whereby the flow of ejected gases is directed in a controlled manner to provide a forward thrust.

There is, however, one main undesirable feature in the use of a radial flow gas turbine engine in a disc-type aircraft. In the event of damage to the engine as a result of structural failure or enemy action and to an extent such that the rotor stops, it would be extremely difficult, if not impossible, to land the aircraft safely without power and it would become necessary for the pilot and the crew to abandon the aircraft. This course of action, besides presenting an undesirable hazard to the occupants would greatly increase the attrition rate of the aircraft.

The main object of the invention therefore is to provide a disc-type aircraft having multi-engine reliability.

Another object of the invention is to provide a disc-type aircraft having an improved basic structure resulting in an increased thrust/weight ratio.

The foregoing and other objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, in which like reference characters indicate corresponding parts throughout the several views, and in which:

FIG. 1 is a perspective view of an aircraft constructed in accordance with the invention;

FIG. 2 is a radial sectional view of the aircraft taken along the line 2—2 of FIG. 1;

FIG. 3 is a radial sectional view of the aircraft taken along the line 3—3 of FIG. 1;

FIG. 4 is a perspective view of a portion of the aircraft with a segment detached, and parts of the segment being broken away to show details of construction;

FIG. 5 is a sectional view, to an enlarged scale, of a typical left-hand engine mount;

FIG. 6 is a perspective view of the shutters and shutter



controls of the aircraft, the shutter controls being shown to an enlarged scale for the sake of clarity;

FIG. 7 is a perspective view, partly broken away, of an engine exhaust nozzle assembly and exhauster duct; and

FIG. 8 is a fragmentary perspective view of the interior of the plenum chamber of the aircraft and showing particularly the air inlet shutters.

The aircraft of the invention is substantially circular in plan form, and in elevation it presents flat double convex surfaces on the central portion of each of which protrude frusto-conical structures; it can be said that the structure is lentiform. The aircraft may be divided into two main sections, namely a core **10** and a series of segments **11** (which preferably are annulus sectors) removably secured to each other and to the core, the segments when secured to each other constituting an annular structure.

The core **10** is defined by an outboard wall, which in the embodiment illustrated is the outboard wall **12** of an annular fuel tank **13**. The fuel tank is constituted by the aforesaid wall **12** which is cylindrical, and by an inboard cylindrical wall **14**, an intermediate cylindrical wall **15**, an upper annular wall **16**, an intermediate annular wall **17**, a lower annular wall **18**, and radial baffles **19**; the intermediate annular wall, the intermediate cylindrical wall, and the radial baffles provide compartments whereby shifting of the fuel is reduced. Preferably the fuel tank is pressurized for high altitude flying. The tank configuration and arrangement described lend themselves to ease of fabrication and provide a basic structure of high strength.

Secured to the inboard cylindrical wall **14** of the tank and extending radially inboardly is a series of shear webs **20** which support at their inboard edges a central cylindrical shell **21** defining a pilot's compartment or occupancy chamber **22**.

Circumferentially arranged on the upper and lower walls of the fuel tank adjacent its outboard periphery are inboardly sloping ribs **23** and **24** which support respectively an upper central skin **25** and a lower central skin **26** in spaced relationship from the upper tank wall and the lower tank wall respectively. The skins are suitably secured to other structural parts of the aircraft core, including the cylindrical wall **21**, and they provide the central outer walls of the aircraft.

The spaces between the upper tank wall **16** and the skin **25**, between the lower tank wall **18** and the skin **26**, and between the inboard tank wall **14** and the cylindrical wall **21** provide an annular plenum chamber. On the upper skin **25** are circumferentially arranged air inlets **27** which are normally closed by spring loaded doors or shutters **28** (see FIG. 8). The ribs **23** and **24** are sheathed by coverings except at the forward portions where the spaces between the ribs provide additional air inlets **29** and **30**. The inlets **29** and **30** are adapted to be closed by sliding doors or shutters **31** and **32** respectively. On the inner edges of these doors are gear teeth which mesh with pinions on the shafts of reversible motors **33** and **34** operable by a suitable control **35** in the pilot's compartment. Extending between adjacent shear webs **20** at their upper and lower extremities are a series of concentric cascades **36** whereby the inboardly flowing air which has entered the inlets is deflected inwardly. The cascades serve not only to give desirable flow characteristics to the air in the plenum chamber but also to stiffen the unsupported edges of the shear webs and improve their stress resistance.

In order to reduce the size of the aircraft it has been found expedient to locate the engines **37** in radially disposed passages provided by generally cylindrical open-ended shells **38** which extend from the outboard tank wall **12** to the inboard tank wall **14**; obviously the ends of the shell are hermetically sealed to the tank walls. On one side of each shell is a track **39** adapted to receive a mounting block **40** attached to a mounting pad **41** on the engine. On the opposite side of the shell **38** is a longitudinal recess **42** which is large enough to receive the side mounted accessories of the particular engine installation. Beneath the recess and secured to the shell is a beaded track **43** adapted to slidably receive a notched mounting block **44** attached to a mounting pad **45** on the engine. Thus an engine conveniently may be slid into its passageway and securely held therein, with its intake end in registration with the plenum chamber and its outlet end extending out of the core **10** of the aircraft.

The eight segments or annulus sectors **11** are similar to each other and therefore only one need be described. Each sector comprises an inboard wall **46** which is of curved cross-section for greater strength, and a series of radially extending substantially triangular ribs **47** covered on their outer edges by upper skin segments **48** and lower skin segments **49**. Incidentally, the skin segments **48** and **49** of the eight annulus sectors and the central skins **25** and **26** of the core **10** together constitute the aerofoil surfaces of the aircraft. Three series of circumferentially spaced intercostals **50**, **51** and **52** extend between adjacent ribs and are secured thereto to provide an exceptionally strong but lightweight structure. The sector may be secured firmly to the core **10** of the aircraft by means of U-shaped members **53** and **54** on the upper and lower edges of the wall **46** and which engage respectively angle brackets **55** and **56** on the core wall **12**. The edges of adjacent sectors may be secured to each other by any suitable means, such as by butt straps; a segment of a butt strap is indicated at **57** in FIG. 4.

In each of the sectors is incorporated an exhaust passage constituted by an exhaust nozzle assembly generally indicated at **58** and an exhauster duct **59** (see FIGS. 4 and 7). The exhaust nozzle assembly includes an outboardly tapering outer casing **60** within which is a saddle-shaped or imperfectly ovoid core **61**; the inboard ends of the casing and of the core are circular and together they provide the end of an annular exhaust nozzle adapted to register with a turbine outlet, whilst their outboard ends abut one of the intercostals **52** and are closed thereby. The casing **60** fairs into the spaced upper and lower walls **62** and **63** of the exhauster duct **59**, and a diametrically extending slot **64** is provided in the core **61** to give continuity to the exhauster duct. The upper skin **48** and the lower skin **49** at their outboard edges meet with the upper and lower walls **62** and **63** of the exhauster duct to provide an exhaust outlet **65**. The exhauster ducts of the sectors are in end-to-end registration, and together they constitute an annularly arranged exhaust passage extending circumferentially around the aircraft and terminating in an annular exhaust outlet.

Spacers **66** which extend longitudinally and radially relative to the exhaust nozzle assembly **58** are provided between the opposed surfaces of the casing **60** and of the core **61** to create a strong structural tie between these elements. Of necessity the webs of the ribs **47** and the intercostals **50** and **51** are provided with recesses and are suitably formed to accommodate the exhaust nozzle assembly **58** and especially the exhauster duct **59**; it will be observed particularly from FIG. 4 that in the web of each rib **47** is a large slot to accommodate the exhauster duct.

To the inboard wall **46** of each of the sectors is attached the outlet end of one of the gas turbine engines **37**, the sector and the engine being separate and readily detachable units. The turbine outlet of the engine is in registration with the exhaust nozzle assembly **58**.

A sector **11** with an engine attached conveniently may be moved into position in the space between adjacent sectors, the engine sliding into the passage provided by shell **38** and being guided and supported by the mounting blocks **40** and **44** which bear respectively on the tracks **39** and **43**. When the sector and the attached engine are in position, the sector is attached to the core and to the adjacent sectors, as previously mentioned.



Encompassing the perimeter of the aircraft and spaced from the annular exhaust outlet **65** is a ring **67** which is triangular in cross-section, one of its faces being opposed to and spaced from the exhaust nozzle **65** and the other two faces converging towards each other and providing continuations of the skins **48** and **49**. The ring and the annular exhaust outlet together provide an upper perimetrical nozzle **68** and a lower perimetrical nozzle **69**. The ring is secured to the ribs through diverging arms **70** which are attached to the ends of the ribs by pins **71**.

Movable shutters **72** and **73**, each consisting of eight sections, are provided for the nozzles **68** and **69** respectively. These shutters are suitably mounted on the upper and lower walls **62** and **63** of the exhauster duct **59**, and they are adapted to slide outboardly to close the nozzles and inboardly to open them. The outboard edges of the shutters may be brought into registration with slots **74** and **75** provided in the ring **67**.

The construction and operation of the aircraft control system and of its nozzles and shutters are not claimed as part of the present invention. They are described in detail in the co-pending application of John Carver Meadows Frost, Serial No. 507,099, filed on May 9, 1955 and entitled "Vertical Take-Off Aircraft Control."

Referring to FIG. 6, the individual shutter sections are connected at each end by rods **76** or **77** to control mechanisms generally indicated at **78** operable by a universally movable control column **79** and by a two-position selector handle **80**. In "take-off position" the selector handle locates the shutters concentrically relative to the two nozzles but moves the upper shutter **72** outboardly to close the upper nozzle **68** and moves the lower shutter **73** inboardly to open the lower nozzle **69**. When the selector handle is shifted from take-off position to "flight position" it moves both shutters forwardly to position them eccentrically relative to the nozzles and at the same time moves the upper shuuter **72** inboardly and the lower shutter **73** outboardly so that the openings in corresponding portions of the upper and lower nozzles are equal; thus both nozzles at their extreme forward portions are fully closed, and the nozzle openings are progressively greater to either side of the said extreme forward portions.

With the selector handle **80** set at either take-off or flight position, movement of the control column **79** in any direction relative to the central or neutral position causes a differential movement of the shutters relative to each other in the said direction. For example, if the control column is moved towards port the port portion of the upper shutter and the starboard portion of the lower shutter will move inboardly to increase the openings in the port portion of the upper nozzle and in the starboard portion of the lower nozzle, and the port portion of the lower shutter and the starboard portion of the upper shutter will move outboardly to decrease the nozzle openings in the port portion of the lower nozzle and in the starboard portion of the upper nozzle. It may thus be seen that, both while taking off and in forward flight, the pilot can effect longitudinal and lateral control of the aircraft by appropriate movements of the control column **79**.

On the port portion and on the starboard portion of the ring **67** are provided rudder ports **81** which are in communication with the exhaust outlet **65**. Suitable shutters **82** to open or close these ports are operated by rudder pedals **83** in the pilot's compartment. Directional control of the aircraft is effected by selective opening and closing of the rudder ports through the operation of the rudder pedals.

On take-off the pilot closes the air inlets **29** and **30** by means of the sliding shutters **31** and **32** to prevent the entrance into the lower inlet of the hot products of combustion ejected from the lower nozzle **69**. This causes the spring loaded doors 28 to open automatically by reason of the fact that the pressure differential between the plenum chamber and the atmosphere overcomes the spring forces. In forward flight the pilot opens the sliding shutters so that the air then enters the inlets 29 and 30, and the spring loaded doors 28 close automatically. The air enters the plenum chamber through the open inlet or inlets, is deflected by the cascades 36 and drawn into the intakes of the gas turbine engines 37.

The engines are of the well known axial flow type, and in each engine air is compressed in an axial flow compressor, then passed through a combustion system to which fuel is added, allowed to expand through a turbine which drives the compressor, after which the products of combustion are exhausted through the exhaust nozzle assembly and the exhauster duct and finally to atmosphere through one or both of the perimetrical nozzles 68 and 69.

To take off, the pilot after closing the air inlets 29 and 30 sets the selector handle 80 at take-off position thus closing the upper nozzle 68 and opening the lower nozzle 69. The gases consequently are ejected downwardly from the lower nozzle 69, and because of the "ground cushion" effect the aircraft, which may have a weight greater than the combined static thrust of all the engines, rises vertically above the ground.

In order to transfer to forward flight, the pilot slowly moves the selector handle 80 to flight position, thus closing the forward portions of both the upper and lower nozzles 68 and 69 and opening the remaining portions. This movement of the selector handle into flight position is done slowly so that the vertical lift from the downwardly directed gases is only gradually destroyed as the aircraft picks up flying speed and acquires lift resulting from the aerodynamic forces on the aerofoil surfaces. As soon as the aircraft has risen some distance from the ground and is in forward flight the air inlets 29 and 30 may be opened, causing the spring loaded doors 28 to close automatically; this allows the aircraft to take advantage of ram in the intake.

Due to the fact that the large rotor of the radial flow engine of the aforementioned application Serial No. 502,-156 has been replaced by a plurality of axial flow engines, an aircraft constructed in accordance with the present invention is not gyroscopically stable. The aircraft, however, can be stabilized in any one of several ways. For example, it is possible to depend entirely on automatic stabilization by means of rate gyros and hydraulic transmission, or stability may be effected by adding weight at the front to move the centre of gravity forward.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred example of the same, and that various changes in the shape, size and arrangement of the parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

What we claim as our invention is:

1. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, a group of gas turbine engines positioned between the aerofoil surfaces in a generally radial arrangement with their intakes directed towards the centre of the structure and their outlets directed towards its perimeter, and means encompassing the engine outlets and directing the products of combustion ejected therefrom to provide a propulsive thrust.

2. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, a group of gas turbine engines positioned between the aerofoil surfaces in a generally radial and approximately equiangular arrangement with their intakes directed towards the centre of the structure and their outlets directed towards its perimeter, and means encompassing the engine outlets and directing the products of combustion ejected therefrom to provide a propulsive thrust.

3. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, a plenum chamber annularly arranged in the structure around its central portion, an air inlet for the plenum chamber in at least one of the aerofoil surfaces, a group of gas turbine engines positioned between the aerofoil surfaces in a generally radial arrangement with their intakes in registration with the plenum chamber and their outlets directed towards the perimeter of the structure, and means encompassing the engine outlets and directing the products of combustion ejected therefrom to provide a propulsive thrust.

4. A disc-type aircraft comprising a core defined by a wall and embodying an occupancy chamber at its centre and an annularly disposed plenum chamber, a group of gas turbine engines in a radial arrangement with their intake ends extending within the core and in registration with the plenum chamber and with their outlet ends facing outboardly, an outboardly tapering annular framework secured to the core around its wall and encompassing the outlet ends of the engines, an annularly arranged exhaust passage in the framework registering with the outlet ends of the engines, opposed aerofoil surfaces sheathing the core, the framework and the engines to provide lift developing surfaces of the aircraft, an opening in at least one of the aerofoil surfaces to provide an air inlet for the plenum chamber, and means adjacent the periphery of the aircraft and co-operating with the exhaust passage to direct the products of combustion ejected from the engines to provide a propulsive thrust.

5. A disc-type aircraft comprising a core defined by a wall and embodying an occupancy chamber at its centre and an annularly disposed plenum chamber, a group of gas turbine engines mounted in the core in a radial arrangement, the intake ends of the engines extending into the plenum chamber and the outlet ends facing outboardly, an annularly arranged fuel tank in the core and occupying mainly the spaces between the engines, an outboardly tapering annular framework secured to the core around its wall and encompassing the outlet ends of the engines, an annularly arranged exhaust passage in the framework registering with the outlet ends of the engines, opposed aerofoil surfaces sheathing the core, the framework and the engines to provide lift developing surfaces of the aircraft, an opening in at least one of the aerofoil surfaces to provide an air inlet for the plenum chamber, and means adjacent the periphery of the aircraft and co-operating with the exhaust passage to direct the products of combustion ejected from the engines to provide a propulsive thrust.

6. A disc-type aircraft comprising a core defined by a wall and embodying an annularly arranged fuel tank, an occupancy chamber at the centre of the core and an annular plenum chamber interposed between the occupancy chamber and the fuel tank, a plurality of radially arranged passages in the fuel tank and opening through the wall, a gas turbine engine in each passage, the intakes of the engines being in communication with the plenum chamber and their outlet ends facing outboardly, an outboardly tapering annular framework secured to the core around its wall and encompassing the outlet ends of the engines, an annularly arranged exhaust passage in the framework registering with the outlet ends of the engines, opposed aerofoil surfaces sheathing the core, the framework and the engines to provide lift developing surfaces of the aircraft, an opening in at least one of the aerofoil surfaces to provide air inlets for the plenum chamber, and means adjacent the periphery of the aircraft and co-operating with the exhaust passage to direct the products of combustion ejected from the engines to provide a propulsive thrust.

7. A disc-type aircraft comprising a core defined by a wall and embodying an occupancy chamber at its centre and a plenum chamber, a plurality of radially arranged passages in the core and opening through the wall, a

series of segments removably secured to each other and to the core, the segments secured to each other constituting an annular structure and the annular structure secured to the core constituting a disc-like structure, gas turbine engines mounted respectively on each segment and having their outlet ends extending towards the outboard edge of the segment, and their intake ends projecting from the inboard edge of the segment, the intake end of each gas turbine engine passing through an opening in the wall and extending into one of the passages provided in the core when the segment on which the engine is mounted in secured to the core, the intake of an engine thus positioned being in communication with the plenum chamber, opposed generally circular aerofoil surfaces sheathing the core and the segments to provide lift developing surfaces of the aircraft, an opening in at least one of the aerofoil surfaces providing an air inlet for the plenum chamber, and means adjacent the periphery of the aircraft to direct the products of combustion ejected from the engine outlets to provide a propulsive thrust.

8. A disc-type aircraft comprising a core defined by a wall and embodying an occupancy chamber at its centre and a plenum chamber, a plurality of radially arranged passages within the core and opening through the wall, gas turbine engines in the passages, the intakes of the engines being in communication with the plenum chamber and their outlet ends facing outboardly, co-operating means of the engines and of the core enabling the engines to be removably slid into the passages, segmental members each secured to the outlet end of an engine and to the core wall, adjacent segmental members being also secured to each other to provide an annular structure within which is the core, opposed generally circular aerofoil surfaces sheathing the core and the segmental members to provide lift developing surfaces of the aircraft, an opening in at least one of the aerofoil surfaces to provide an air inlet for the plenum chamber, an exhaust passage in each segmental member and having one end in registration with the outlet of the engine to which the member is secured, the exhaust passages of the series of segmental members together constituting an annularly arranged exhaust passage through which the products of combustion flow radially outboardly from the engine outlets, and means adjacent the periphery of the aircraft and encompassing the annularly arranged exhaust passage to direct the products of combustion ejected therefrom to provide a propulsive thrust.

9. A disc-type aircraft comprising a core embodying an occupancy chamber at its centre and a plenum chamber, a plurality of radially arranged passages in the core, a series of segmental members removably attached at their inboard sides to the periphery of the core, adjacent segmental members also being removably secured to each other, the series of segmental members together constituting an annular structure disposed around the core, gas turbine engines secured to the segmental members and having their intake ends projecting from the inboard sides of the segmental members, the engines slidably entering the core passages when the segmental members are assembled to the core and being nested in the passages with their intakes in communication with the plenum chamber, a nozzle assembly in each segmental member in registration with an engine outlet and including a casing and a core spaced therefrom, an exhauster duct in each segmental member provided by opposed generally parallel walls which blend with the casing of the nozzle assembly, the exhauster ducts of the series of segmental members being in registration and together providing an annularly arranged exhaust passage through which the products of combustion may flow radially outboardly from the engine outlets, and means encompassing the annularly arranged exhaust passage to direct the products of combustion to provide a propulsive thrust.



10. A disc-type aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, a plenum chamber in the structure, a group of gas turbines positioned between the aerofoil surfaces in a generally radial arrangement with their intakes in registration with the plenum chamber and their outlets directed toward the perimeter of the structure, a port for an air inlet on one of the aerofoil surfaces and disposed at an angle to that surface so that air may be forced therein during forward flight of the aircraft, a shutter for the said port, manually operable means for opening and closing the shutter, a second port for an air inlet substantially in the plane of the upper aerofoil surface, a closure for the second port, biasing means urging the closure to closed condition, the biasing means holding the closure in closed condition when the shutter is open and the pressure differential between the atmosphere and the air in the plenum chamber overcoming the biasing means and opening the closure when the shutter is closed and the gas turbine engines are in operation, and means encompassing the engine outlets and directing the products of combustion ejected therefrom to provide a propulsive thrust.

11. A disc-type aircraft comprising a generally lentiform structure sheathed by opposed upper and lower aerofoil surfaces which provide lift developing surfaces, gas turbine engine means positioned between the aerofoil surfaces and having a peripheral outlet adjacent the perimeter of the structure, a port for an air inlet for the gas turbine engine means on one of the aerofoil surfaces and disposed at an angle to that surface so that the air may be forced therein during forward flight of the aircraft, a shutter for the said port. manually operable means for opening and closing the shutter, a second port for an air inlet for the gas turbine means substantially in the plane of the upper aerofoil surface, a closure for the said second port, and biasing means urging the closure to closed condition, the biasing means holding the closure in closed condition when the shutter is open and the pressure differential between the atmosphere and the air within the aircraft overcoming the biasing means and opening the closure when the shutter is closed and the gas turbine engine means is in operation.

12. An aircraft as claimed in claim 11, in which housings are provided on each of the aerofoil surfaces, the said housings having edge surfaces angularly disposed to the aerofoil surfaces and which create discontinuities in the aerofoil surfaces, the first mentioned port being located in one of the said edge surfaces.

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VERTICAL TAKE-OFF AIRCRAFT CONTROL

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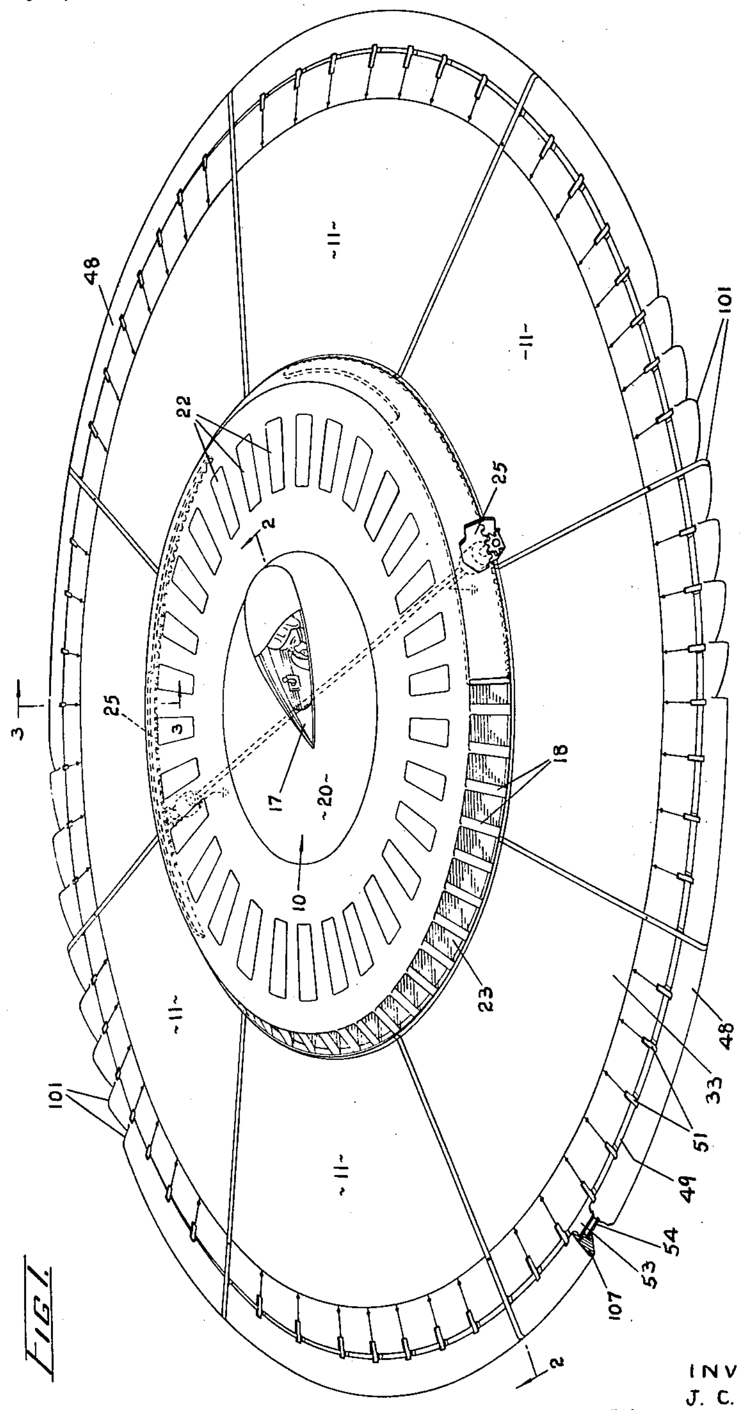


FIG. 1

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VERTICAL TAKE-OFF AIRCRAFT CONTROL

Filed May 9, 1955 7 Sheets-Sheet 2

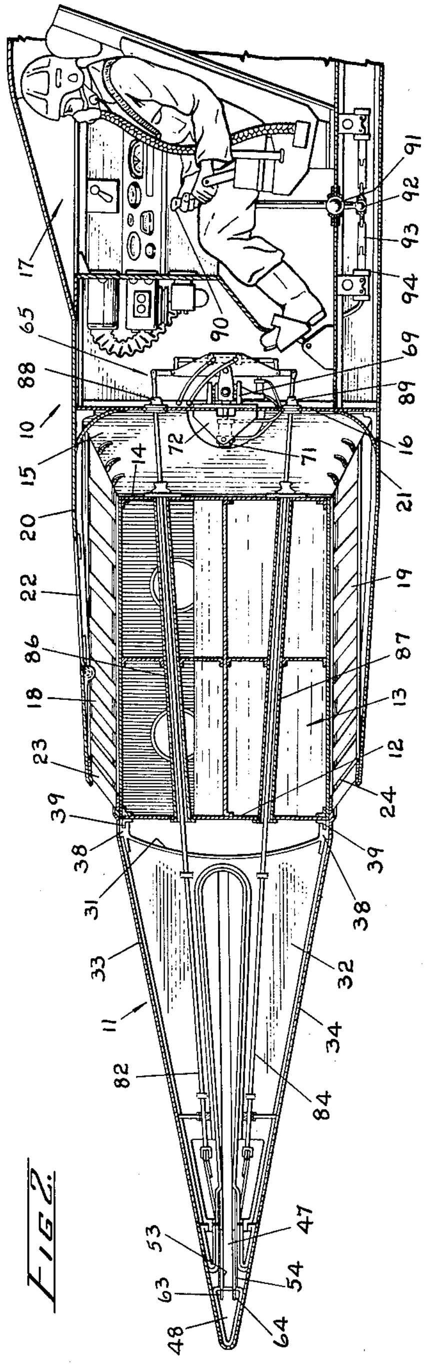
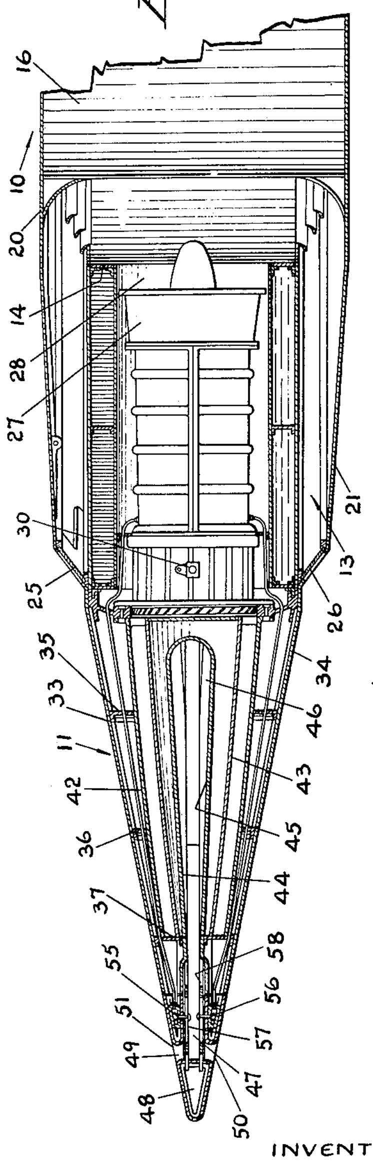


FIG. 2.

FIG. 3.



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VERTICAL TAKE-OFF AIRCRAFT CONTROL

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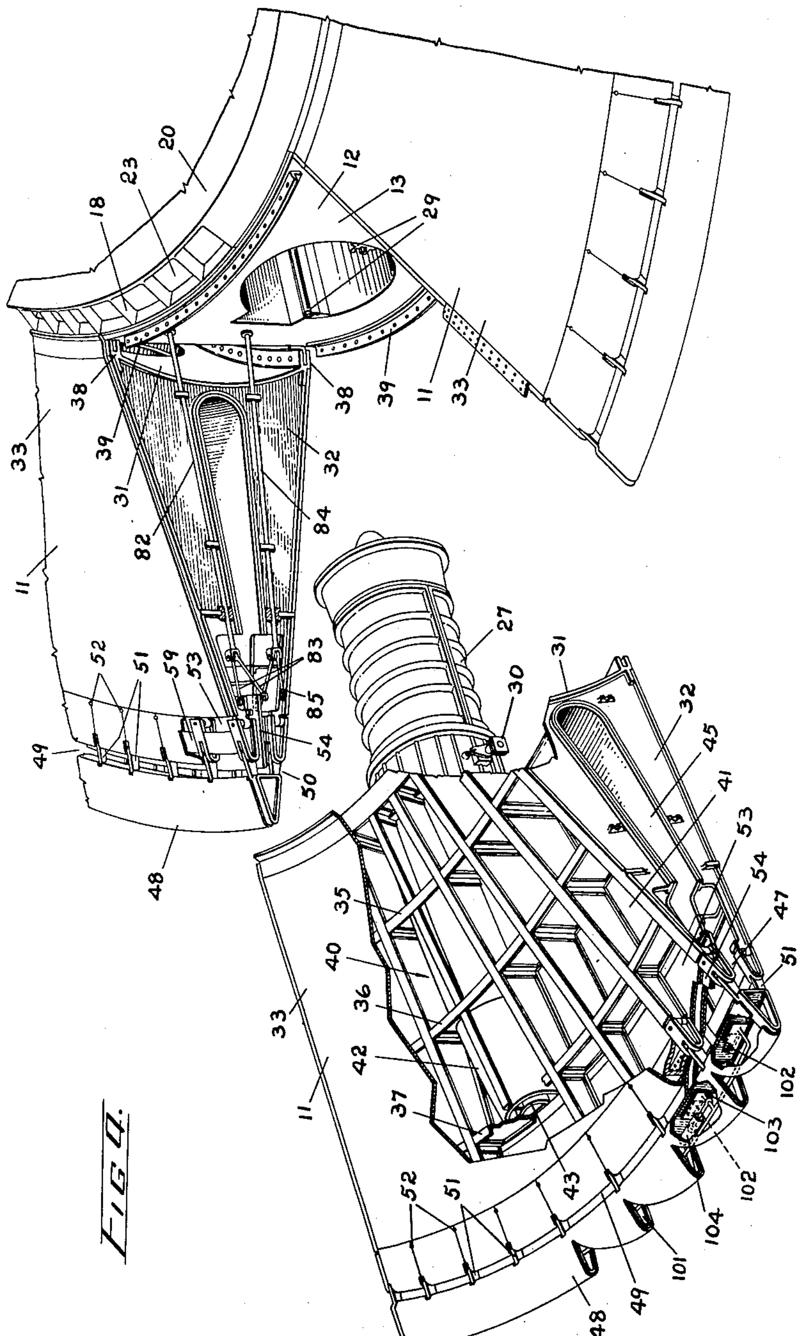


FIG. 4.

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VERTICAL TAKE-OFF AIRCRAFT CONTROL

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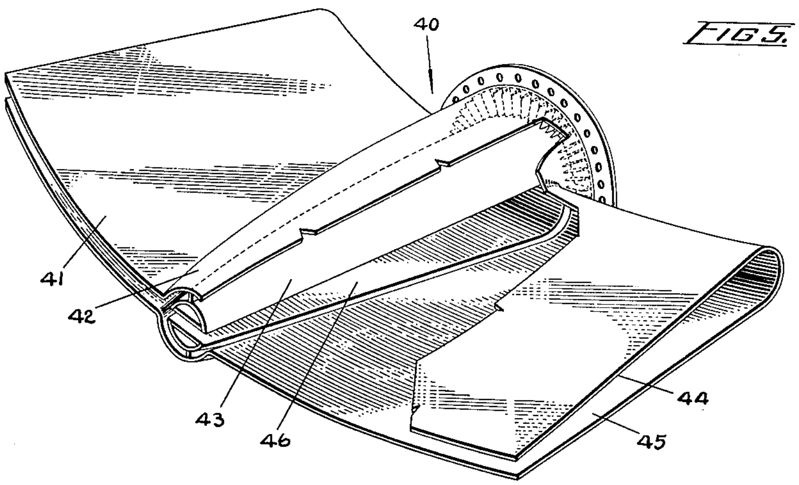
FIG. 5.



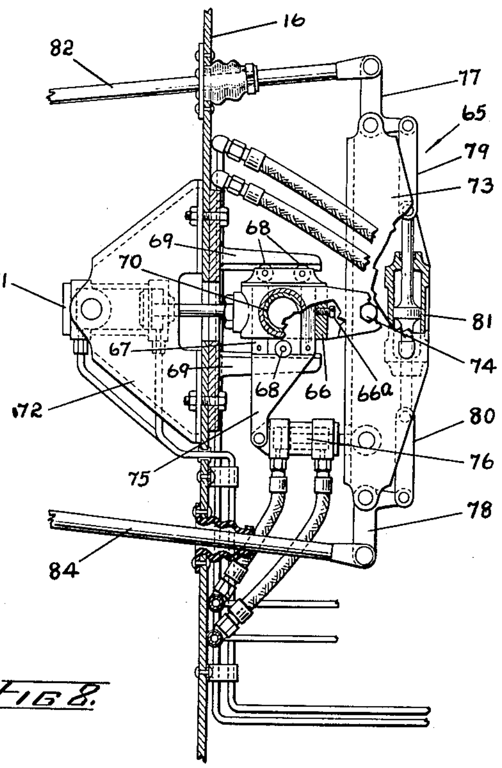




FIG. 8.

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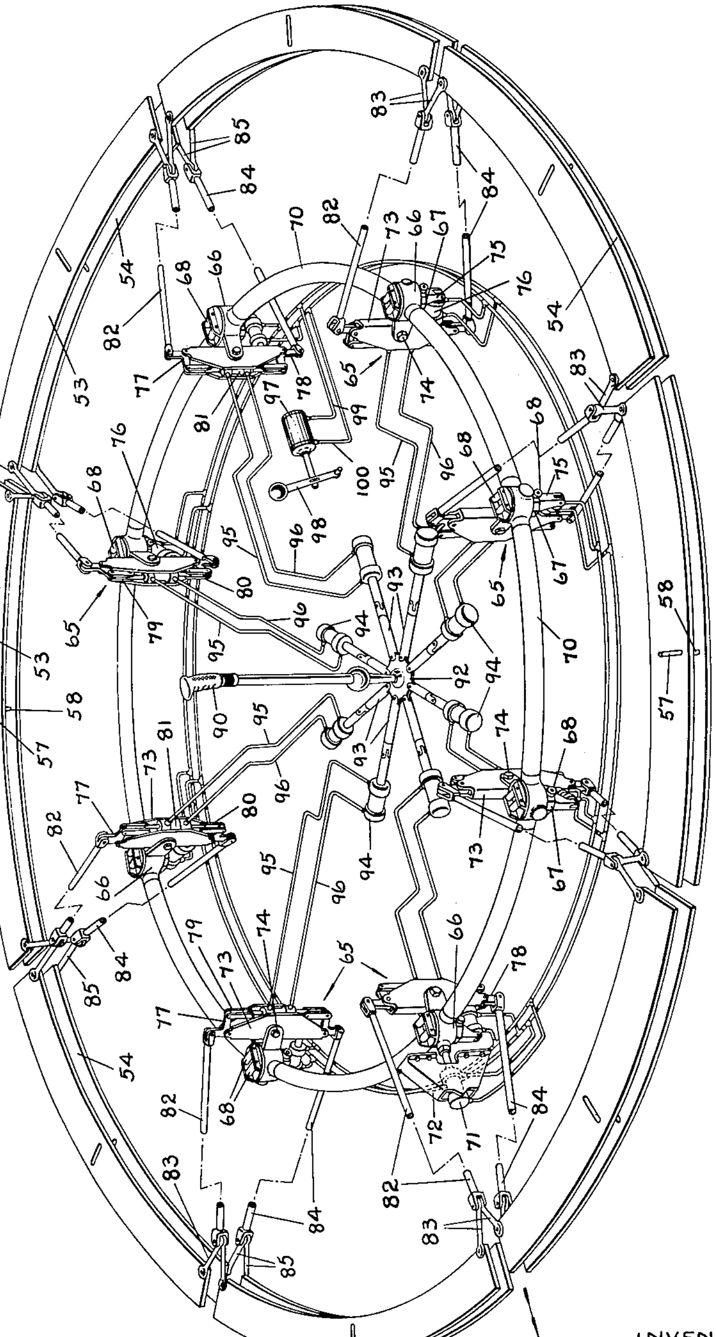
FIG. 6.



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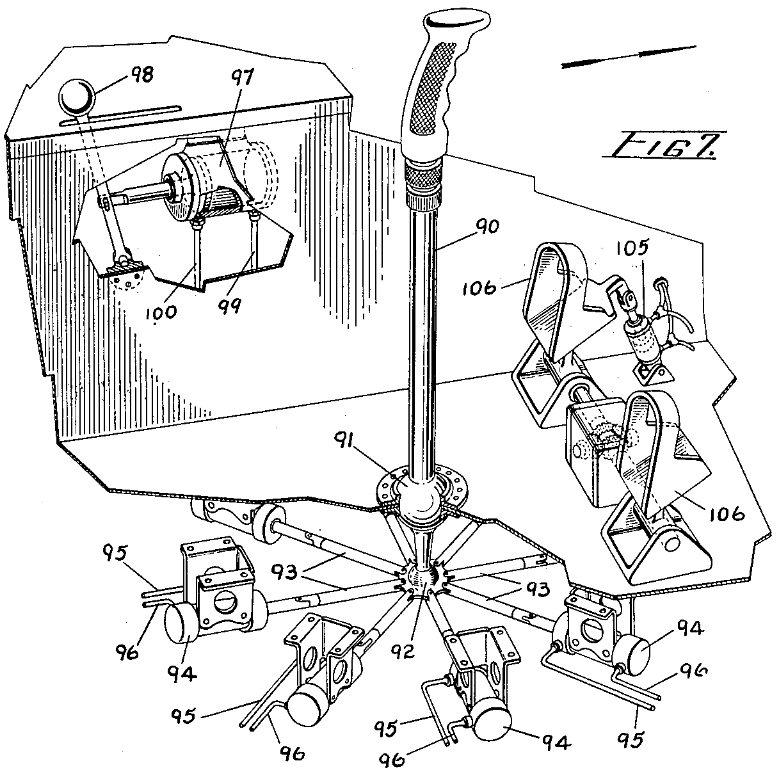


FIG 7.

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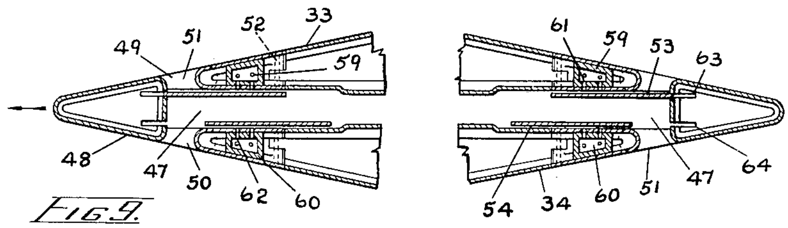


FIG. 9.

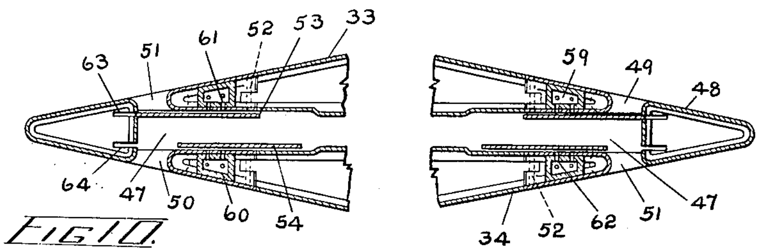


FIG. 10.

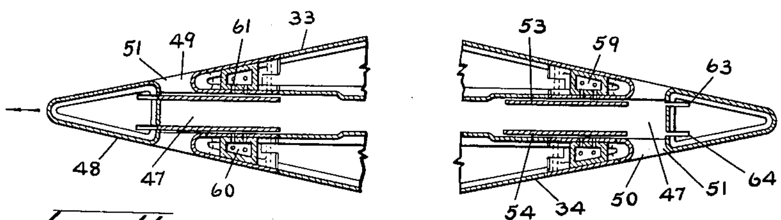


FIG. 11.

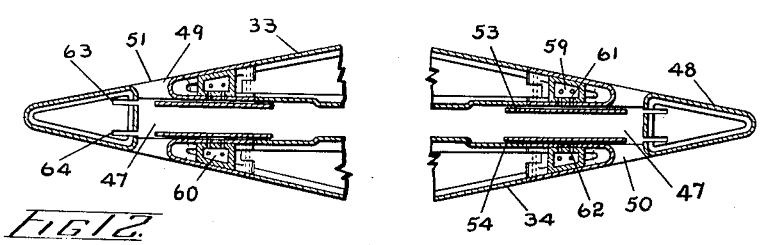


FIG. 12.

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United States Patent Office

3,020,002
Patented Feb. 6, 1962

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3,020,002

# VERTICAL TAKE-OFF AIRCRAFT CONTROL

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Filed May 9, 1955, Ser. No. 507,099
Claims priority, application Great Britain May 11, 1954
14 Claims. (Cl. 244—15)

This invention relates to the propulsion and control of disc-type or circular aircraft deriving a propulsive thrust from a stream of high-speed gases flowing within the aircraft in generally radial directions and discharged from the periphery thereof. The invention is believed to be a significant improvement over the aircraft disclosed in the co-pending patent application of John Carver Meadows Frost and Thomas Desmond Earl, Serial No. 688,804, filed on October 1, 1957, and entitled "Disc-Type Aircraft."

Although the aircraft of the aforementioned co-pending application has many desirable features, it has been found that undesirably high operating forces are required to move the perimetrical annular member whereby flight control is achieved. This is because in flight the member is subjected to high aerodynamic loads, and any change in its position must be made against these loads. It therefore is the main object of the present invention to provide a disc-type aircraft having flight controls which require a minimum control operating force.

It is another object of the invention to provide a disc-type aircraft capable of destroying an enemy aircraft by ramming without suffiering serious damage to itself.

The foregoing and other objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, in which like reference characters indicate corresponding parts throughout the several views, and in which:

FIG. 1 is a perspective view of an aircraft constructed in accordance with the invention;

FIG. 2 is a radial sectional view of the aircraft taken along the line 2—2 of FIG. 1;

FIG. 3 is a radial sectional view of the aircraft taken along the line 3—3 of FIG. 1;

FIG. 4 is a perspective view of a portion of the aircraft with a segment detached, and parts of the segment being broken away to show some of its interior;

FIG. 5 is a perspective view, partly broken away, of an engine exhaust nozzle assembly and exhaustor duct;

FIG. 6 is a perspective view of the shutters and shutter controls of the aircraft, the shutter controls being shown to an enlarged scale for the sake of clarity;

FIG. 7 is a fragmentary perspective view showing the main pilot operated controls in the pilot's compartment;

FIG. 8 is a side elevational view, partly in section, of the forward control jack assembly;

FIG. 9 is a fragmentary longitudinal diametrical cross-sectional view of the aircraft, showing particularly the positions of the forward and aft portions of the nozzle shutters in vertical take-off;

FIG. 10 is a fragmentary transverse diametrical cross-sectional view of the aircraft, showing particularly the positions of the port and starboard portions of the nozzle shutters in vertical take-off;

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FIG. 11 is a fragmentary longitudinal diametrical cross-sectional view of the aircraft, showing particularly the positions of the forward and aft portions of the nozzle shutters in forward flight.

FIG. 12 is a fragmentary transverse diametrical cross-sectional view of the aircraft, showing particularly the positions of the port and starboard portions of the nozzle shutters in forward flight.

For greater convenience, throughout the description certain terms of positional relationship are used. The terms "outboard" (or "outboardly") and "inboard" (or "inboardly") denote, respectively, greater and lesser distances from the directional axis of the aircraft, and the terms "outer" and "inner" denote greater and lesser distances from a medial plane between the aerofoil surfaces of the aircraft.

The aircraft of the invention is substantially circular in plan form, and in elevation it presents flat double convex surfaces on the central portion of each of which protrude frusto-conical structures; it can be said that the structure is lentiform. The aircraft which is described may be divided into two main sections, namely a core **10** and a series of segments **11** (which preferably are annulus sectors) removably secured to each other and to the core, the segments when secured to each other constituting an annular structure. The structure of the aircraft and of its engine arrangement are not claimed as part of the present invention. They are described in considerably greater detail in the copending application of John Carver Meadows Frost and Thomas Desmond Earl, Serial No. 507,100 filed on May 9, 1955, and entitled "Disc Aircraft With Multiple Radially Disposed Gas Turbine Engines."

The core **10** is defined by an outboard wall which may be the outboard wall **12** of an annular fuel tank **13**. Secured to the inboard cylindrical wall **14** of the tank and extending radially inboardly is a series of shear webs **15** which support at their inboard edges a cylindrical shell **16** defining a pilot's compartment **17**.

Circumferentially arranged on the upper and on the lower walls of the fuel tank adjacent its outboard periphery are inboardly inclined ribs **18** and **19** which support respectively an upper central skin **20** and a lower central skin **21** in spaced relationship from the upper tank wall and the lower tank wall respectively. The spaces between the upper tank wall and the upper skin, between the lower tank wall and the lower skin, and between the inboard tank wall **14** and the cylindrical shell **16** provide an annular plenum chamber. On the upper skin **20** are circumferentially arranged air inlets which are normally closed by spring loaded doors **22**. Additional air inlets **23** and **24** are adapted to be closed by pilot-operated sliding doors **25** and **26** respectively.

The engines **27** are located in radially disposed passages provided by generally cylindrical open-ended shells **28** which extend from the outboard tank wall **12** to the inboard tank wall **14**; obviously the ends of the shell are hermetically sealed to the tank walls. Suitable inter-engaging tracks **29** and mounting blocks **30** are provided on the shell and on the engine respectively so that the engine conveniently may be slid into its passage and securely held therein, with its intake end in registration with the plenum chamber and its outlet end extending out of the core **10** of the aircraft.

The eight annulus sectors **11** are similar to each other; they are removably secured to each other and to the core, and together they constitute an annular structure. Each sector comprises an inboard wall 31 and a series of radially extending substantially triangular ribs 32 covered on their outer edges by upper skin segments 33 and lower skin segments 34. The skin segments 33 and 34 of the eight sectors and the central skins 20 and 21 of the core 10 together constitute the aerofoil surfaces of the aircraft. Three series of circumferentially spaced intercostals 35, 36 and 37 extend between adjacent ribs and are secured thereto. The sectors may be secured firmly to the core 10 of the aircraft by means of U-shaped members 38 which engage angle brackets 39 on the core wall 12. The edges of adjacent sectors may be secured to each other by any suitable means such as by butt straps.

In each of the sectors is incorporated an exhaust passage constituted by an exhaust nozzle assembly generally indicated at 40 and by an exhaustor duct 41 (see FIGS. 4 and 5). The exhaust nozzle assembly includes an outboardly tapering outer casing 42 within which is a saddle-shaped core 43; the inboard ends of the casing and of the core are circular and together they provide the end of an annular exhaust nozzle adapted to register with a turbine outlet, whilst their outboard ends abut one of the intercostals 37 and are closed thereby. The casing 42 fairs into the spaced upper and lower walls 44 and 45 of the exhaustor duct 41, and a diametrically extending slot 46 is provided in the core 43 to give continuity to the exhaustor duct. The upper skin 33 and the lower skin 34 at their outboard edges meet with the upper and lower walls 44 and 45 of the exhaustor duct to provide an exhaust outlet 47. The exhaustor ducts of the sectors are in end-to-end registration, and together they constitute an annular duct which can be said to encompass the engine outlets.

Spaced from the perimeter of the exhaust outlet 47 and defining the perimeter of the aircraft is a ring 48 which is triangular in cross-section, its inboard face being opposed to and spaced from the exhaust outlet 47 and the other two faces converging towards each other and providing continuations of the skins 33 and 34. The gaps between the outboard edges of the skins 33 and 34 and the inboard edges of the converging faces of the ring can be considered to be annular slots in the aerofoil surfaces, and these annular slots together with the exhaust outlet 47 and the space between the inboard face of the ring 48 and the perimeter of the said exhaust outlet provide an upper annular exhaust nozzle 49 and a lower annular exhaust nozzle 50. The ring is secured to the ribs through inboardly diverging arms 51 which are attached to the ends of the ribs by pins 52.

Movable shutters 53 and 54, each consisting of eight sections, are provided for the nozzles 49 and 50. The shutters are slidably mounted on recessed portions of the exhaustor duct walls 44 and 45, being held thereagainst by headed bolts 55 and 56 which pass through slots 57 and 58 in the shutters. To reduce friction between the surfaces of the shutters and the walls 44 and 45, annular pressure boxes 59 and 60 are provided in each sector, and these communicate with the last stage of the compressor of the engine attached to the particular sector. Air escapes through holes 61 and 62 provided in the pressure box inner walls and in the walls 44 and 45 into the spaces between the latter walls and the shutters, so that in effect air bearings are provided for the shutters.

The shutters are adapted to slide outboardly to close the nozzles and inboardly to open them. The outboard edges of the shutters may be brought into registration with slots 63 and 64 in the inboard face of the ring 48.

Mounted in an equiangular arrangement on the cylindrical shell 16 are eight similar shutter motor units generally indicated at 65. Each unit comprises a hollow body 66 within which is spigoted an octagonal head 67 which may be firmly attached to the body in the required angular relationship by a screw 66*a*; the head and the body may be assembled in any one of eight different angular relationships. On the upper and on the lower faces of the heads 67 are provided roller bearings 68 which are adapted to slide on retaining ways 69 mounted on the cylindrical shell 16. It will be observed from FIG. 6 that the roller bearings 68 for all eight motor units are so oriented that the motor units can slide only in a fore and aft direction relative to the longitudinal axis of the aircraft; obviously, the ways 69 on which the roller bearings are slidable are oriented similarly. The eight motor units are interlinked by curved tubular sections which together provide a rigid ring 70. Thus, the eight motor units cannot move relative to each other but they are constrained to move in unison, and only in a fore and aft direction.



The fore and aft movement of the eight motor units 65 rigidly connected together by the ring 70 is effected by a jack 71 the casing of which is anchored to the wall 16 by a bracket and pin assembly 72 and the piston of which is connected to the body 66 of the front motor unit. Actuation of the jack 71 will cause the ring and the eight motor units to move in a fore and aft direction.

Each motor unit also includes an arm 73 which is secured at its centre by a pivot 74 to an extension of the body 66. Extending downwardly from the head 67 is a bracket 75 which is so oriented relative to the head 67 that a jack 76 pivotally secured to its lower end has its longitudinal axis disposed radially with respect to the ring 70. The piston of the jack 76 is pivotally connected to the arm 73 adjacent its lower end. Operation of the jack 76 will cause swinging movement of the arm 73 about the pivot 74 so that as its lower end moves inboardly its upper end moves outboardly.

Pivotally mounted at the upper and at the lower ends respectively of the arm 73 are bell cranks 77 and 78 connected by links 79 and 80 respectively to the piston of a jack 81. As may be seen particularly from FIG. 8, when the piston of the jack 81 is centrally located the two bell cranks are similarly disposed, whilst if the piston is moved from its central position the free arm of one bell crank moves inboardly while the free arm of the other bell crank moves outboardly; thus the bell cranks operate differentially.

The free arm of the upper bell crank 77 of each motor unit 65 is connected through a control rod 82 and links 83 to the mutually adjacent ends of the shutter segments of the upper shutter 53 which are located radially opposite the particular motor unit. Similarly, the free arm of the lower bell crank 78 of each motor unit is connected through a control rod 84 and links 85 to the mutually adjacent ends of the shutter segments of the lower shutter 54 which are located radially opposite the particular motor unit. The control rods 82 and 84 respectively pass through tubes 86 and 87 which span from the outboard wall 12 of the fuel tank 13 to its inboard wall 14. Suitable seals 88 and 89 are provided where the control rods pass through the cylindrical shell 16.

Inboard and outboard movement of the shutters 53 and 54 may thus be effected by three agencies. Firstly, an upward movement of the piston of any jack 81 relative to its central position will cause an outboard movement of the upper shutter portion and an inboard movement of the lower shutter portion radially opposite the particular jack. A downward movement of the piston of any jack 81 obviously operates the shutters in a manner converse to that described. As will be described subsequently, the eight jacks 81 are controlled in such a manner that diametrically opposite jacks invariably operate inversely to each other. Secondly, inboard movements of the pistons of the jacks 76 will swing the upper ends of the arms 73 outboardly and their lower ends inboardly, thus causing outboard movement of the upper shutter 53 and inboard movement of the lower shutter 54. As will be explained subsequently, all of the eight jacks 76 operate in unison so that the entire upper shutter and the entire lower shutter respectively move outboardly and inboardly (or vice versa) as a result of the operation of the jacks 76. Finally, actuation of the jack 71 will cause the eight motor units 65 to move in a fore and aft direction, thus moving the upper and lower shutters forwardly or rearwardly.

A control column 90 is pivoted on a universal joint 91 in the floor of the pilot's compartment 17 and it terminates at its lower end in a ball and socket joint 92. Rod and link mechanisms 93 radiate from the joint 92, and they are operably connected to the pistons of equiangularly spaced hydraulic pumps 94. Each pump 94 is connected at opposite ends through tubes 95 and 96 to the opposite ends of the jack 81 of the radially opposite motor unit 65.

It will be apparent, particularly from an examination of FIG. 6, that movement of the control column 90 in any direction will cause a downward movement of the piston of the jack 81 which is located in the direction and sense of the particular movement of the control column, and will cause an upward movement of the piston of the jack 81 of the motor unit which is located in the direction of but in the opposite sense to the movement of the control column. The jacks 81 of motor units which are located in positions intermediate the direction of a particular movement of the control column will respond only to the vectorial component of motion with which they are directly in line. Movement of the control column 90 in any direction relative to its central or neutral position therefore causes a differential movement of the upper shutter 53 and of the lower shutter 54. As an example, if the control column is moved towards port, the port portion of the upper shutter and the starboard portion of the lower shutter will move inboardly to increase the effective openings in the port portion of the upper nozzle 49 and in the starboard portion of the lower nozzle 50, and the port portion of the lower shutter and the starboard portion of the upper shutter will move outboardly to decrease the effective openings in the port portion of the lower nozzle 50 and in the starboard portion of the upper nozzle 49.

In the pilot's compartment also is located a two-position pump 97, the piston of which may be moved from one position to the other by a selector handle 98. The pump 97 is connected at opposite ends by means of distributor lines 99 and 100 to the opposite ends of the jacks 76 of each of the motor units 65 and to the opposite ends of the jack 71. In FIGS. 6 and 7 the selector handle 98 is shown in "flight position." In that position, the eight motor units 65 and their ring 70 have been caused to move forwardly in unison, thus closing the forward portions of both the nozzles 49 and 50 by means of the shutters 53 and 54 and opening the remaining portions, the nozzle openings progressively increasing from the extreme forward portion to the extreme aft portion. If the selector handle is moved to the alternative or "take-off position," the jack 71 will cause the eight motor units 65 and the ring 70 to move rearwardly in unison, and simultaneously the jacks 76 of the eight motor units will swing the upper ends of the arms 73 outboardly and their lower ends inboardly, thus moving the upper shutter 53 outboardly to close the upper nozzle and moving the lower shutter 54 inboardly to open the lower nozzle.

The positions of the shutters when the selector handle 98 is at take-off position are shown in FIGS. 9 and 10. It will be noted that in that position the upper nozzle 49 is fully closed while the lower nozzle 50 is fully open. The positions of the shutters when the selector handle is at flight position are shown in FIGS. 11 and 12. The forward portions of both the upper and lower nozzles are then fully closed, the aft portions are fully open, and the port and starboard portions are partially open; more specifically, the shutters are so positioned that the effective openings in the nozzles progressively increase from the extreme forward portions to the extreme aft portions.

Referring particularly to FIGS. 1 and 4, louvres 101 are provided on the port and starboard portions of the ring 48; air from the exhaust outlet 47 may be supplied to the louvres through rudder ports 102 which are located



in the inboard face of the ring. Suitable shutters 103 to open and close these ports are hydraulically actuated by jacks 104 controlled by a pump 105 which is operated by a pair of differentially connected rudder pedals 106 in the pilot's compartment.

Directional control of the aircraft is effected by selective opening and closing of the rudder ports 102 through the operation of the rudder pedals. The additional thrust component caused by the exhaust gases ejected selectively through the port or starboard louvres 101 is sufficient to cause an unbalance of the forces about the directional axis of the aircraft to provide directional control.

On take-off the pilot closes the air inlets 23 and 24 by means of the sliding shutters 25 and 26 to prevent the entrance into the lower inlet of the hot products of combustion ejected from the lower nozzle 50. This causes the spring loaded doors 22 to open automatically by reason of the fact that the pressure differential between the plenum chamber and the atmosphere overcomes the spring forces. In forward flight the pilot opens the sliding shutters so that the air then enters the inlets 23 and 24, and the spring loaded doors 22 close automatically.

The engines 27 of the aircraft in which the invention is embodied are of the well known axial flow type. The air after entering the plenum chamber through the open inlet or inlets is drawn into the intakes of each of the engines to be compressed in an axial flow compressor, then is passed through a combustion system to which fuel is added, and is allowed to expand through a turbine which drives the compressor. The products of combustion are exhausted through the exhaust nozzle assembly 40 and the exhaustor duct 41, and finally to atmosphere through one or both of the nozzles 49 and 50.

To take off, the pilot after closing the air inlets 23 and 24 sets the selector handle 98 at take-off position thus closing the upper nozzle 49 and opening the lower nozzle 50. The gases consequently are ejected downwardly from the lower nozzle 50, and because of the "ground cushion" effect the aircraft, which may have a weight greater than the combined static thrust of all the engines, rises vertically above the ground.

In order to transfer to forward flight, the pilot slowly moves the selector handle 98 to flight position, thus closing the forward portions of both the upper and lower nozzles 49 and 50 and opening the remaining portions. This movement of the selector handle into flight position is done slowly so that the vertical lift from the downwardly directed gases is only gradually destroyed as the aircraft picks up speed and acquires lift resulting from the aerodynamic forces on the aerofoil surfaces.

As soon as the aircraft has risen from the ground and is in forward flight the air inlets 23 and 24 may be opened, causing the spring loaded doors 22 to close automatically; this allows the aircraft to take advantage of ram in the intake.

Both while taking off and in forward flight, the pilot can effect longitudinal and lateral control of the aircraft by appropriate movements of the control column.

By making the nose section of the ring 48 of armour plate, as shown at 107, enemy aircraft can be destroyed without appreciable danger to the aircraft of the invention, by the simple method of ramming. The aircraft of the invention will not sustain any damage because of its high speed (of the order of Mach 2.75 in level flight) and the attendant high energy potential which allows the aircraft to penetrate and pass through a target.

The form of the invention herein shown and described is to be considered merely as an example. The details of the hydraulic control system are essentially schematic and by way of example only, and they are not essential parts of the invention. Obviously many changes in the construction shown not only are possible but may be desirable in order that the aircraft may have optimum performance. Such changes may, of course, be made without departing from the spirit of the invention or the scope of the subjoined claims.

What I claim as my invention is:

1. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, and shutter control means operable to move the shutters selectively and thus control the relative magnitudes of the streams from the nozzles.

2. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, each of the nozzles extending around the periphery of the structure, individual shutters for the nozzles and separately movable to vary the nozzle openings, and shutter control means operable to move the shutters selectively and thus control the relative magnitudes of the streams from the nozzles.

3. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, and a control for the shutters to operate the shutters in unison and conditionable to a first condition to substantially close the upper nozzle and open the lower nozzle and to a second condition to open both nozzles.

4. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, and a control for the shutters to operate the shutters in unison and conditionable to a first condition to substantially close the upper nozzle and open the lower nozzle and to a second condition to partly open both nozzles.

5. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, and a control for the shutters to operate the shutters in unison and conditionable to a first condition to substantially close the upper nozzle and open the lower nozzle and to a second condition to close the forward portions of both nozzles and open the remaining portions.

6. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, and a control for the shutters to operate the shutters in unison and conditionable to a first condition to substantially close the upper nozzle and open the lower nozzle and to a second condition to open both shutters to an extent which provides substantially zero nozzle openings at the extreme forward portions of the nozzles and maximum nozzle openings at the extreme aft portions of the nozzles, the nozzle openings progressively increasing from the said extreme forward portions to the said extreme aft portions.



7. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet, an annularly arranged slot in each of the aerofoil surfaces adjacent its perimeter, exhaust passages connecting each of the slots with the outlet of the engine means, the slots and passages thus providing annularly arranged nozzles through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, and shutter control means operable to move the shutters selectively and thus control the relative magnitudes of the streams from the nozzles.

8. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, and a differential control for the shutters to move corresponding portions of the two shutters differentially thus decreasing the opening of a portion of one nozzle as the opening of the corresponding portion of the other nozzle is increased.

9. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper nozzle and a lower nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for the nozzles and separately movable to vary the nozzle openings, a control for the shutters to operate the shutters in unison and conditionable to a first condition to substantially close the upper nozzle and open the lower nozzle and to a second condition to close the forward portions of both nozzles and open the remaining portions, and a differential control for the shutters superimposed on the first-mentioned control to move corresponding portions of the two nozzles differentially thus decreasing the opening of a portion of one nozzle as the opening of the corresponding portion of the other nozzle is increased.

10. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet, an annular duct provided by

generally parallel upper and lower walls encompassing the outlet of the engine means, a ring spaced from the perimeter of the duct and defining the perimeter of the aircraft, an annularly disposed slot in each of the aerofoil surfaces and in registration with the space between the ring and the perimeter of the duct, the slots, the duct and the space between the ring and the perimeter of the duct providing annular nozzles through which the air from the engine means may be ejected in two streams having opposite components of thrust, a group of annularly arranged shutter plates mounted adjacent each of the duct walls for sliding movement towards and away from the ring to close and open the nozzles to varying extents, and shutter control means operable to move the shutter plates selectively and thus control the relative magnitudes of the streams from the two nozzles.

11. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper annularly arranged nozzle and a lower annularly arranged nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for each nozzle, each shutter including a plurality of annularly arranged shutter segments slidable outboardly and inboardly to close and open the nozzles, the shutter segments for opposed portions of the upper and lower nozzles providing pairs of shutter segments, motor units connected to pairs of segments and linked thereto to move the shutters into nozzle-closing and nozzle-opening positions, the motor units including elements which when actuated move in one sense the upper segments of the pairs to which the respective units are connected and move in the opposite sense the lower segments of the said pairs, the said elements thus opening and closing the opposed portions of the nozzles differentially, and pilot-operated means to selectively actuate the motor unit elements.

12. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper annularly arranged nozzle and a lower annularly arranged nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for each nozzle, each shutter including a plurality of annularly arranged shutter segments slidable outboardly and inboardly to close and open the nozzles, the shutter segments for opposed portions of the upper and lower nozzles providing pairs of shutter segments, motor units connected to pairs of segments and linked thereto to move the shutters into nozzle-closing and nozzle-opening positions, the motor units including elements which when actuated move in one sense the upper segments of the pairs to which the respective units are connected and move in the opposite sense the lower segments of the said pairs, the said elements thus opening and closing the opposed portions of the nozzles differentially, pilot-operated means to selectively actuate the motor unit elements, and means of the pilot-operated means operatively linking the elements of motor units connected to the shutter segments of diametrically opposite upper and lower nozzle portions to move in unison in substantially the same direction and sense the shutter segments of diametrically opposite upper nozzle portions and to move in unison in substantially the same said direction but in a sense opposite to the said sense the shutter segments of diametrically opposite lower nozzle portions.

13. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provides lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper annularly arranged nozzle and a lower annularly arranged nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for each nozzle, each shutter including a plurality of annularly arranged shutter segments slidable outboardly and inboardly to close and open the nozzles, the shutter segments for opposed portions of the upper and lower nozzles providing pairs of shutter segments, motor units connected to pairs of segments and linked thereto to move the shutters into nozzle-closing and nozzle-opening positions, the motor units including elements conditionable to a first condition to position the upper shutters in upper nozzle closing position and to position the lower shutters in lower nozzle opening position and conditionable to a second condition to position the upper and the lower shutters in substantially equal partial nozzle closing positions, means interconnecting the motor units including means to shift the units in unison in a fore and aft direction and thus move the shutters connected thereto in a fore and aft direction, the said shifting means being conditionable to a first condition where the units position the shutters concentrically relative to the angularly arranged nozzles and to a second condition where the units position the shutters in a position eccentric of the said concentric position and forward thereof, and pilot-operated means to condition the elements and the motor unit shifting means at their first condition and thus close the upper nozzle and open the lower nozzle and to alternatively condition the elements and the motor unit shifting means at their second condition to close the forward portions of both nozzles and open the remaining portions.

14. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the outlet including an upper annularly arranged nozzle and a lower annularly arranged nozzle through which the air from the engine means may be ejected in two streams having opposite components of thrust, individual shutters for each nozzle, each shutter including a plurality of annularly arranged shutter segments slidable outboardly and inboardly to close and open the nozzles, the shutter segments for opposed portions of the upper and lower nozzles providing pairs of shutter segments, motor units connected to pairs of segments and linked thereto to move the shutters into nozzle-closing and nozzle-opening positions, the motor units including first elements which when actuated move in one sense the upper segments of the pairs to which the respective units are connected and move in the opposite sense the lower segments of the said pairs, the said first elements thus opening and closing the opposed portions of the nozzles differentially, a first pilot-operated means to selectively actuate the motor unit first elements, means of the first pilot-operated means operatively linking the first elements of motor units connected to the shutter segments of diametrically opposite upper and lower nozzle portions to move in unison in substantially the same direction and sense the shutter segments of diametrically opposite upper nozzle portions and to move in unison in substantially the same said direction but in a sense opposite to the said sense the shutter segments of diametrically opposite lower nozzle portions, the motor units also including second elements conditionable to a first condition to position the upper shutters in upper nozzle closing position and to position the lower shutters in lower nozzle opening position and conditionable to a second condition to position the upper and lower shutters in substantially equal partial nozzle closing positions, means interconnecting the motor

units including means to shift the units in unison in a fore and aft direction and thus move the shutters connected thereto in a fore and aft direction, the said shifting means being conditionable to a first condition where the units position the shutters concentrically relative to the annularly arranged nozzles and to a second condition where the units position the shutters in a position eccentric of the said concentric position and forward thereof, and a second pilot-operated means to condition the second elements and the motor unit shifting means at their first condition and thus close the upper nozzle and open the lower nozzle and to alternatively condition the second elements and the motor unit shifting means at their second condition to close the forward portions of both nozzles and open the remaining portions.

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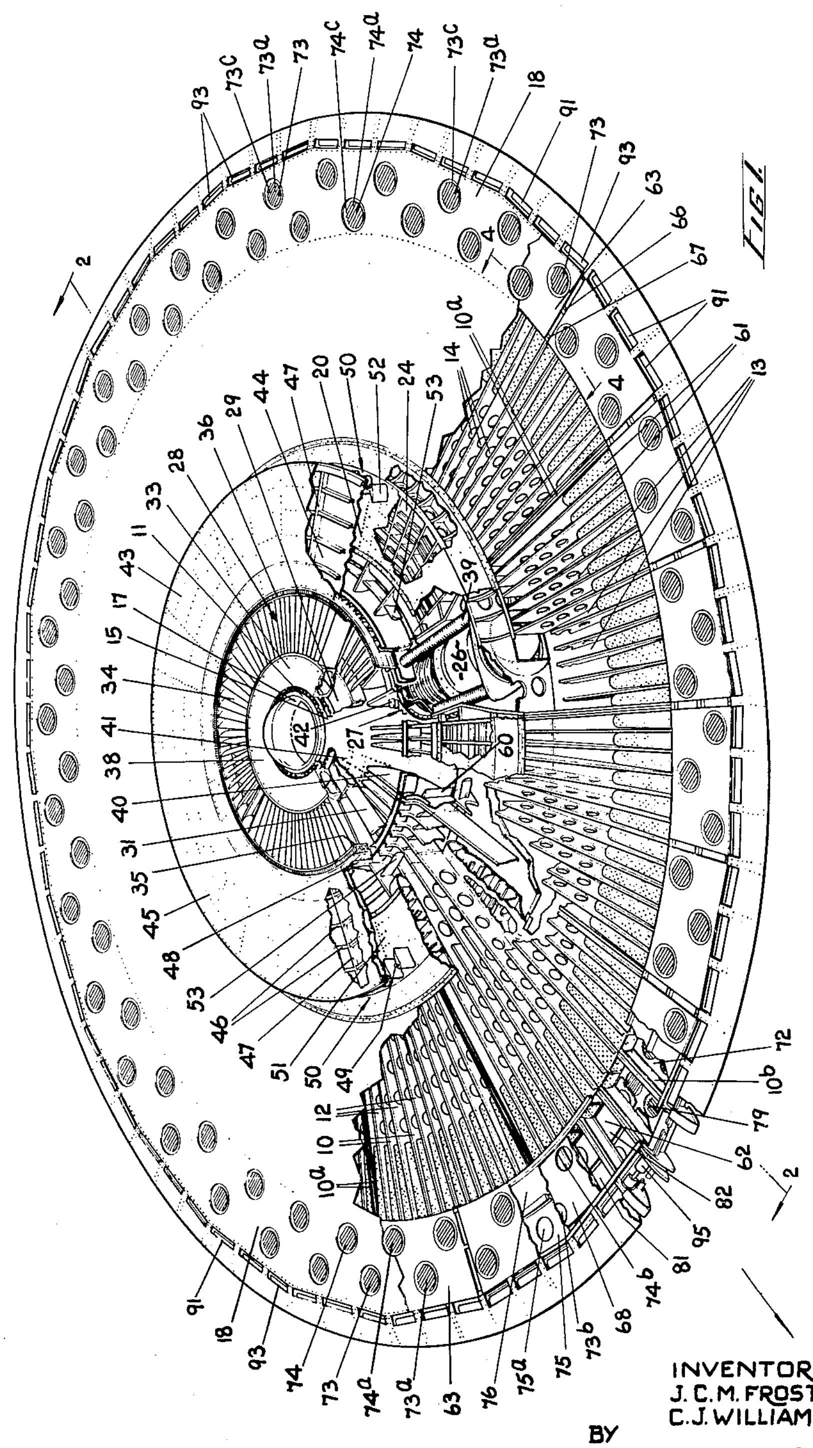
Feb. 6, 1962 J. C. M. FROST ET AL 3,020,003

DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

Filed July 2, 1956 11 Sheets-Sheet 1

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DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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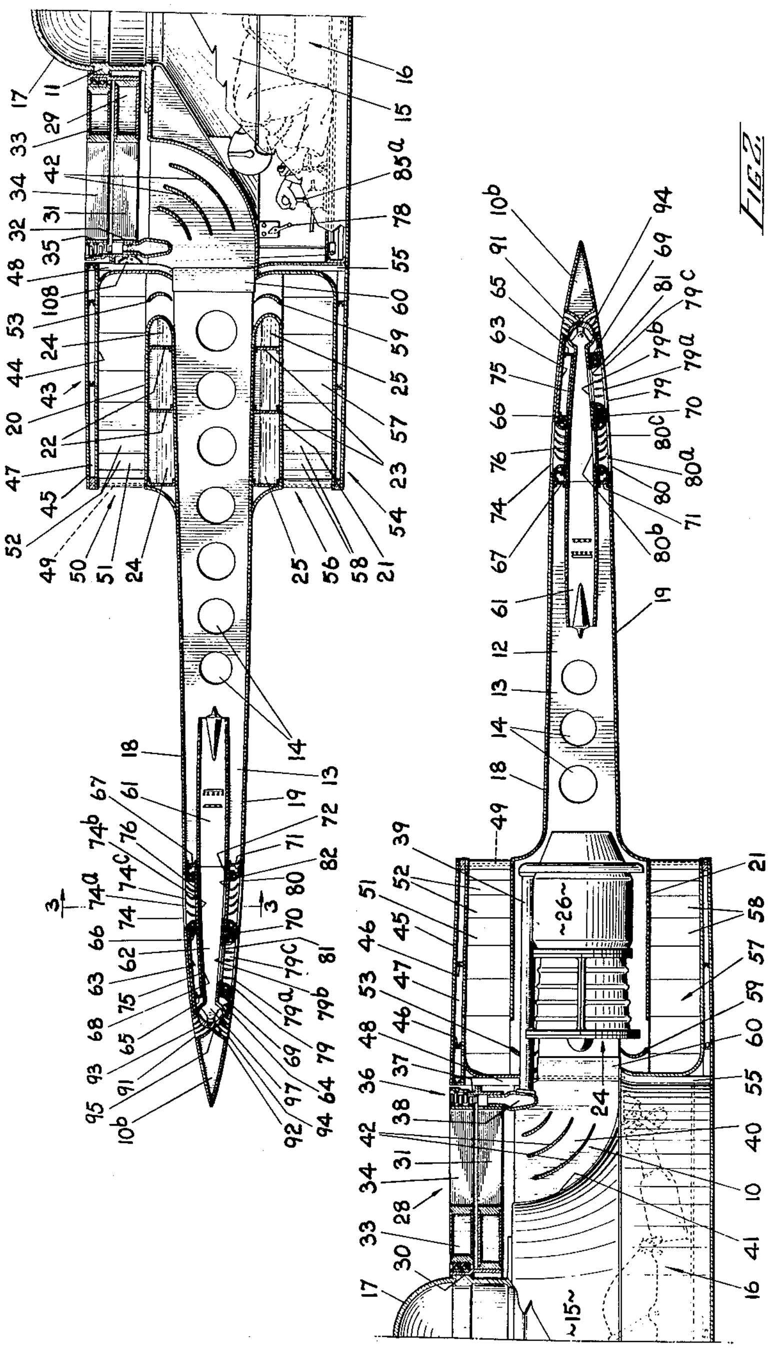

FIG. 2.

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DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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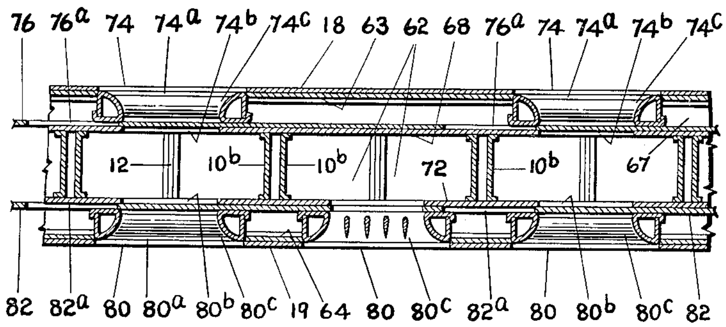


FIG 3.

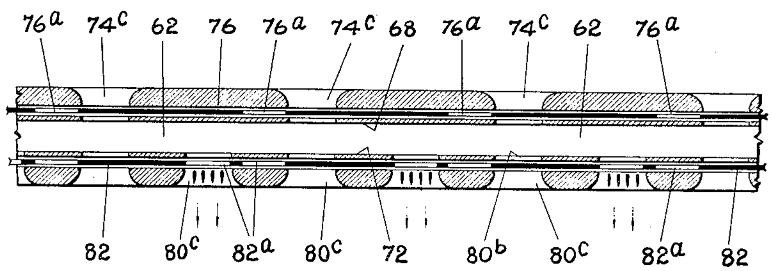


FIG 3A.

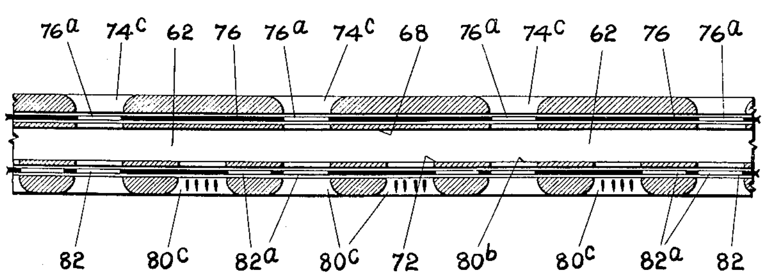


FIG 3B.

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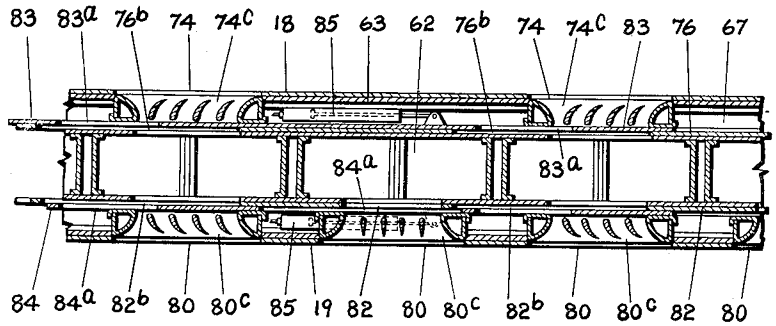


FIG 4.

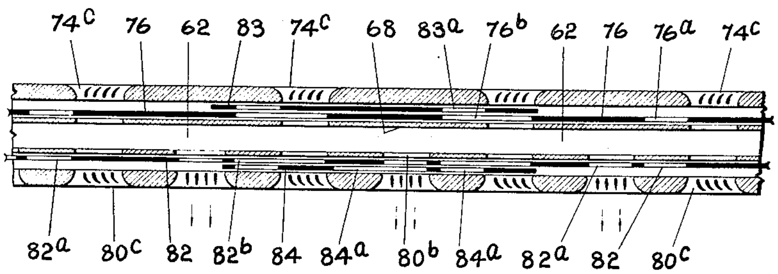


FIG 4A.

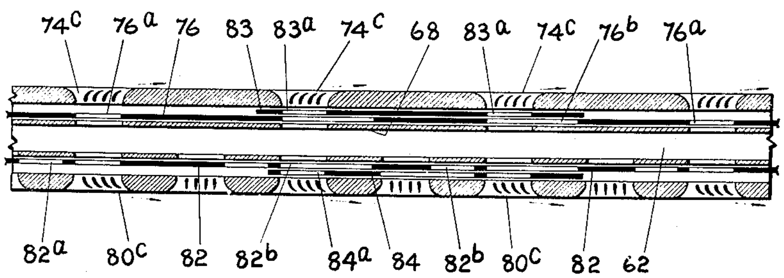


FIG 4B.

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Feb. 6, 1962 J. C. M. FROST ET AL 3,020,003

DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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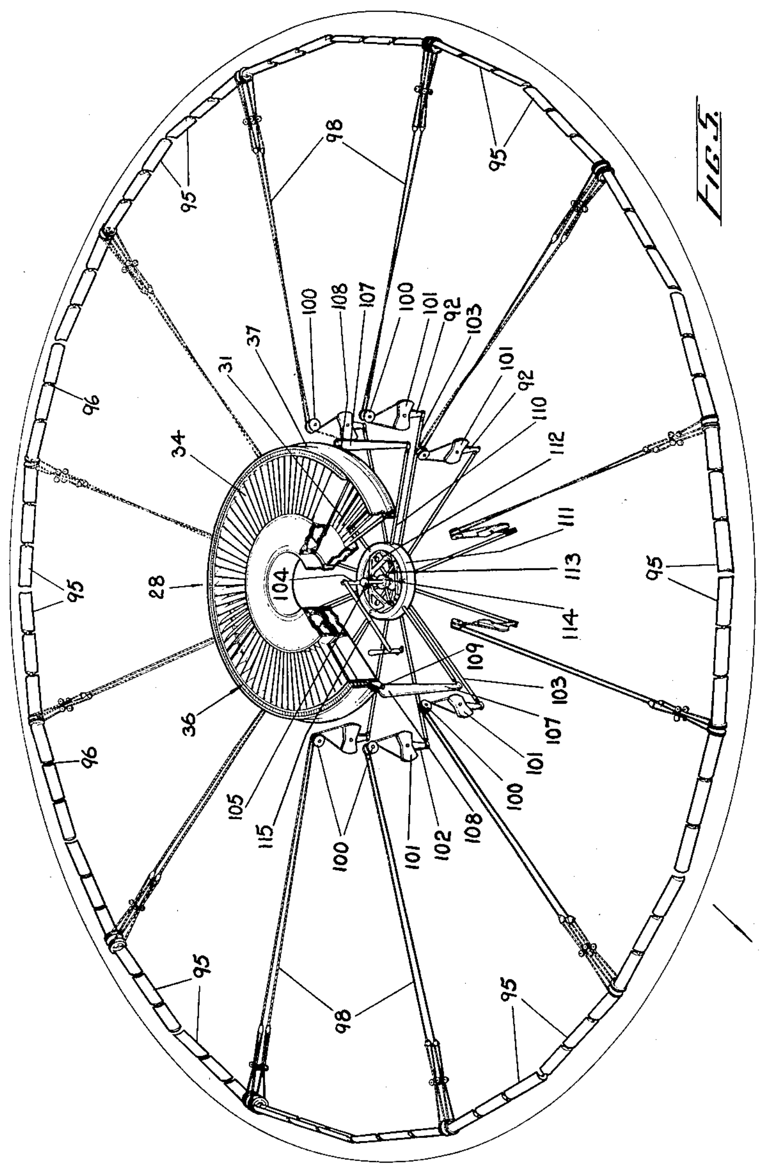

FIG. 5

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DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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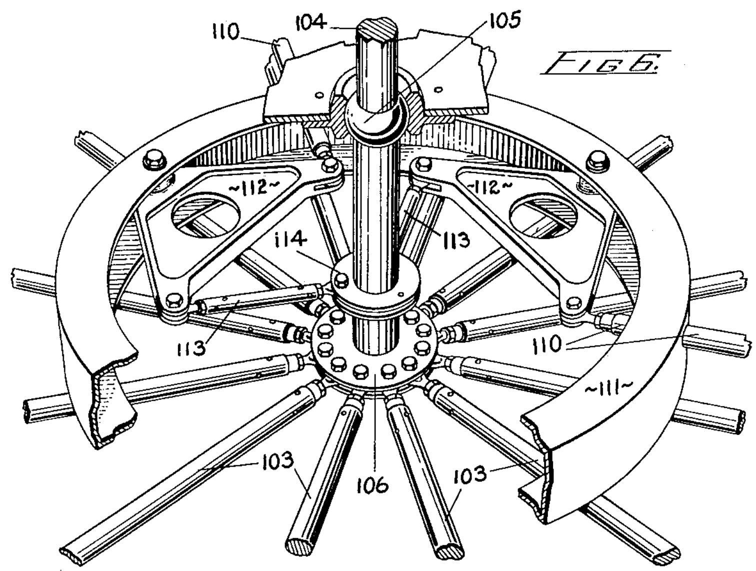


FIG. 6.

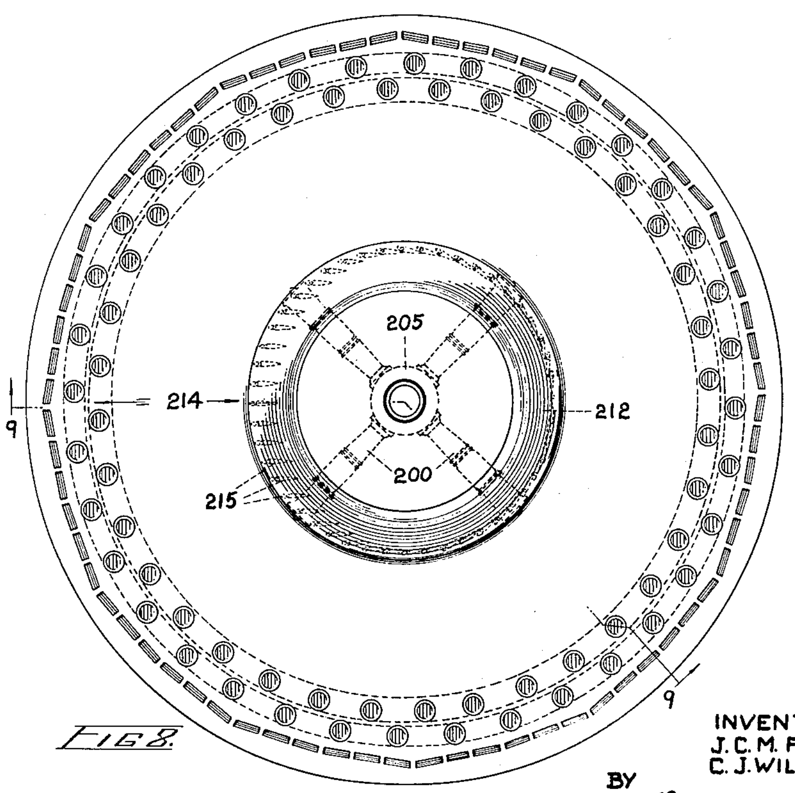


FIG. 8.

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DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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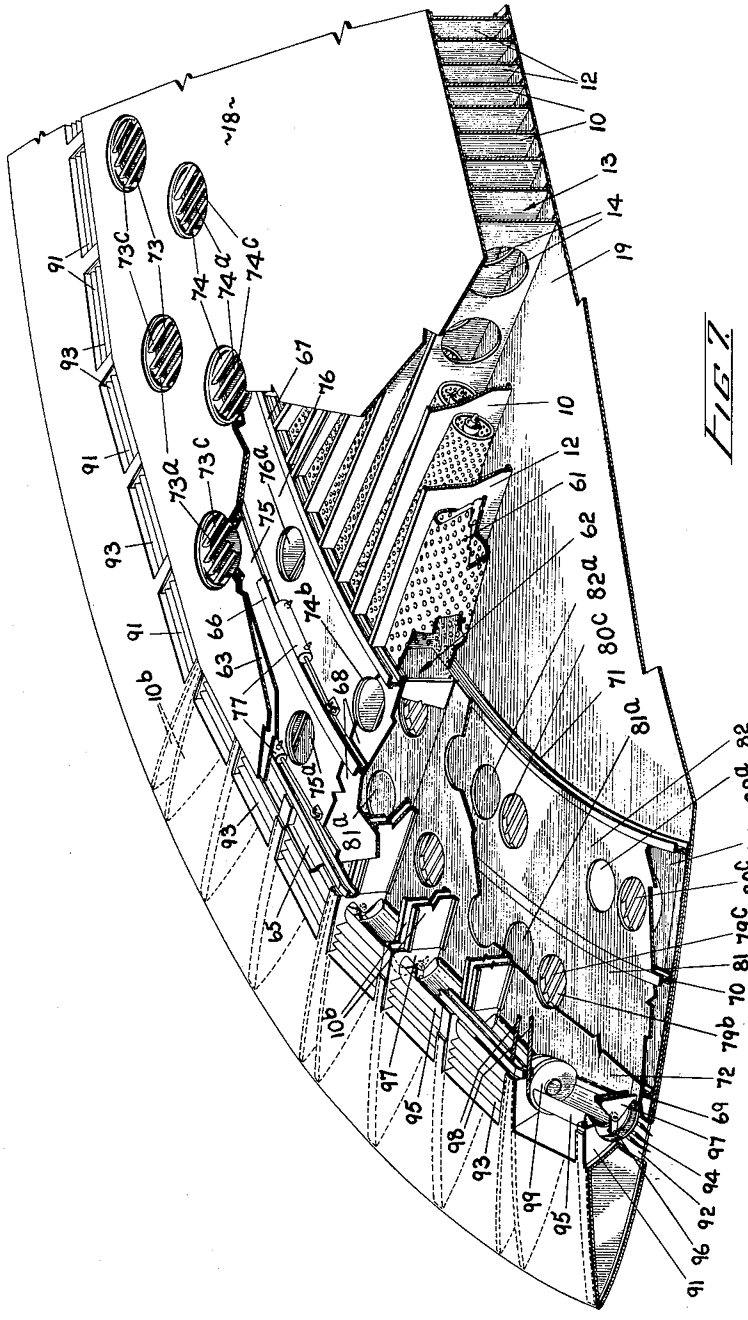


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Filed July 2, 1956



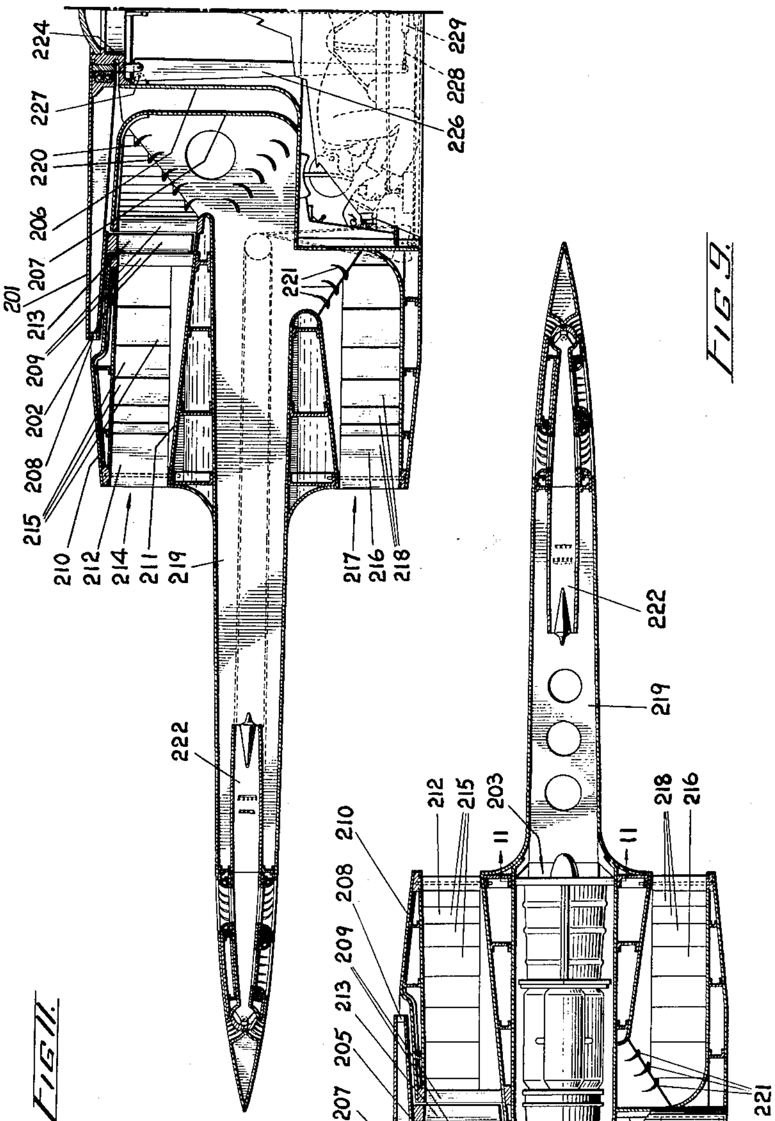
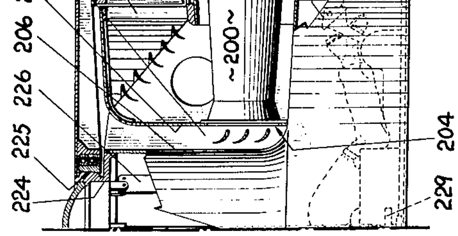

FIG. 9.

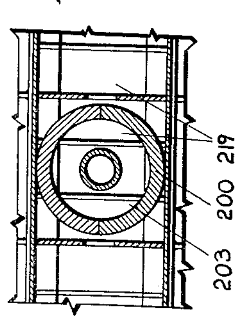

FIG. 11.

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DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES



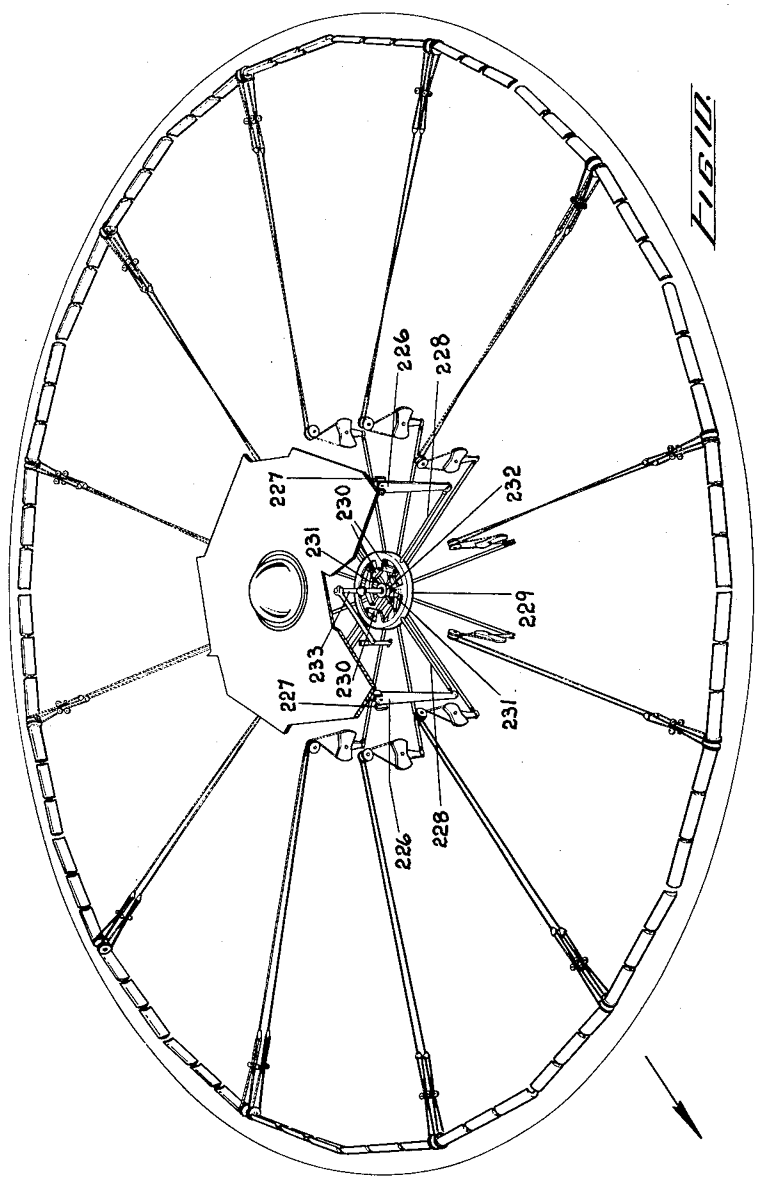


FIG.10.

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DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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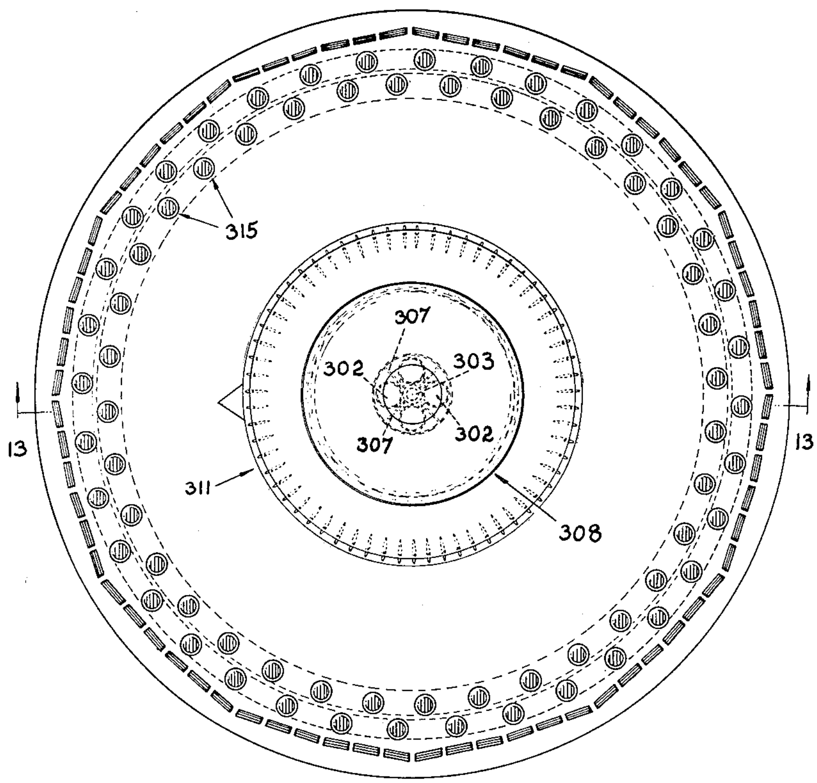


FIG. 12.

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DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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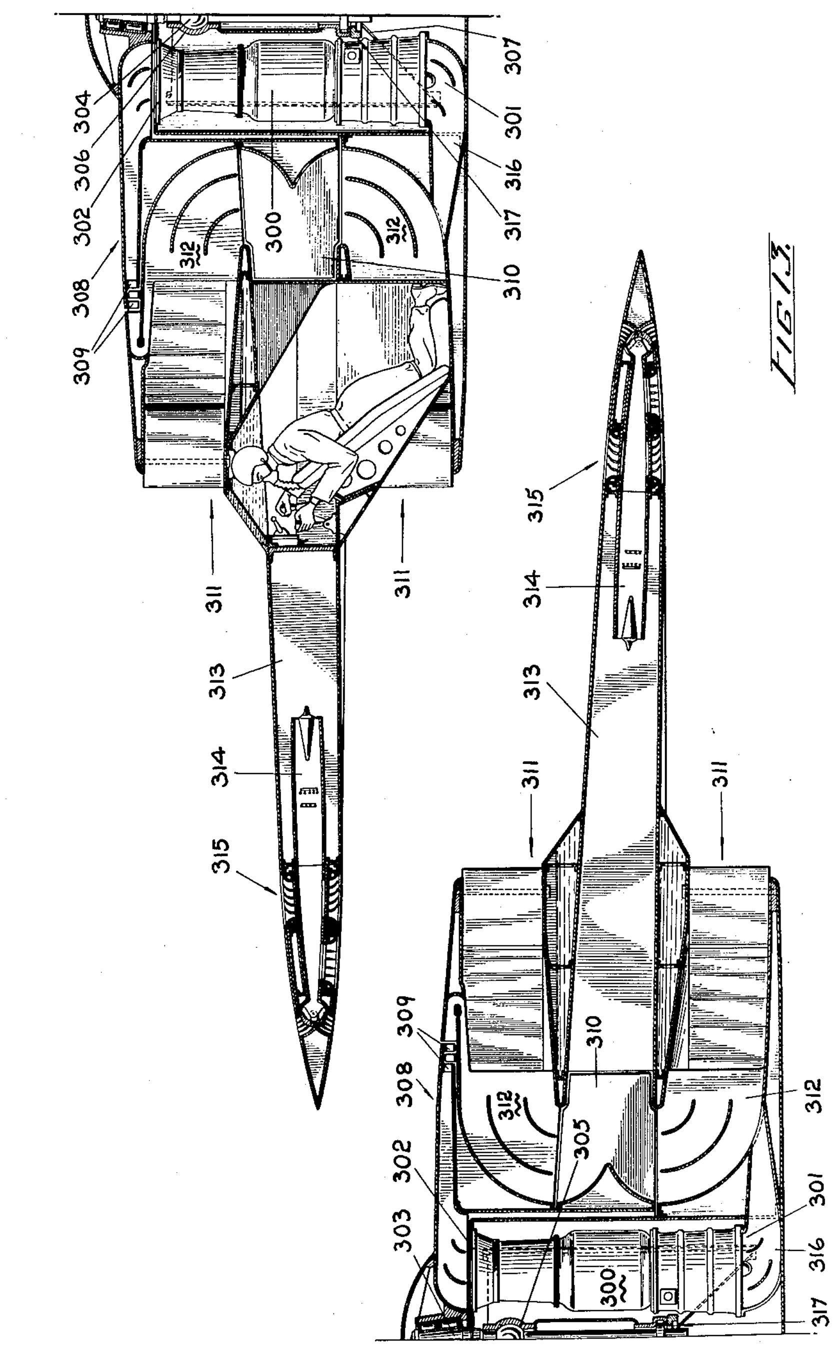


FIG. 13

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## DISC AIRCRAFT WITH GAS TURBINE AND RAM JET ENGINES

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This invention relates to aircraft and more particularly to disc-type or circular aircraft deriving a propulsive thrust from a stream of high speed gases flowing within the aircraft in generally radial directions and discharged from the periphery thereof.

Co-pending patent application Serial No. 507,100, dated May 9, 1955, and filed by John Carver Meadows Frost and Thomas Desmond Earl, discloses a circular aircraft having multiple radially disposed gas turbine engines. Opposed aerofoil surfaces, which cover the engines, converge towards each other in an outboard direction from their central inboard portions to their perimetrical edges to provide a structure which can be described as being generally lentiform. Air enters inlets provided in the aerofoil surfaces, then, after passing through a central circular plenum chamber, flows radially outboardly through a plurality of radially disposed axial flow gas turbine engines. The engines are so arranged that their axes of rotation are equi-angularly spaced from each other; the products of combustion are discharged into an annularly arranged exhaust passage from which they are discharged to atmosphere through a bifurcated nozzle. By suitable control means which actuate shutters, the gases can be caused to flow so that the aircraft will take off vertically and also will fly under complete control in horizontal flight.

Present day axial flow gas turbine engines have been developed to a high degree of thermal efficiency. However, it can be shown that, under certain conditions, the efficiency of the ram-jet engine surpasses that of the gas turbine engine. The high efficiency of the ram-jet engine is attainable only after the intake velocity exceeds a minimum critical velocity; consequently the ram-jet engine heretofore has been very inefficient at low aircraft speed. Ram-jet engines therefore have been used in aircraft installations only in combination with gas turbine engines or rocket engines whereby the aircraft can first reach a first predetermined minimum speed, or as a means of propulsion for rotating the blades of helicopters where, by disposing the engines at the blade tips, fairly high intake velocity may be attained even while the aircraft remains stationary.

It is the main object of the invention, therefore, to provide an aircraft which can effectively utilize the ram-jet engine even at low or varying forward speeds.

It is another object of the invention to provide a disc-type aircraft with a much more efficient arrangement than has been visualized previously.

It is a further object of the invention to provide a disc-type aircraft having greatly reduced structure and engine weights.

The foregoing and other objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, in which like reference characters indicate corresponding parts throughout the several views, and in which:

FIG. 1 is a broken away perspective view of a first embodiment of an aircraft constructed in accordance with the invention;

FIG. 2 is a diametrical cross-sectional view of the aircraft of FIG. 1, taken along the line 2—2 of FIG. 1;



FIG. 3 is a fragmentary cross-sectional view taken along the line 3—3 of FIG. 2 and showing particularly the construction of typical thrust outlets;

FIG. 3*a* is a diagrammatic view of a typical group of upper and lower thrust outlets showing the position of the shutters in "vertical take-off" condition;

FIG. 3*b* is a diagrammatic view similar to FIG. 3*a* and showing the position of the same shutters in "forward flight" condition;

FIG. 4 is a fragmentary cross-sectional view taken along the line 4—4 of FIG. 1, and showing particularly the port "directional control" outlets;

FIG. 4*a* is a diagrammatic view of the port directional control outlets showing their shutters in closed position, the thrust outlet shutters being shown in vertical take-off condition;

FIG. 4*b* is a diagrammatic view similar to FIG. 4*a* showing the directional control shutters in open position, the thrust outlet shutters being shown in forward flight condition;

FIG. 5 is a perspective view of the aircraft stabilizing and trim control system, which for greater clarity is shown removed from the aircraft and in a fictitious unsupported condition;

FIG. 6 is a broken away fragmentary perspective view to an enlarged scale of the central portion of the stabilizing and trim control system;

FIG. 7 is a broken away fragmentary perspective view of a typical outboard segment of the aircraft;

FIG. 8 is a plan view of a second embodiment of an aircraft constructed in accordance with the invention;

FIG. 9 is a cross-sectional view of the aircraft of FIG. 8, taken along the line 9—9 of FIG. 8;

FIG. 10 is a perspective view of the stabilizing and trim control system of the aircraft of FIGS. 8 and 9, which for greater clarity is shown removed from the aircraft and in a fictitious unsupported condition;

FIG. 11 is a fragmentary cross-sectional view taken along the line 11—11 of FIG. 9;

FIG. 12 is a plan view of a third embodiment of an aircraft constructed in accordance with the invention; and

FIG. 13 is a cross-sectional view of the aircraft of FIG. 12, taken along the line 13—13 of FIG. 12.

Referring to FIGS. 1–7, an aircraft constructed in accordance with the invention includes a large number (seventy-two, to be exact) of radially arranged main ribs **10** secured at their inboard ends to a flanged central ring **11**. Each twelfth main rib **10** is a dual rib as indicated at **10***a*, and the outboard segments **10***b* of the main ribs **10** are constituted by two flanged plates disposed back-to-back. Interposed between adjacent main ribs **10** are short ribs **12**, the outboard ends of which terminate on the same circle as the inboard ends of the rib segments **10***b*. The spaces between adjacent ribs provide ducts **13** which are interconnected by series of holes **14**.

The inboard ends of the main ribs **10** abut a truncated conical housing **15** which together with the space defined by the ring **11** provides part of a pilot's compartment generally indicated at **16**. The pilot's compartment is covered by a hemispherical sealable closure **17**, and in the compartment are located instruments and flying controls.

The outer edges of the ribs are sheathed by upper and lower skins or aerofoils **18** and **19**; the inboard portions of these aerofoils together with plates **20** and **21** and circumferentially arranged spacers **22** and **23** provide substantially annular fuel compartments **24** and **25**. The annular continuity of the fuel compartments is broken only by the spaces required to accommodate three equi-angularly spaced radially disposed axial flow gas turbine engines **26** having inboardly facing inlets **27**. Of necessity, the gas turbine engines take parts of the spaces which otherwise would be occupied by some of the ribs 10.

Suitably mounted on the ring 11 for limited universal movement is an axial flow air compressor generally indicated at 28. The compressor includes an annular stator housing 29 on the inboard periphery of which is provided a segmental spherical bearing 30 which is in engagement with a complementary bearing surface of the ring 11; the centre of these registering bearings approximately coincides with the centre of the aircraft, and thus the housing 29 and the parts that are supported thereby can pivot to a limited extent about the said centre, for a purpose which will be described subsequently. Extending outboardly from the housing 29 and secured thereto are the stator blades 31 of the compressor, which are encompassed by a shroud 32. Mounted for rotation relative to the stator housing 29 is a similar rotor housing 33 which supports at its outboard periphery an impeller 34 encompassed by a shroud 35. The compressor 28 is powered by a multistage axial flow turbine generally indicated at 36. The turbine includes a stator ring 37 secured in spaced relationship to the shroud 32 and extending around the impeller shroud 35 in spaced relationship thereto; the turbine stator blades extend inboardly from the ring 37 whilst the turbine rotor blades extend outboardly from the impeller shroud 35. A circumferential trough-like nozzle 38 which is positioned in recesses provided in the upper edges of the ribs 10 is in registration with the annular space between the shroud 32 and the stator ring 37.

The three axial flow gas turbine engines 26 have outlets which face outboardly to direct a portion of the products of combustion into the ducts 13 provided by the radial ribs. However, an appreciable proportion of the products of combustion of these three engines is bled from their combustion systems and is conveyed by ducts 39 to the nozzle 38. Thus, the turbine 36 is driven by the combustion systems of the gas turbine engines 26 and in turn it drives the impeller 34 of the compressor 28; in other words, the gas turbine engines provide an engine to drive the compressor. Air supplied by the compressor 28 initially flows inwardly in duct 40 and is deflected by a circumferential curved wall 41 and by cascades of vanes 42 to flow outboardly through the radial ducts 13 defined by the ribs 10 and 12; a fraction of the air enters the inlets 27 of the three gas turbine engines 26 to support combustion of the fuel therein.

A double-walled annular disc generally indicated at 43 is constituted by inner and outer skins 44 and 45 respectively, which are spaced by circumferential ribs 46 and by radial ribs 47. The disc 43 is supported at its inboard periphery by struts 48 which extend outwardly from the ribs 10, and at its outboard periphery by hinge pins 49 which extend outwardly from the plate 20 of the fuel compartment 24. The disc 43 is spaced from the plate 20 to define a circumferential air inlet 50 and to provide a plenum chamber 51. Freely movable vanes 52 are mounted in the air inlet 50 on hinges provided by the pins 49. The vanes are so constructed and arranged that they open automatically whenever the force of the air which strikes them exceeds the local pressure within the plenum chamber 51; if the force applied to a group of vanes is less than the pressure in the plenum chamber 51 the particular vanes will close thus blocking that portion of the inlet 50. A fixed circumferential vane 53 deflects inwardly the air entering the inlet 50 and flowing through the plenum chamber 51, the said air then flowing outboardly through the radial ducts 13.

At the lower central portion of the aircraft is a double-walled disc 54 which is similar to the disc 43 except that its central portion is closed. It is supported at its outboard periphery by hinge pins which extend outwardly from the plate 21 of the fuel compartment 25; it also is supported by struts 55 which extend outwardly from the ribs 10. The disc 54 is spaced from the plate 21 to define



a circumferential inlet 56 and a plenum chamber 57. Around the inlet 56 is a series of hinged vanes 58 similar in construction and in operation to the vanes 52, and within the plenum chamber 57 is a fixed circumferential vane 59 which deflects inwardly the air entering the inlet 56 and flowing through the plenum chamber 57, the said air then flowing outboardly through the radial ducts 13.

In order to prevent air which enters the inlets 50 and 56 from flowing back into the compressor 28, there is provided a series of circumferentially arranged doors 60 which are so constructed that they close if the air pressure in the plenum chambers 51 and 57 exceeds the pressure of the air supplied by the compressor, and open automatically if the conditions are reversed. Thus, if the compressor 28 is in operation and the aircraft is not moving forward so that no air is being rammed into the inlets 50 and 56, the doors 60 will remain open. On the other hand, if the aircraft is flying at a forward velocity such that the pressure caused by the air being rammed into the inlets 50 and 56 exceeds the pressure of the air compressed by the compressor 28, the doors 60 automatically will close.

Within each duct 13 and adjacent its outboard end is a flame tube 61 which discharges its products of combustion to atmosphere through an annular outlet constituted by a series of shuttered nozzles. Each duct 13 and the flame tube 61 within the duct constitutes a ram jet engine.

The outboard ends of the short ribs 12 are flush with the outlet ends of the flame tubes 61, so that the efflux from pairs of adjacent flame tubes is combined in chambers 62 defined by the outboard segments 10*b* of adjacent pairs of main ribs 10. To the inner surface of the portion of the upper skin 18 which sheaths the rib segments 10*b* is secured an upper sub-skin 63, and similarly to the inner surface of the portion of the lower skin 19 which sheaths the rib segments 10*b* is secured a lower sub-skin 64. Spaced from the sub-skin 63 by channels 65, 66 and 67, and interposed between these channels and the upper edges of the rib segments 10*b* is an upper inner skin 68. Similarly, spaced from the lower sub-skin 64 by channels 69, 70 and 71, and interposed between these channels and the lower edges of the rib segments 10*b* is a lower inner skin 72.

In each of the skin 18, the upper sub-skin 63, and the upper skin 68 are provided two series of mutually opposed or registering ports, namely a series of outboard ports 73 and a series of inboard ports 74 in the upper skin 18, a series of outboard ports 73*a* and a series of inboard ports 74*a* in the sub-skin 63, and a series of outboard ports 73*b* and a series of inboard ports 74*b* in the upper inner skin 68. The registering series of outboard ports 73, 73*a* and 73*b* are positioned in a circumferential arrangement, and the registering series of inboard ports 74, 74*a* and 74*b* are positioned in a circumferential arrangement inboard of the outboard series and concentric therewith. The registering ports 73, 73*a* and 73*b* of the outboard series and the registering ports 74, 74*a* and 74*b* of the inboard series are so spaced circumferentially that circumferentially adjacent ports of the outboard series communicate with alternate chambers 62, and circumferentially adjacent ports of the inboard series communicate with intermediate chambers 62. In the ports 73*a* and 74*a* of the sub-skin 63 are positioned nozzles 73*c* and 74*c* respectively, which nozzles are spanned by louvres which are so oriented as to direct the flow of gases in a rearward direction relative to the direction of flight of the aircraft. The nozzles also are in registration with the ports 73 and 74 respectively of the upper skin 18. Thus each chamber 62 is provided with one upper outlet to atmosphere through the registering ports of one series or of the other, together with the nozzles 73*c* and 74*c*.

Interposed between the sub-skin 63 and the inner skin 68 and guided respectively by channels 65 and 66 and by channels 66 and 67 is an outboard series of upper shutters 75 and an inboard series of upper shutters 76. The shutters are annular sectors, and the shutters of each series are assembled in end-to-end relationship to provide two annular series of shutters. The two annular series of shutters slide in unison on circular paths under the control of suitable hydraulic jacks 77 actuated by a selector control 78 in the pilot's compartment. The outboard shutters 75 are provided with holes 75*a* which, when the shutters are in a "first condition" (i.e., open) register with the ports 73, 73*a* and 73*b* to allow the gases from the flame tubes 61 to be ejected through the nozzles 73*c*. Similarly, the shutters 76 are provided with holes 76*a* which, when the shutters are in a "first condition" (i.e., open) register with the ports 74, 74*a* and 74*b* to allow the gases from the flame tubes 61 to be ejected through the nozzles 74*c*. When the shutters 75 and 76 are in a "second condition" (i.e., closed) their holes are out of registration with the ports, and the gases thus are prevented from being ejected therethrough.

In each of the skin 19, the lower sub-skin 64, and the lower inner skin 72 are provided two series of mutually opposed or registering ports (see FIG. 7), namely a series of outboard ports 79 and a series of inboard ports 80 in the skin 19, a series of outboard ports 79*a* and a series of inboard ports 80*a* in the sub-skin 64, and a series of outboard ports 79*b* and a series of inboard ports 80*b* in the lower inner skin 72. The registering series of outboard ports 79, 79*a* and 79*b* are positioned in the same circumferential arrangement as the registering series of upper outboard ports 73, 73*a* and 73*b*, but there is twice the number of ports 79, 79*a* and 79*b* as there is of ports 73, 73*a* and 73*b*, one-half of the ports 79, 79*a* and 79*b* being directly opposite ports 73, 73*a* and 73*b*, and the other half being intermediate the said ports. Likewise the registering series of inboard ports 80, 80*a* and 80*b* are positioned in the same circumferential arrangement as the registering series of inboard ports 74, 74*a* and 74*b*, but there is twice the number of ports 80, 80*a* and 80*b* as there is of ports 74, 74*a* and 74*b*, one-half of the ports 80, 80*a* and 80*b* being directly opposite ports 74, 74*a* and 74*b*, and the other half being intermediate the said ports. In the ports 79*a* and 80*a* of the sub-skin 64 are positioned nozzles 79*c* and 80*c* respectively, which register with the ports 79 and 80 respectively of the skin 19. Thus each chamber 62 is provided with two possible lower outlets to atmosphere, namely the ports of the outboard series 79, 79*a* and 79*b* and together with their nozzles 79*c* the ports of the inboard series 80, 80*a* and 80*b* together with their nozzles 80*c*. The nozzles which are opposite the upper nozzles 73*c* and 74*c* are spanned by louvres which are so oriented as to direct the flow of gases in a rearward direction relative to the direction of flight of the aircraft, whilst the remaining or intermediate nozzles are spanned by louvres which are so oriented as to direct the flow of gases downwardly.

Interposed between the sub-skin 64 and the lower inner skin 72 is an outboard series of lower shutters 81 and an inboard series of lower shutters 82. In construction and in operation these shutters are generally similar to the previously described upper shutters 75 and 76, but they include twice as many holes as are provided in the upper shutters; they operate in unison with the upper shutters under the control of the pilot's selector control. When the shutters 81 and 82 are in a "first condition," one half of the group of holes 81*a* and 82*a* are in registration with the ports having nozzles 79*c* and 80*c* which direct the flow of gases in a rearward direction (the remaining ports being blocked by solid portions of the shutters), whilst when the shutters are in a "second condition," the other half of the holes are in registration with the ports having nozzles 79*c* and 80*c* which direct the flow of gases downwardly (the remaining ports being blocked by solid portions of the shutters).

FIG. 3*a* is a diagrammatic view of a group of outboard upper and lower thrust outlets showing the position of the shutters in vertical take-off position; only an inboard group of outlets has been illustrated, the outboard outlets being similar. It will be observed that the holes 76*a* of the upper shutters 76 are out of registration with the ports 74 and their nozzles 74*c*, so that the gases are prevented from being ejected therethrough. On the other hand, the holes 82*a* of the lower shutters 82 are in registration with selected ports 80, namely those which have nozzles 80*c* which direct the flow of gases downwardly; the ports 80 having nozzles 80*c* which direct the flow of gases in a rearward direction are blocked by solid portions of the shutters.

FIG. 3*b* is similar to FIG. 3*a*, but it shows the position of the same shutters in "forward flight" position. A comparative study of FIG. 3*a* and 3*b* will show that the shutters have been shifted by one step. The upper ports 74 and their nozzles 74*c* no longer are blocked by the shutters 76 but instead they are in registration with the holes 76*a* thereof so tha thereof so that there is a rearwardly directed flow of gases. Also, the holes 82*a* of the lower shutters 82 are in registration with selected ports 80 having nozzles 76*c* which direct the flow of gases in a rearward direction, whilst the ports 80 having nozzles 80*c* which direct the flow of gases downwardly are blocked.

In order to effect directional control of the aircraft there are provided at the port side and at the starboard side of the aircraft pairs of outboard upper nozzles 73*c*, inboard upper nozzles 74*c*, outboard lower nozzles 79*c* and inboard lower nozzles 80*c* having special shutter arrangements; these nozzles together with the co-operating ports 73, 74, 79 and 80 and the shutters provide the "directional control" outlets. The port outboard directional control outlets are illustrated in FIG. 4, which is a fragmentary cross-sectional view taken along the line 4—4 of FIG. 1; the non-illustrated port outboard directional control outlets are similar to the inboard ones. The starboard directional control outlets are similar to the port directional control outlets, and therefore they are not illustrated.

The portions of the shutters 75, 76, 81 and 82 which are opposite the directional control outlets are provided with elongated slots as indicated at 76*b* and 82*b* in FIG. 4 (the slots in the shutters 75 and 81 not being illustrated), so as to permit a continuous flow of gases through the outlets controlled by these shutter portions. Superimposed on the slotted portions of the respective shutters 76 and 82 are directional control shutters 83 and 84 having holes 83*a* and 84*a* which are adapted to register with the ports and nozzles of the corresponding pairs of directional control outlets.

The directional control shutters at opposite sides of the aircraft are differentially operated by a hydraulic system, including jacks 85 (see FIG. 4) and a control 85*a* situated in the pilot's compartment. With the control 85*a* at the neutral position, the shutters 83 and 84 (and the corresponding shutters on the starboard side) will block the directional control outlets and thus the aircraft will travel in a straight path. By operating the control 85*a* the pilot will cause the shutters 83 and 84 to slide so that the holes 83*a* and 84*a* will come into registration with the corresponding rearwardly directed nozzles, thus increasing the thrust on the port side of the aircraft and causing the aircraft to turn about its directional axis. The turning moment will vary with the extent by which the holes 83*a* and 84*a* are in registration with the corresponding ports and nozzles. If he wishes to turn the aircraft in the opposite direction, the pilot will actuate in a similar manner the direction control shutters on the starboard side.

In FIG. 4*a*, which is a diagrammatic view of the port directional control outlets, the shutters 76 and 82 are in vertical take-off condition. The directional control shutters 83 and 84 are closed so that the holes 83*a* and 84*a* are out of registration with the ports and nozzles of the corresponding pairs of directional control outlets and thus there will be no turning moment on the aircraft. It will be noted however that although the directional control outlets are closed air nevertheless is being ejected through the downwardly directed outlets.

FIG. 4*b* is similar to FIG. 4*a*, but the shutters **76** and **82** are shown in forward flight condition and the directional control shutters **83** and **84** are fully open, that is, their holes **83*a*** and **84*a*** are in registration with the ports and nozzles of the corresponding pairs of directional control outlets. Thus air is ejected through these outlets, and since the corresponding outlets at the starboard side of the aircraft would be fully closed, the thrust on the port side of the aircraft will be greater than on the starboard side and the aircraft will turn about its directional axis towards starboard.

Adjacent the periphery of the aircraft in its upper and lower skins are opposed series of generally rectangular nozzles provided to trim and to stabilize the aircraft. Referring to FIGS. 1, 2, and 7, the space between the inner skins **68** and **72** at their outboard edges opens into a bifurcated duct which terminates in upper nozzles **91** and in lower nozzles **92**. In the nozzles are located cascades of vanes **93** and **94** which are so oriented as to direct the ejected gases vertically up or vertically down, respectively. Crescent shaped shutters **95** are mounted within the nozzles and they are adapted to vary the flow characteristics of the nozzles by opening and closing them so as to selectively permit and prevent the ejection of gases therefrom.

The shutters **95** are mounted on rods **96** which are in turn supported by the ends of the rib segments **10*b*** by means of arms **97**. The shutters are of such a length that they span the spaces between the ribs **10*b***, and the rods **96** connect the shutters in groups of three. Each shutter group is paired with one adjoining group for actuation by control cables **98**. The control cables, which in part are located in the spaces between the dual ribs **10*a***, are suitably coupled to the shutters through pulleys **99**; they also pass over pulleys **100** and around quadrants **101**. The quadrants **101** which are equiangularly spaced around the central portion of the aircraft are caused to rotate by cranks **102** to which are connected one of the ends of reciprocatable control rods **103**. A control stick **104** is mounted to a fixed portion of the aircraft by means of a ball and socket joint **105**, and its lower end is provided with a universal mounting **106** to which are attached the other ends of the control rods **103**. It will be apparent that movement of the control stick in any direction will cause a corresponding movement of the control rods **103** thus actuating the cables **98** and selectively varying the position of the shutters **95** relative to the nozzles **91** and **92** to open the nozzles to varying extents or to close them.

In order to provide automatic stability for the aircraft, the gyroscopic forces of the impeller **34** of the compressor **28** are utilized and fed back into the control system. The stator ring **37** is stabilized at three equi-angular points by vertical arms **107** pivotally mounted on the aircraft structure by pins **108**. Each arm at its upper end is pivotally attached to the ring **37** by a pin **109**, and it is pivotally attached at its lower end to one end of a rod **110**. The rods **110** pass through oversize holes in the rim of a ring **111** and are each secured to a free end of one of three bell cranks **112** mounted at their fulcrums to the flanges of the ring **111**. The other ends of the bell cranks are connected through links **113** to a ring **114** of the control stick **104**. By this arrangement, the impeller **34** (which provides a gyroscope) and the control means of the trim and stabilizing nozzles are linked so that the forces which tend to change the attitude of the aircraft will be counteracted by the controlled flow of the efflux from the outlet.

In operation, with the aircraft on the ground, in order to prepare for take-off the pilot sets the selector control to the take-off position, thereby setting the upper shutters **75** and **76** at the "second condition," thus blocking the flow of gases through the upper nozzles **73*c*** and **74*c***, and also



setting the lower shutters **81** and **82** at the "second condition" so that the gases flow only through the lower nozzles **79*c*** and **80*c*** having louvres which direct the flow of gases downwardly. The three axial flow gas turbine engines **26** are then started, thereby driving the turbine **36** which in turn drives the impeller **34**. Air drawn by the impeller is compressed and flows inwardly in the duct **40**, opening the doors **60** and building up pressure in the plenum chambers **51** and **57** thereby closing the vanes **52** and **58**. When the impeller **34** reaches its operating speed, sufficient mass flow of air will be induced into the duct **40** and forced through the radial ducts **13** and out of the lower downwardly directed nozzles **79*c*** and **80*c*** to raise the aircraft vertically from the ground. The high mass flow of downwardly directed gases, coming as it does initially as individual jets from closely spaced discreet nozzles, coheres to form a downwardly directed cylindrical sheet which supports the aircraft by means of the static thrust together with the "ground cushion effect" present in a cylindrical stream.

When the desired altitude has been reached the pilot can transfer to forward flight by moving the selector control slowly to the "forward flight" position. In so doing the upper shutters **75** and **76** and the lower shutters **81** and **82** gradually move to the "first condition"; thus, the upper nozzles **73*c*** and **74*c*** gradually open whilst the lower nozzles **79*c*** and **80*c*** which are downwardly directed gradually close and those which are rearwardly directed gradually open. As a consequence, all the gases are ejected in a rearward direction, causing the aircraft to move forwardly.

In the procedure just described, the aircraft has been caused to hover and to assume forward flight by means of a mass flow of cold gases. If desired, and in order to increase the thrust output, the flame tubes **61** may be "lit" and their total thrust will be added to the thrust from the gas turbine engines.

The flow conditions in the ducts **13** are such that the flame tubes will operate efficiently solely on air inducted by the impeller **34**. This makes possible the efficient operation of the aircraft as a ram-jet at low or even at zero aircraft velocities. The pilot may, if he wishes, in the case of a heavily loaded aircraft or when a rapid take-off and climb are desired, 'light" his flame tubes as soon as the impeller **34** reaches the required speed.

When the velocity in forward flight has become sufficiently great, the forwardly facing vanes **52** and **58** in the inlets **50** and **56** respectively will open, and the ram pressure in the plenum chambers **51** and **57** and in the radial ducts **13** will be high enough to cause the desired flow conditions through the flame tubes **61**. When this velocity is attained, the gas turbine engines **26** can be throttled back to an extent sufficient only to maintain the required gyroscopic forces in the impeller to provide automatic stability so that the aircraft will operate as a ram-jet engine. When the engines **26** are throttled back the pressure in the duct **40** is lowered, and, because of the higher air pressure in the plenum chambers **51** and **57**, the doors **60** will close automatically.

Automatic longitudinal or lateral stability control of the aircraft is effected by manipulation of the shutters **95** to direct a vertical stream of gases from a selected portion of the periphery of the aircraft to cause a moment which will correct for the instability. If, for example, there is a resultant downwardly directed force at the nose of the aircraft which causes the nose to drop, the initial rotation of the aircraft about its lateral axis will impose a downward force on the forward portion of the rotating impeller **34**. Since the impeller in the aircraft described is rotating in a counterclockwise direction, it will precess downwardly to the left because of the gyroscopic forces. This precession force will be transmitted through the ring **37** to the arms **107** and will be such as to move the control stick **104** and the attached control rods **103** in a forward direction. This forward movement of the control rods will cause the fore and aft quadrants **101** to rotate in a direction which will open the rear shutters **95** to direct a stream of gases vertically upwards through the rear upper nozzles **91** and which will open the forward shutters **95** to direct a stream of gases vertically downwards through the front lower nozzles **92**, thus producing a moment which will counteract the moment caused by the disturbing force.

Flight control by the pilot is effected by manipulation of the control stick **104**. This may be done directly, if space permits, by extending the upper portion of the stick beyond the ball and socket joint **105** in order to provide a hand grip for the pilot. If direct operation is not possible because of space limitations or because of cockpit layout, the pilot may be provided with a remote control stick connected by a servo mechanism or by mechanical means **115** to the control stick **104**.

It will be realized that, although the gyroscopic forces of the impeller **34** are used to effect automatic stability, they do not predominate the control forces so that there is no need to displace the operation of the shutters by 90° relative to the direction of the required force.

The aircraft illustrated in FIGS. 8–11 essentially is similar to the aircraft previously described. It differs therefrom in that four radially disposed axial flow gas turbine engines **200** are provided (instead of three), in the disposition of these engines, in the construction and arrangement of its turbine **201** and of its compressor **202**, and in structural details of its stabilizing and trim control system.

Four gas turbine engines **200** are disposed with their inlets **203** facing outboardly and their outlets **204** facing inboardly and registering with an annular cylindrical passage **205** defined by fixed walls **206** and **207** which form a part of the aircraft structure. The products of combustion from the engines **200** are ejected into the passage **205** and they flow therein upwardly and then outboardly to cause rotation of the impeller **208** of the reaction turbine **201**. Two rings of compressor stator blades **209** bridge walls **210** and **211** of a plenum chamber **212**; extending downwardly from the impeller of the turbine **201** and interposed between the rings of stator blades **209** are rotor blades **213** of the radial flow compressor **202**.

The plenum chamber **212** has a circumferential inlet or intake **214** provided with freely movable vanes **215** similar in construction and in operation to the vanes **52** of the first described embodiment. In the lower portion of the aircraft is another plenum chamber **216** having a circumferential inlet or intake **217** and freely movable vanes **218**. In FIGS. 8 and 9 the vanes **215** and **218** are shown in the positions which they assume when the aircraft is in forward flight; when the aircraft is effecting vertical takeoff, all of the vanes **215** and **218** are open.

The plenum chambers **212** and **216** in effect are branches of an air displacement passage, which branches extend inboardly and inwardly from the inlets **214** and **217** and meet to provide a common passage which includes ducts **219** defined by the radially disposed ribs of the aircraft.

In operation, air enters the circumferential inlets **214** and **217**, flows inboardly through the plenum chambers **212** and **216** and is then deflected inwardly by circumferential cascades of vanes **220** and **221** in the common passage and finally flows radially outboardly through the ducts **219**. A fraction of the air enters the inlets **203** of the four gas turbine engines **200** whilst the remainder passes through the flame tubes **222** in the same manner as in the embodiment of the invention previously described.

The control system is similar to that of the first embodiment of the invention and therefore it will not be described in detail. It differs therefrom in the construction and arrangement of the means whereby the gyroscopic forces of the impeller **208** of the reaction turbine **201** are utilized and fed back into the control system.

At the upper end of the cylindrical wall **206** is a flanged ring **224** on the periphery of which is a segmental spherical bearing **225**. The impeller **208** of the turbine **201** (which impeller also provides the rotor of the compressor **202**) has a complementary bearing in engagement with the segmental spherical bearing **225**; thus the rotor is mounted on the ring **224** for limited universal movement. The rotor is stabilized at four equiangular points by vertical arms **226** pivotally mounted to the cylindrical wall **206** by pins **227**. Each of the four arms at its upper end is pivotally attached to a dependent arm of the rotor bearing, which arm extends through a slot in the ring **224**, and it is pivotally attached at its lower end to one end of a rod **228**. The four rods **228** pass through oversize holes in the rim of a ring **229** and they are each secured to a free end of one of four bell cranks **230** mounted at their fulcrums to the flange of the ring **229**. The other ends of the bell cranks are connected through links **231** to a ring **232** of the control stick **233**. Apart from the fact that the gyroscopic device just described has a four point stabilizing support whilst the gyroscopic device of the first embodiment of the invention has a three point stabilizing support, the construction and the operation of the two devices are the same.

The aircraft illustrated in FIGS. 8–11 is controlled and is operated in substantially the same manner as the aircraft of FIGS. 1–7. Since all the air enters the aircraft through the inlets **214** and **217** and there is no special inlet for the compressor **202**, this aircraft does not have any doors equivalent to the doors **60** of the aircraft first described. The main advantage of the aircraft of FIGS. 8–11 over the aircraft of FIGS. 1–7 is due to the fact that the compressor is located in the air passage proper, and not in an inlet in the upper surface of the aircraft. With the aircraft of FIGS. 1–7, in forward flight one side of the impeller would be meeting the air at a very high speed and be almost stalled, whereas on the other side the relative velocity would be nearly zero. This condition produces not only a loss in thrust but also produces a rolling moment due to the imbalance of thrust. Furthermore, with the inlet disposed as it is in the aircraft of FIGS. 1–7 and with the aircraft in forward flight, the air is required to bend through 90° to enter the inlet and high losses are suffered especially at the higher forward speeds.

In the aircraft of FIGS. 1–7 the three axial flow engines **26** have inboardly facing inlets and outboardly facing outlets, whilst in the aircraft of FIGS. 8–11 the four axial flow engines have outboardly facing inlets and inboardly facing outlets. This suggests the possibility of disposing the axial flow engines in other manners, and according to a third embodiment of the invention which is illustrated in FIGS. 12 and 13 it is proposed to position four axial flow engines **300** around the vertical central axis of the aircraft with their inlets **301** facing downwardly and their outlets **302** facing upwardly. At the centre of the aircraft is a vertical shaft **303** on a portion of which is a spherical bearing **304**. The shaft through its bearing is supported by the spherical bearing surfaces **305** of a tubular housing **306**, which housing rigidly is secured to the aircraft structure by four radially disposed plates **307**. Rotatably mounted at the upper end of the shaft is a rotor generally indicated at **308** and which provides both the impeller of a radial flow turbine **309** and the impeller of a centrifugal compressor **310**.

Air enters upper and lower circumferential inlets **311**, flows inboardly through plenum chambers **312**, is deflected inwardly, is compressed by the compressor, and is ejected outboardly through ram jet engines provided by ducts **313** and flame tubes **314**, and finally through thrust outlets generally indicated at **315** and which are similar to the outlets of the two embodiments of the invention previously described. A fraction of the air enters the downwardly facing inlets **301** of the axial flow engines **300** through ducts **316** which are connected to the lower plenum chamber **312**. The products of combustion of the four axial flow engines **300** are ejected from the engine outlets **302** and they then power the radial flow turbine **309**.

As in the previously described embodiments of the invention the gyroscopic forces of the rotor **308** are utilized and fed back into the control system so as to operate the stabilizing and trim nozzles of the aircraft. The spherical bearing **304** enables the shaft **303** to swing (within limits) relative to the tubular housing **306**. Any change in the attitude of the aircraft will cause the rotor **308** to tilt slightly relative to the supporting structure of the aircraft, thus swinging the shaft **303**. This swinging movement is sensed by a suitable device located adjacent the lower end of the shaft **303** and generally indicated at **317** and is fed back into the control system of the stabilizing and trim nozzles; the control system essentially is similar to that of the two aircrafts previously described.

An aircraft constructed according to the third embodiment of the invention has a number of advantages, the majority of which are mechanical. Because of the type of compressor used, it has now become possible to reduce the tip speed of its blades by over 25% with a corresponding reduction in rotor speed. Furthermore, it has become possible to materially reduce the length of hot ducting by disposing the engines vertically in the centre as well as improving the basic radial structure since it is not now disturbed by the engines. Also, with the centrifugal impeller placed as it is, the impeller draws air equally from both the upper and the lower intake ducts and so precludes any tendency for the formation of any moments about the pitch axis.

It is to be understood that the forms of the invention herewith shown and described are to be taken only as examples of the same, and that various changes in the construction and arrangement of the parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims. It will be noted that by the constructions described not only is a saving of fuel effected through the use of the highly efficient ram-jet engines, but a major saving also has been made in engine and in structural weight due to the inherent light weight of ram-jet engines.

What we claim as our invention is:

1. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, means in the passage to supply air under compression to the ram jet engines, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

2. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, an air compressor in the passage to supply air under compression to the ram jet engines, engine means to operate the compressor, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.



3. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, an air compressor in the passage to supply air under compression to the ram jet engines, a gas turbine coupled to the compressor to operate it, a gas generator to operate the turbine, and means at the outlet to ocntrol selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

4. An aircraft comprising a generally lentiform structure including a core and a plurality of generally radially disposed ribs extending from the core in outboard directions, opposed aerofoil surfaces sheathing the core and the ribs and providing lift developing surfaces, the ribs defining radially arranged ducts, an air displacement passage within the structure and having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the passage including the said ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, means to supply air under compression to the ram jet engines, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

5. An aircraft comprising a core of generally circular cross-section, an annular hollow disc extending outboardly from the perimeter of the core, the core and the disc together providing a generally lentiform structure having opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake in the core and an annularly arranged outlet adjacent the perimeter of the disc, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, an air compressor in the core including a rotor having an axis of rotation which substantially coincides with the central axis of the core, the compressor supplying air under compression to the ram jet engines, engine means to operate the compressor, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

6. An aircraft comprising a core of generally circular cross-section, an annular hollow disc extending outboardly from the perimeter of the core, the core and the disc together providing a generally lentiform structure having opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake in the perimeter of the core and an annular intake at the upper axial end of the core, the passage also having an annularly arranged outlet adjacent the perimeter of the disc, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, an air compressor in the core including a rotor in the annular intake and having an axis of rotation which substantially coincides with the central axis of the core, the compressor supplying air under compression to the ram jet engines, engine means to operate the compressor, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

7. An aircraft comprising a core of generally circular cross-section, an annular hollow disc extending out-

boardly from the perimeter of the core, the core and the disc together providing a generally lentiform structure having opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake in the perimeter of the core and an annular intake at the upper axial end of the core, the passage also having an annnular arranged outlet adjacent the perimeter of the disc, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, an air compressor in the core including a rotor in the annular intake and having an axis of rotation which substantially coincides with the central axis of the core, the compressor supplying air under compression to the ram jet engines, a gas turbine coupled to the compressor rotor to operate it, a plurality of gas turbine engines positioned in the passage to receive air from the intake, duct means to convey expanding products of combustion from the gas turbine engines to the gas turbine to operate the latter, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

8. An aircraft comprising a core of generally circular cross-section, an annular hollow disc extending outboardly from the perimeter of the core, the core and the disc together providing a generally lentiform structure having opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and including a first plenum chamber having a perimetrical intake in the perimeter of the core and a second plenum chamber having an annular intake at the upper axial end of the core, the passage also having an annularly arranged outlet adjacent the perimeter of the disc, the passage including a plurality of radially disposed ducts between the plenum chambers and the outlet, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, an air compressor in the core including a rotor in the annular intake and having an axis of rotation which substantially coincides with the central axis of the core, the compressor supplying air under compression to the ram jet engines, engine means to operate the compressor, an alternative supply of air under compression for the ram jet engines being provided through the perimetrical intake when the aircraft is in forward flight, doors separating the two plenum chambers, the doors being freely movable and automatically closing when the local pressure in the first plenum chamber exceeds the local pressure in the second plenum chamber and thus preventing the escape of air from the perimetrical intake through the annular intake, the doors automatically opening under the reverse conditions, a series of circumferentially arranged movable vanes in the perimetrical intake, the vanes automatically opening whenever the force of the air which strikes them exceeds the local pressure within the first plenum chamber and automatically closing under the reverse condition, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

9. An aircraft comprising a core of generally circular cross-section, an annular hollow disc extending outboardly from the perimeter of the core, the core and the disc together providing a generally lentiform structure having opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and including a plenum chamber having a perimetrical intake in the perimeter of the core and an annularly arranged outlet adjacent the perimeter of the disc, the air displacement passage including a plurality of generally radially disposed ducts between the plenum chamber and the outlet, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, a turbine in the core including an impeller having an axis of rotation which substantially coincides with the central axis of the core, a radial flow compressor in the plenum chamber coaxial with the turbine and including a rotor portion fast to the impeller of the turbine, a gas turbine engine in the passage, a duct to convey the products of combustion of the gas turbine engine to the impeller of the turbine to operate the latter, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

10. An aircraft comprising a core of generally circular cross-section, an annular hollow disc extending outboardly from the perimeter of the core, the core and the disc together providing a generally lentiform structure having opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure, the passage including branches which extend inboardly and inwardly into the core from intakes in the perimeter of the core at each side of the disc, the said branches meeting and blending to provide a common passage which includes a plurality of generally radially disposed ducts which extend outboardly within the disc to an annularly arranged outlet adjacent the perimeter of the disc, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, a turbine in the core including an impeller having an axis of rotation which substantially coincides with the central axis of the core, a radial flow air compressor in the upper branch of the passage, the compressor including a rotor portion coaxial with and fast to the impeller of the turbine, air under compression being supplied to the ram jet engines by the compressor when the aircraft is in vertical flight and by the ramming effect in the intakes when the aircraft is in forward flight, a plurality of gas turbine engines in the passage, a duct to convey the products of combustion of the gas turbine engines to the impeller of the turbine to operate the latter, and means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust.

11. An aircraft comprising a general lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, a rotary air compressor in the passage to supply air under compression to the ram jet engines, engine means to operate the compressor, the compressor including a rotor mounted on the structure for limited universal movement relative thereto and which provides a gyroscope sensitive to forces tending to change the attitude of the aircraft, means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust, and means linking the control means and the gyroscope so that the forces which tend to change the attitude of the aircraft will be counteracted by the controlled flow of the efflux from the outlet.

12. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, a rotary

air compressor in the passage to supply air under compression to the ram jet engines, engine means to operate the compressor, the compressor including a rotor mounted on the structure for limited universal movement relative thereto and which provides a gyroscope sensitive to forces tending to change the attitude of the aircraft, means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust, said means including trim and stabilizing nozzles, means to vary the flow characteristics of the nozzles, means to operate the flow characteristic varying means selectively, and means linking the flow characteristic varying means and the gyroscope so that the forces which tend to change the attitude of the aircraft will be counteracted by the thrust from the nozzles.

13. An aircraft comprising a generally lentiform structure sheathed by opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake and having an annularly arranged outlet adjacent the perimeter of the structure, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, a rotary air compresor in the passage to supply air under compression to the ram jet engines, engine means to operate the compressor including a rotor mounted on the structure for limited universal movement relative thereto and which provides a gyroscope sensitive to forecs tending to change the attitude of the aircraft, means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust, the said means including upwardly directed and downwardly directed trim and stabilizing nozzles through which the products of combustion are ejected in localized streams having opposite components of thrust, shutters for the nozzles to vary the flow characteristics thereof, means to operate the shutters selectively, and means linking the control means and the gyroscope so that the forces which tend to change the attitude of the aircraft will be counteracted by the thrust from the nozzles.



14. An aircraft comprising a core of generally circular cross-section, an annular hollow disc extending outboardly from the perimeter of the core, the core and the disc together providing a generally lentiform structure having opposed aerofoil surfaces which provide lift developing surfaces, an air displacement passage within the structure and having an intake in the core and an annularly arranged outlet adjacent the perimeter of the disc, the air displacement passage including a plurality of generally radially disposed ducts, flame tubes positioned in the ducts adjacent the outlet to eject their products of combustion therethrough, the ducts and the flame tubes together providing ram jet engines, an air compresor in the core including a rotor having an axis of rotation which substantially coincides with the central axis of the core, the compressor supplying air under compression to the ram jet engines, engine means to operate the compressor, the rotor being mounted in the core for limited universal movement relative thereto, the rotor thus providing a gyroscope sensitive to forces tending to change the attitude of the aircraft, means at the outlet to control selectively the flow of the efflux from the outlet to provide a controlled propulsive thrust, and means linking the control means and the gyroscope so that the forces which tend to change the attitude of the aircraft will be counteracted by the controlled flow of the efflux from the outlet.

No references cited.

Feb. 27, 1962 J. C. M. FROST ET AL 3,022,963

DISC-TYPE AIRCRAFT WITH PERIPHERAL JET CONTROL

Original Filed May 9, 1955 5 Sheets-Sheet 1

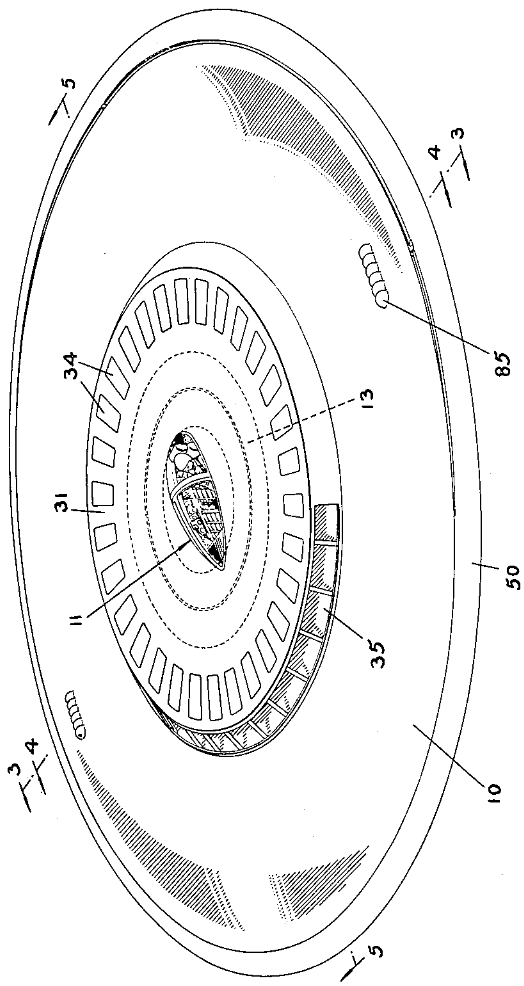


FIG. 1

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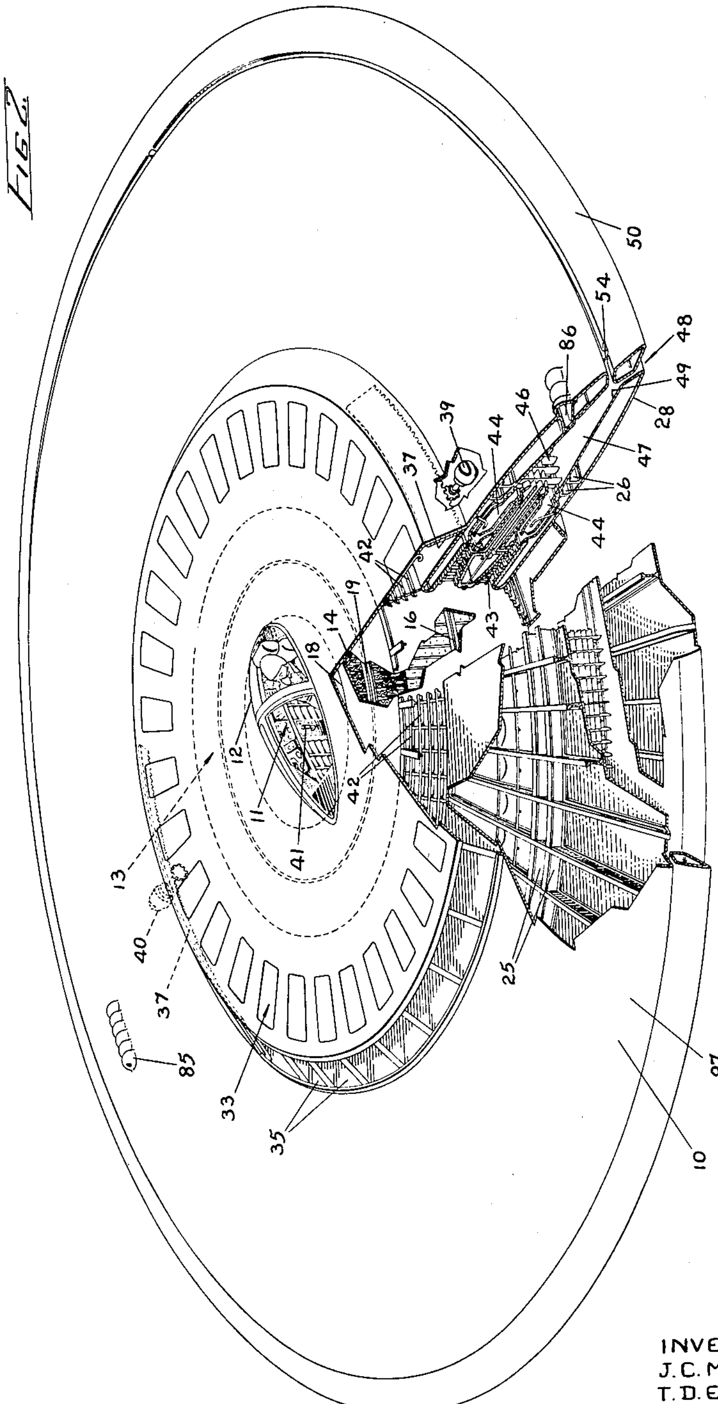
DISC-TYPE AIRCRAFT WITH PERIPHERAL JET CONTROL

Original Filed May 9, 1955 5 Sheets-Sheet 2

FIG. 2

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DISC-TYPE AIRCRAFT WITH PERIPHERAL JET CONTROL

Original Filed May 9, 1955 5 Sheets-Sheet 3

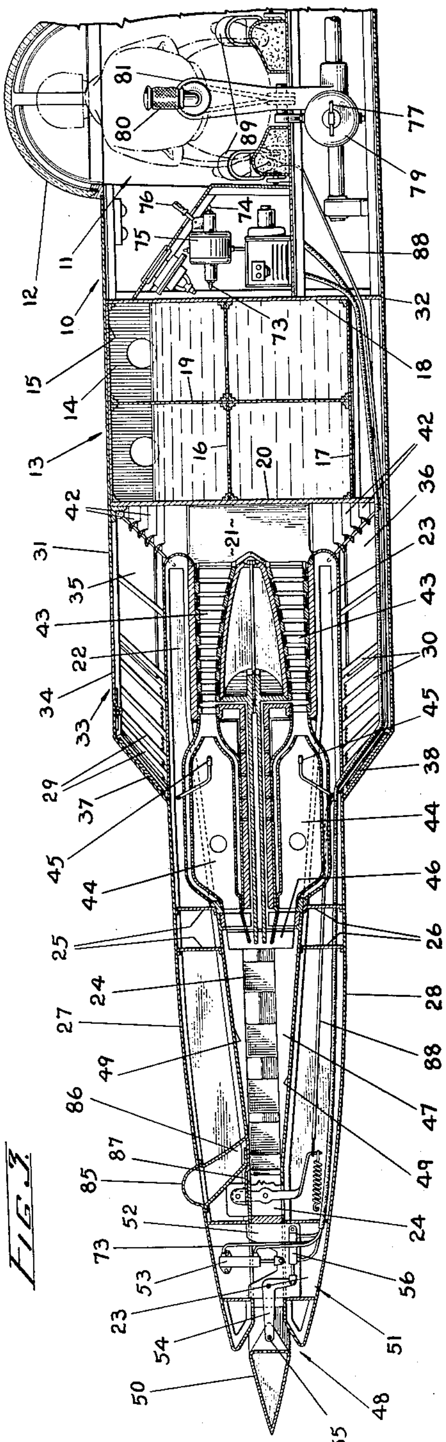

FIG. 3

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DISC-TYPE AIRCRAFT WITH PERIPHERAL JET CONTROL

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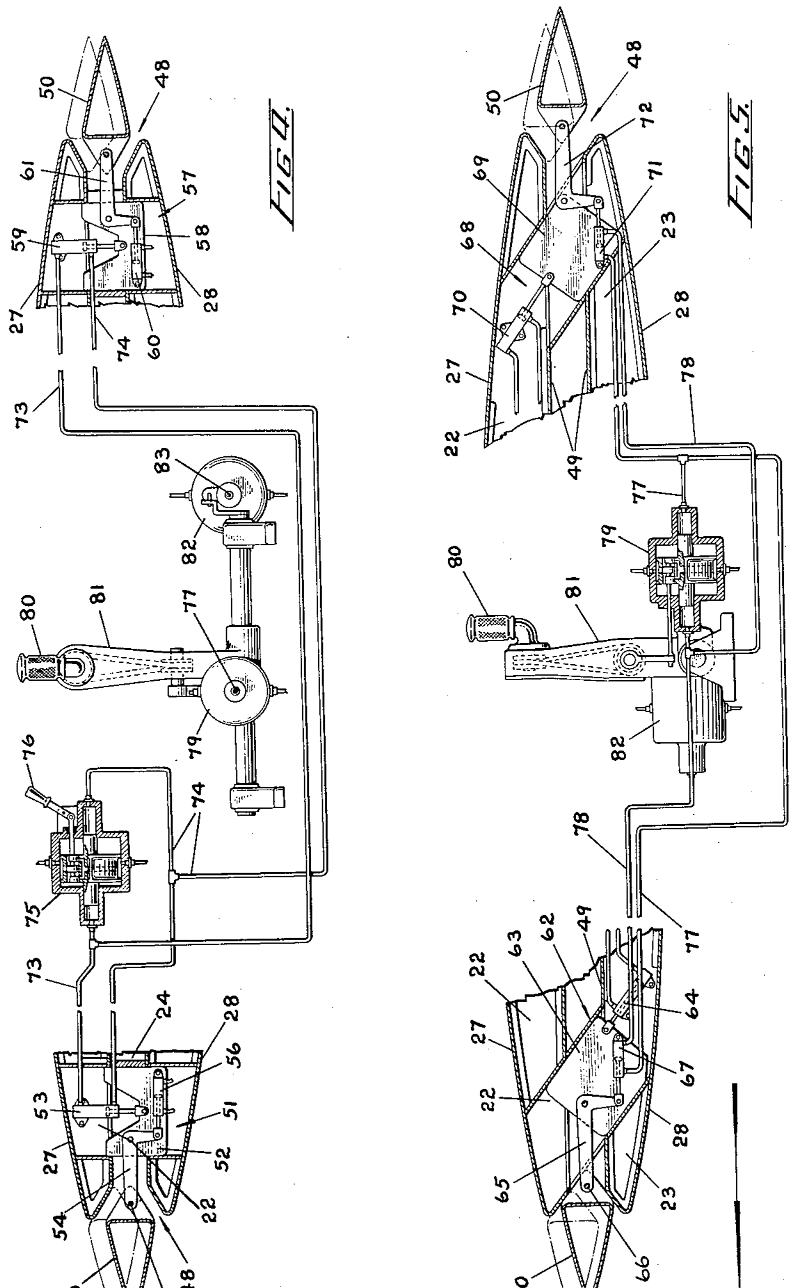

FIG. 4.

FIG. 5.

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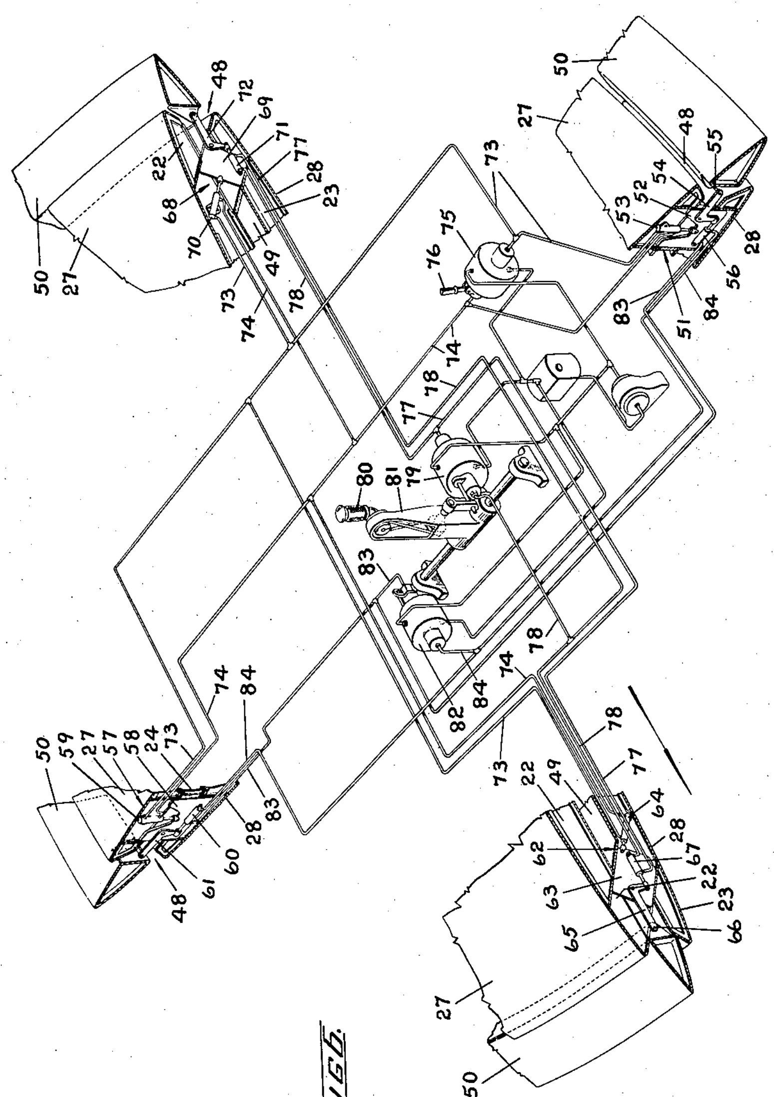

FIG. 6

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United States Patent Office 3,022,963
Patented Feb. 27, 1962



3,022,963

# DISC-TYPE AIRCRAFT WITH PERIPHERAL JET CONTROL

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Continuation of application Ser. No. 507,098, May 9, 1955. This application Oct. 1, 1957, Ser. No. 688,804
Claims priority, application Great Britain May 11, 1954
23 Claims. (Cl. 244—15)

This application is a continuation of our application Serial No. 507,098, filed May 9, 1955, now abandoned.

The invention relates to the propulsion and control of disc-type or circular aircraft deriving a propulsive thrust from a stream of high speed gases flowing within the aircraft in generally radial directions and discharged from the periphery thereof. An aircraft of this type is disclosed in the co-pending patent application of John Dubbery, John Carver Meadows Frost and Thomas Desmond Earl, Serial No. 684,615, filed on September 17, 1957.

The co-pending application Serial No. 684,615 describes an aircraft which comprises a structure of generally lenticular form and which is sheathed by opposed aerofoil surfaces converging towards each other in an outboard direction from their central inboard portions to their perimetrical edges, and a radial flow gas turbine engine disposed between the said aerofoil surfaces and having a disc-like rotor the plane of rotation of which is approximately parallel to the medial plane between the said opposed surfaces. Air enters inlets provided in the aerofoil surfaces, then after passing through plenum chambers it flows radially outboardly through a double-sided multi-stage radial flow compressor of a gas turbine engine, then into an annularly arranged combustion system of the engine where it supports the combustion of the fuel and from which the products of combustion or gases expand through a radial flow turbine of the engine into a peripheral passage, whence they flow radially outboardly through a perimetrical orifice which forms a constituent part of a Coanda nozzle. The Coanda nozzle is constituted by a gap defined by the perimeter of the upper aerofoil surface and by the upper surface of a hollow toroidal element which perimetrically encompasses the aerofoil surfaces and the lower surface of which blends with the lower aerofoil surface. The gases issuing from the passage are deflected around the toroidal element and adhere to its surface. Co-operating with the Coanda nozzle are means whereby the entrainment on one side of the orifice may be varied selectively at various sectors, and means whereby various sectors of the orifice selectively may be obstructed in toto or in part. More specifically, circumferentially spaced holes are provided in the upper surface of the toroidal element and they are connected through valves responsive to the pilot's controls to an air supply of the engine. By the selective adjustment of the controls the pilot can cause air to be admitted to any desired group of holes, thereby varying selectively the direction and magnitude of the jet emitted in various sectors of the peripheral nozzle, to provide control of the aircraft.

The above described arrangement has been found in practice to cause excessive drag at supersonic speeds. Furthermore, in forward flight, the gases issuing from the forward portion of the aircraft are caused to flow along the under surface of the aircraft and so prevent the use of an air intake on that surface. Consequently, an air intake can be provided only on the upper surface of the aircraft, and as a result of this lack of symmetry large pitching moments may be set up at supersonic speeds.

The main object of the invention is to provide an im-



proved method of propelling and controlling a disc-type aircraft, and of initiating its take-off.

Another object of the invention is to provide control means for a disc-type aircraft which will minimize drag at supersonic speeds.

A further object of the invention is to provide control means for a disc-type aircraft which allows the use of upper and lower air intakes.

The foregoing and other objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, in which like reference characters indicate corresponding parts throughout the several views, and in which:

FIG. 1 is a perspective view of an aircraft which embodies the invention, and viewed from above;

FIG. 2 is a perspective view of the said aircraft, partly broken away to show the internal construction;

FIG. 3 is a radial sectional view of the aircraft taken substantially transversely of the direction of flight, and more particularly as indicated by lines 3—3 of FIG. 1;

FIG. 4 is a fragmentary diametrical cross-sectional view of the aircraft, as indicated by the lines 4—4 of FIG. 1, and showing the port and starboard outboard portions and only the relevant pilot's controls in the central portion;

FIG. 5 is a fragmentary diametrical cross-sectional view of the aircraft, as indicated by the lines 5—5 of FIG. 1, and showing the fore and aft outboard portions and only the relevant pilot's controls in the central portion; and

FIG. 6 is a fragmentary perspective view of the aircraft, partly in section and partly in schematic form, and intended particularly to illustrate the control system.

For greater convenience, throughout the description certain terms of positional relationship are used. The terms "outboard" (or "outboardly") and "inboard" (or "inboardly") denote, respectively, greater and lesser distances from the axis of rotation of the rotor which constitutes the centre of the aircraft, and the terms "outer" and "inner" similarly denote greater and lesser distances from a medial plane between the areofoil surfaces, which plane substantially coincides with the plane of the rotor. The terms "vertical," "upwardly," and "downwardly" denote directions approximately normal to the aforesaid medial plane.

It is well known to those skilled in the art that a jet is deflected around the radius in a Coanda nozzle situated in still air by reason of the fact that a positive pressure differential exists between the extended wall of the nozzle and the atmosphere beyond the jet. As the jet issues from the orifice, it is in effect pushed against the extended wall by this difference in pressure, provided that the radius of the wall is not less than a predetermined minimum which is governed by the "effective" pressure of the atmosphere beyond the jet. For a nozzle situated in still air at atmospheric pressure, this radius must be of the order of three times the height or thickness of the orifice from which the jet issues. The radius of the extended wall correspondingly can be reduced for increases in the "effective" pressure beyond the jet: that is, if the "still air" pressure of the atmosphere beyond the jet increases, the required radius of the wall can be decreased correspondingly. Moreover, if a velocity is imparted to the still air at atmospheric pressure, the "effective" pressure is thereby increased, thus making possible the use of a wall having a smaller radius.

The aircraft of the invention is substantially circular in plan form, and in elevation it presents flat double convex surfaces on the central portion of each of which protrude frusto-conical structures; it can be said that the structure is of generally lenticular form, or is "lentiform."

An aircraft embodying the invention may comprise a central cylindrical shell 10 which houses a pilot's compartment 11 and in which are located the necessary flying instruments and controls. The pilot's compartment is covered by a sealable closure 12.

Encompassing the cylindrical shell 10 is an annular fuel tank generally indicated at 13, and which is constituted by radial baffles 14, an upper annular wall 15, an intermediate annular wall 16 and a lower annular wall 17, and by an inboard cylindrical wall 18, an intermediate cylindrical wall 19 and an outboard cylindrical wall 20.

Radially extending struts 21 are firmly secured to the outboard cylindrical wall 20 of the tank. Secured to the struts 21 are the inboard ends of an upper series of radially disposed ribs 22 and of a lower series of radially disposed ribs 23, an upper rib and the opposed lower rib which is spaced therefrom constituting a pair of ribs. The ribs of each pair are spaced adjacent their outboard ends by a circumferentially arranged group of outboard struts 24; circumferentially disposed stiffeners 25 and 26 are also provided between adjacent ribs.

An annular upper skin 27 is secured to the outer edges of the upper ribs 22, and a similar annular skin 28 is secured to the outer edges of the lower ribs 23. Extending outwardly from the inboard portion of the ribs 22 and 23 and of their skins 27 and 28 are sloping ribbed structures 29 and 30 which are covered respectively by skins 31 and 32; these skins extend inboardly to cover the annular fuel tank and the pilot's compartment. The portions of the aircraft covered by the skins 31 and 32 are frusto-conical, and the skins of these frusto-conical portions together with the skins 27 and 28 constitute the opposed aerofoil surfaces of the aircraft.

On the flat portion of the upper skin 31 are provided circumferentially arranged air inlets 33 which are normally closed by spring loaded doors 34. On the forward sectors of the sloping portions of the skins 31 and 32 are additional air inlets 35 and 36 adapted to be closed by sliding doors 37 and 38 respectively. The inner edges of the doors 37 and 38 are provided with gear teeth which mesh with pinions on the shafts of motors 39 and 40 operable by a suitable control 41 in the pilot's compartment.

In operation, air enters the inlets 33 or the inlets 35 and 36, is deflected inwardly by cascades 42, then after passing through a central plenum chamber it flows radially outboardly through a double-sided multi-stage compressor 43, then into an annularly disposed combustion system 44 where it supports combustion of the fuel supplied from the fuel tank to the nozzles 45. The products of combustion expand through a single-stage radial flow turbine 46 into an annular jet exhauster duct 47; the flow of products of combustion through the jet exhauster duct is in generally radial directions. The compressor and the turbine have a common rotor which in the construction illustrated is supported by radial load and axial load air bearings.

From the jet exhauster duct 47 the products of combustion pass through a perimetrical orifice or outlet 48 and thence to atmosphere to provide a propulsive thrust.

The orifice 48 and the exhauster duct 47 are constituted by spaced annular plates 49 secured to the inner edges of the ribs 22 and 23 respectively, and which at their outboard edges diverge to blend with the outboard edges of the skins 27 and 28.

The orifice 48 is substantially V-shaped in cross-section, and encompassing it is an annulus or annular plug 50. The cross-section of the annulus 50 and its diameter are so dimensioned that when the annulus is positioned concentrically in the orifice it may make circumferential contact with one of the orifice walls but be spaced from the opposed wall to define a passage. The inboard diameter of the annulus is less than the outboard diameter of the orifice so that outward movement of the annulus (i.e., movement in a direction normal to the medial plane between the aerofoil surfaces) is limited by the orifice walls. The annulus is diamond-shaped, and preferably its inboard faces are disposed at angles of say 60° relative to the medial plane, and its outboard faces are disposed at angles of say 30° relative to the medial plane. The inboard faces blend smoothly with the outboard faces to form continuous symmetrical upper and lower surfaces.



It will be seen from the drawings that the orifice 48 and the annulus 50 together constitute a bifurcated duct when the annulus is in the centralized position (i.e., coincides with the medial plane) so that the products of combustion are separated or bifurcated to form jets having opposed vertical components of thrust. When the annulus is moved outwardly from the centralized position a resultant vertical component of thrust will be produced in a sense opposite the sense of movement of the annulus relative to the centralized position. The edges of the orifice walls and of the annulus are radiused generously to provide corners around which the gases may bend in accordance with the Coanda effect.

Referring particularly to FIGS. 4, 5 and 6, the annulus 50 is provided at four points with supporting means whereby portions of it may be displaced outwardly relative to the orifice (i.e. in a direction normal to the medial plane between the aerofoil surfaces) and whereby it may also be displaced as a whole eccentrically relative to the orifice (i.e. in a direction parallel to the aforesaid medial plane).

The port supporting means generally indicated at 51 comprises a plate 52 slidably mounted in suitable guides under the control of a hydraulic jack 53, the body of the jack being anchored on a rib 22 and its piston being connected to the plate 52. Pivotally mounted on the plate 52 is a bell crank 54, one end of which is connected to the annulus 50 through a pin 55 spanning a slot in the annulus. The other end of the bell crank is pivotally connected to the piston of a jack 56, the body of the said jack being anchored on the plate 52. It will be apparent from an examination of FIG. 3 or 4 that actuation of the jack 53 will cause outward movement of a portion of the annulus relative to its centralized position in the orifice, whilst actuation of the jack 56 will cause movement of the said portion of the annulus 50 in an arc, the main component of motion being vertical (i.e., inwardly and outwardly).

The starboard annulus supporting means which is generally indicated at 57 is similar to the port supporting means. It includes a plate 58 adapted to slide vertically in suitable guides under the control of a hydraulic jack 59 which is anchored to a rib 22. It also includes a jack 60 coupled to a bell crank 61 which is connected to the annulus. The jacks 56 and 60 although connected in parallel move differentially, i.e. they cause the portions of the annulus to which they are connected to move in opposite senses.

The forward annulus supporting means generally indicated at 62 comprises a plate 63 mounted for sliding movement in suitable sloping guides under the control of a jack 64; the body of the jack is anchored on a rib 23, while its piston is connected to the plate 63. Pivotally mounted on the plate is a bell crank 65, one end of which is connected to the annulus 50 through a pin 66 which spans a slot in the annulus and the other end of which is connected to the piston of a jack 67 anchored on the plate 63.

When the piston of the jack 64 is positioned as shown in FIG. 5 it holds the forward portion of the annulus in centralized position relative to the orifice and also eccentrically relative thereto, thus sealing the forward portion of the orifice. If the jack 64 is actuated to shift its piston to the alternative position, the forward portion of the annulus will move to the position shown in chain dotted lines in FIG. 5, that is, it will move outwardly and outboardly relative to the orifice to assume a concentric position. When the piston of the jack 64 is in the said alternative position, actuation of the jack 67 will cause movement of the forward portion of the annulus in an arc, the main component of motion being vertical and in a downward sense; movement in an upward sense obviously is not possible. When the forward portion of the annulus is in the centralized position as shown in full lines in FIG. 5, the jack **67** is inoperative.

The aft annulus supporting means which is generally indicated at **68** is substantially similar to the forward supporting means **62**. It includes a plate **69** mounted for sliding movement in suitable sloping guides under the control of a jack **70** anchored on a rib **22**. It also includes a jack **71** coupled to a bell crank **72** which is connected to the annulus **50**.

When the piston of the jack **70** is positioned as shown in FIG. 5 it holds the aft portion of the annulus in such a position that the annulus as a whole is eccentric relative to the orifice and the aft portion is in centralized position relative thereto; actuation of the jack **72** will cause movement of the aft portion of the annulus **50** in an arc, the main component of motion being vertical. If the jack **70** is actuated to shift its piston to the alternative position, the aft portion of the annulus will move outwardly relative to its centralized position and also inboardly to assume a concentric position relative to the orifice; when the piston of the jack **70** is in the said alternative position, the jack **71** may be actuated only to move the annulus inwardly.

The jacks **53**, **59**, **64** and **70** are connected in parallel and operable in unison. They are connected through hydraulic lines **73** and **74** to a suitable two-position servo motor **75** in the pilot's compartment and which is conditionable by a selector handle **76**. The selector handle may be set at "flying position" as illustrated in FIG. 4, or at "take-off position." When the selector handle is at flying position the annulus **50** is in the position shown in full lines in the drawings, that is, it is disposed eccentrically relative to the orifice. If the selector handle **76** is moved to the alternative or take-off postion the servo motor **75** will cause the annulus **50** to move to the chain dotted position of FIGS. 4 and 5; the port and starboard portions of the annulus will move outwardly relative to the medial plane, whilst the forward portion will move outwardly and outboardly, and the aft portion will move outwardly and inboardly. Thus with the selector handle **76** in the take-off position the annulus is disposed concentrically relative to the orifice but outwardly relative to the medial plane to make circumferential contact with the upper wall of the orifice and to provide in co-operation with the lower wall a downwardly directed annular gap.

The forward jack **67** and the aft jack **71** are connected through hydraulic lines **77** and **78** to a multi-position servo motor **79** which is controlled by the lateral movements of a control handle **80** mounted on a control column **81**. Since the details of construction of the control system and particularly of the servo motors are not essential parts of the invention, these features will not be described in detail. However, the operation of the control system easily may be understood by an examination of the drawings.

When the selector handle **76** is in flying position, movement of the control handle **80** towards starboard will apply pressure to the right-hand side of the piston of the aft jack **71** thus urging the aft portion of the annulus **50** downwardly so that the exhaust gases cause a resultant upward thrust on the aft portion of the aircraft. The movement of the control handle **80** towards starboard has no effect on the forward jack **67** when the selector handle **76** is in flying position since the forward portion of the annulus is then centralized in the orifice and in effect is wedged therein. When the selector handle **76** is in flying position, movement of the control handle **80** towards port will cause the aft portion of the annulus to move upwardly so that the exhaust gases cause a resultant upward thrust on the aft portion of the aircraft; the forward portion of the annulus does not move since it is wedged in the orifice.

When the selector handle **76** is in take-off position, movement of the control handle **80** to starboard will cause the aft portion of the annulus to move downwardly but will have no effect on the forward portion of the annulus, whilst movement of the control handle to port will cause the forward portion of the annulus to move downwardly but will have no effect on the aft portion of the annulus.

The port jack **56** and the starboard jack **60** are controlled by the fore and aft movement of the control column **81** which is connected by a suitable linkage to the control valve of a servo motor **82**. Servo motor **82**, which is similar in construction to the servo motor **79**, is connected by hydraulic lines **83** and **84** to the jacks **56** and **60**. The operation of these two jacks can best be understood if it is assumed that selector handle **76** is in flying position so that the annulus **50** is in the position shown in full lines in FIGS. 4 and 5. If the control column **81** is moved forwardly the port jack **56** will be actuated to move the port side of the annulus downwardly thus increasing the upward thrust of the exhaust gases on the port side of the aircraft, whilst the starboard jack **60** will be actuated to move the starboard side of the annulus upwardly, thus increasing the downward thrust of the gases on the starboard side of the aircraft. If the pilot pulls back the control column, the operation of the jacks **56** and **60** is reversed with a consequent reversal of the direction of the increased thrust on the sides of the aircraft.

When the selector handle **76** is in take-off position the upper inboard portion of the annulus **50** is in contact with the upper wall of the orifice. If the control column **81** is moved either forwardly or rearwardly from neutral position when the selector handle is in take-off position, either the port side or the starboard side of the annulus (depending on the direction in which the control column is moved) will move downwardly whilst the other side will be unable to move.

Rerawardly directed louvres **85** are provided in the upper aerofoil surface of the port and starboard sides of the aircraft. These louvres are connected by ducts **86** to the jet exhauster duct **47**; thus a small fraction of the exhaust gases may be ejected to atmosphere through the louvres. The ducts may be opened or closed selectively by sliding shutters **87** which are linked by flexible actuating cables **88** to the respective rudder pedals **89** situated in the pilot's compartment. The additional thrust component caused by the exhaust gases ejected selectively through the port or starboard louvres **85** is sufficient to cause an unbalance of the forces about the yaw axis of the aircraft to provide directional control.

In operation, with the aircraft on the ground in a horizontal attitude, the pilot sets the control column **81** and the control handle **80** in central or neutral position so that the annulus **50** lies parallel to the medial plane of the aircraft. To take off, the selector handle **76** is placed at take-off position (the position opposite to that shown in FIG. 4) thus actuating the jacks **53**, **59**, **64** and **70** to locate the annulus in the position shown by chain dotted lines in FIGS. 4 and 5. The exhaust gases thus issue downwardly from the nozzle **48** providing a vertical component of thrust and the aircraft is borne vertically upwardly. The "ground cushion" effect as described in co-pending application Serial No. 502,156 is of assistance in causing take-off of the aircraft. The pilot, by controlling the engine output, is able to raise the aircraft from the ground in vertical ascent while the aircraft retains a horizontal attitude. In order to change from vertical take-off or hovering to forward slight, the selector handle **76** is moved gradually to flight position, thus operating the jacks **53**, **59**, **64** and **70** to move the forward portion of the annulus **50** inboardly with a consequential outboard movement of its aft portion and also to centralize the entire annulus relative to the medial plane. The annulus thus assumes the position shown in solid lines in FIGS. 4 and 5.

Lateral and longitudinal control of the aircraft is achieved through the manipulation of the control column **81** and of the control handle **80**. It will be understood that, in aircraft of this type utilizing a radial flow gas turbine engine, the gyroscopic effect of the rotor must be considered when designing an effective control system. In this respect, it is well known to those skilled in the art, that in order to correct a movement which affects the stability of the aircraft, the correcting moment must be applied 90° to the movement affecting the stability, and in a sense depending on the direction of the rotor. It has been assumed herein that the engine rotor rotates clockwise; consequently, for example, an up force must be applied to the port side of the aircraft in order to correct for a downward movement of the forward side of the aircraft.

A forward movement of the control column **81** will actuate the jacks **56** and **60** to cause the port portion of the annulus to move downwardly and to cause the starboard portion to move upwardly, thus applying a downward force to the port side and an upward force to the starboard side and causing the aircraft to "nose down." The jacks **56** and **60** will operate in the reverse manner if the column is pulled back, thus causing the aircraft to "nose up." If the control handle **80** is moved towards port the aft jack **71** will move downwardly thus applying a downward force to the aft portion of the nozzle and causing the port side of the aircraft to tilt downwardly. If the control handle **80** is moved to starboard, the jack **71** will operate in the reverse manner thus causing the starboard side of the aircraft to tilt downwardly.

When the selector handle **76** is in take-off position the aircraft can be trimmed by the operation of the control handle **80** and of the control column **81** in the same manner as described above. Of course, when the selector handle **76** is in take-off position the upper face of the annulus **50** is in circumferential contact with the upper wall of the orifice **48** so that no portion of the annulus can move upwardly, but some portion of the annulus will move downwardly in response to any movement of the control handle **80** or of the control column **81**.

By manipulation of the control handle **80** and of the control column **81** the annulus **50** may be moved in any direction relative to the orifice, within limits set mainly by its dimensions. In so doing it is possible to direct at least 80% of the jet in such a manner that it has a thrust component in the desired direction. In forward flight the remaining 20% of the thrust is recovered completely due to the Coanda principle of an attendant increase in the deflection of a jet around a wall when the effective pressure is increased.

It will be seen from the foregoing that by suitable movements of the annulus it is possible to accomplish all the control functions necessary to achieve complete control of the aircraft at all times.

The form of the invention herein shown and described is to be considered merely as an example. The details of construction of the engine do not form part of the invention, whilst the details of the control system are essentially schematic and by way of example only and are not an essential part of the invention. Obviously many changes in the construction shown not only are possible but may be desirable in order that the aircraft may have optimum performance. Such changes may, of course, be made without departing from the spirit of the invention or the scope of the subjoined claims.

What we claim as our invention is:

1. An aircraft comprising a lentiform structure, means for ejecting gases at high velocity from said aircraft through a substantially annular outlet generally encompassing the aircraft adjacent its outboard periphery, the gases being ejected in the form of a stream generally radial to the yaw axis of the aircraft at a multiplicity of positions distributed about the outlet, means for bifurcating said stream upon its ejection into two diverging streams and for directing said streams to have components of thrust parallel to said yaw axis but of opposite sense.



2. An aircraft as defined in claim 1 wherein said means for bifurcating said stream includes means for selectively reducing one of said two streams to zero to direct all of said gases into the other stream.

3. An aircraft as defined in claim 1 including means for varying the magnitudes of the two streams to thereby vary the relative magnitudes of said components.

4. An aircraft comprising a lentiform structure, means for ejecting gases at high velocity from said aircraft through a substantially annular outlet generally encompassing the aircraft adjacent its outboard periphery, the gases being ejected in the form of a stream generally radial to the yaw axis of the aircraft at a multiplicity of positions distributed about the outlet, means for bifurcating said stream upon its ejection into two diverging streams and for directing said streams to have components of thrust parallel to said yaw axis but of opposite sense, and means for varying the relative magnitudes of said components of thrust of the two streams.

5. An aircraft as defined in claim 1 wherein said means for bifurcating said stream comprises an annular member encompassing said outlet.

6. An aircraft as defined in claim 5 wherein said annular member is provided with at least one surface adjacent said outlet arranged at an angle to the plane of said stream.

7. An aircraft as defined in claim 5 wherein said annular member is provided with outwardly diverging surfaces adjacent said outlet arranged to deflect the gases of said stream into two streams having components of thrust parallel to said yaw axis, and means for moving said member to vary the relative magnitudes of said components of thrust.

8. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and having walls defining an outlet adjacent the perimeter of the structure and from which the air is ejected, the outlet extending around the periphery of the aircraft, an annularly arranged member encompassing the outlet and positioned in the path of the ejected air, the member in co-operation with the walls of the outlet providing two nozzles through which the air is ejected with opposite components of thrust, and means to control the relative magnitudes of the opposite components of thrust of the air ejected through the nozzles.

9. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected, the outlet extending around the periphery of the aircraft, a movable annularly arranged member encompassing the outlet, and means to adjustably position the member in the outlet to control the direction of flow of the ejected air to provide a propulsive thrust.

10. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected, the outlet extending around the periphery of the aircraft, a movable annularly arranged member encompassing the outlet and against the surface of which the ejected air impinges, the impinged surface comprising two contiguous surfaces at an acute angle to each other, means controlling the position of the member relative to the outlet in a direction

normal to the medial plane of the aircraft, and means for shifting the member relative to the outlet in directions parallel to the aforesaid medial plane.

11. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected in generally radial directions, the outlet extending around the periphery of the aircraft and being defined by outboardly diverging opposed annular walls, a movable annularly arranged member encompassing the outlet, the cross-section of the member and its diameter being so dimensioned that when the member is positioned concentrically in the outlet it may make circumferential contact with one of the outlet walls but be spaced from the opposed wall to define therewith an outlet passage, and means to adjustably position the member in the outlet to control the direction of flow of the ejected air and thus provide a propulsive thrust.

12. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected in generally radial directions, the outlet extending around the periphery of the aircraft and being defined by outboardly diverging opposed annular walls, a movable annularly arranged member encompassing the outlet, the cross-section of the member and its diameter being so dimensioned that when the member is positioned concentrically in the outlet it may make circumferential contact with one of the outlet walls but be spaced from the opposed wall to define therewith an outlet passage, means controlling the position of the member in the outlet in a direction normal to the medial plane between the aerofoil surfaces, and means for shifting the member eccentrically relative to the outlet.

13. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected in generally radial directions, the outlet extending around the periphery of the aircraft and being defined by outboardly diverging opposed annular walls, a movable annularly arranged member encompassing the outlet, the cross-section of the member and its diameter being so dimensioned that when the member is positioned concentrically in the outlet it may make circumferential contact with one of the outlet walls but be spaced from the opposed wall to define therewith an outlet passage, and means to adjustably position the member in the outlet to control the direction of flow of the ejected air and thus provide a propulsive thrust, the member being positionable relative to an outlet wall to constitute therewith a Coanda nozzle.

14. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected in generally radial directions, the outlet extending around the periphery of the aircraft and being defined by outboardly diverging opposed annular walls, a movable annularly arranged member encompassing the outlet, the cross-section of the member and its diameter being so dimensioned that when the member is positioned concentrically in the outlet it may make circumferential contact with one of the outlet walls but be spaced from the opposed wall to define therewith an outlet passage,



supporting means for the member and conditionable to hold the member at a take-off position where the member is concentric with the outlet and at a flying position where the member is eccentric with the outlet, and pilot operated means to condition the supporting means.

15. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected in generally radial directions, the outlet extending around the periphery of the aircraft and being defined by outboardly diverging opposed annular walls, a movable annularly arranged member encompassing the outlet, the cross-section of the member and its diameter being so dimensioned that when the member is positioned concentrically in the outlet it may make circumferential contact with one of the outlet walls but be spaced from the opposed wall to define therewith an outlet passage, supporting means for the member and conditionable to hold the member at a take-off position where the member is concentric with the outlet and at a flying position where the member is eccentric with the outlet, the supporting means including means for shifting the member relative to the outlet in a direction generally normal to the medial plane of the aircraft so as to trim the aircraft when the member is held concentrically or eccentrically by the supporting means.

16. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected in generally radial directions, the outlet extending around the periphery of the aircraft and being defined by outboardly diverging opposed annular walls, a movable annularly arranged member encompassing the outlet, the cross-section of the member and its diameter being so dimensioned that when the member is positioned concentrically in the outlet it may make circumferential contact with one of the outlet walls but be spaced from the opposed wall to define therewith an outlet passage, means for movably supporting the member at each of its front, rear, and two side sectors, each of the said means comprising elements operable in unison to locate selectively the member at a take-off position where it is substantially concentric with the outlet and at a flying position where it is displaced eccentrically relative to the outlet in a rearward direction to seal the front portion of the outlet, and elements to shift the rear and the side sectors in a direction transverse to the medial plane of the aircraft so as to trim the aircraft, and pilot operated means for operating the elements.

17. An aircraft comprising a generally lentiform structure which is sheathed by opposed aerofoil surfaces which provide lift developing surfaces, engine means within the structure and embodying an air displacement passage having an intake and an outlet adjacent the perimeter of the structure and from which the air is ejected in generally radial directions, the outlet extending around the periphery of the aircraft and being defined by outboardly diverging opposed annular walls, a movable annularly arranged member encompassing the outlet, the cross-section of the member and its diameter being so dimensioned that when the member is positioned concentrically in the outlet it may make circumferential contact with one of the outlet walls but be spaced from the opposed wall to define therewith an outlet passage, means for movably supporting the member at each of its front, rear, and two side sectors, each of the said means comprising elements operable in unison to locate selectively the member at a take-off position where it is substantially concentric with the outlet and at a flying position where it is displaced

eccentrically relative to the outlet in a rearward direction to seal the front portion of the outlet, an element to shift the rear sector in a direction transverse to the medial plane of the aircraft, elements to shift the side sectors in unison in a direction transverse to the aforesaid medial plane but in respectively opposite senses, and pilot controlled means for selectively operating the elements.

18. An aircraft comprising a generally lentiform structure sheathed by opposed lift developing surfaces, a gas displacement passage in the structure having an intake and having a substantially annular outlet adjacent to the periphery of the structure, the passage extending generally radially relatively to the yaw axis of the aircraft in a multiplicity of diverging directions, the annulus defining the outlet being disposed generally perpendicular to the yaw axis, means for impelling gas to flow through the passage from the intake to the outlet in a plurality of centrifugal directions relative to the yaw axis, and further means, associated with the outlet, for bifurcating the stream of gases passing through the outlet into two diverging streams and operable to direct said streams to provide components of thrust on the aircraft parallel to the yaw axis and of opposite sense.

19. An aircraft as defined in claim 18, wherein said means for bifurcating said stream includes means for selectively reducing one of said two streams to zero to direct all of said gases into the other stream.

20. An aircraft as defined in claim 18, including means for varying the magnitudes of the two streams to thereby vary the relative magnitudes of said components.

21. An aircraft as defined in claim 18, wherein said means for bifurcating said stream comprises an annular member encompassing said outlet.

22. An aircraft comprising a generally lentiform structure sheathed by opposed lift developing surfaces, a gas displacement passage in the structure having an intake and a substantially annular outlet adjacent to the periphery of the structure, the passage extending generally radially relatively to the yaw axis of the aircraft in a multiplicity of diverging directions, the annulus defining the outlet being disposed generally perpendicular to the yaw axis, means for impelling gas to flow through the passage from the intake to the outlet in a plurality of centrifugal directions relative to the yaw axis, further means, associated with the outlet, for bifurcating the stream of gases passing through the outlet into two diverging streams, said further means being operable to direct said streams to provide components of thrust on the aircraft parallel to the yaw axis and also to vary the relative magnitudes of said components of thrust.



23. An aircraft comprising a generally lentiform structure sheathed by opposed lift developing surfaces, a gas displacement passage in the structure having an inlet and a substantially annular outlet adjacent to the periphery of the structure, the passage extending generally radially relatively to the yaw axis of the aircraft in a multiplicity of diverging directions, the annulus defining the outlet being disposed generally perpendicular to the yaw axis, means for impelling air to flow through the passage from the intake in a plurality of centrifugal directions relative to the yaw axis, means for compressing the centrifugally flowing air, means for burning fuel in the compressed air, the combustion gases resulting from the burning of the fuel being emitted as a stream from the outlet, and further means, associated with the outlet, for bifurcating the stream of gases emitted from the outlet into two diverging streams and operable to direct said streams to provide components of thrust on the aircraft parallel to the yaw axis and of opposite sense.

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ROTATING DISC TYPE AIRCRAFT

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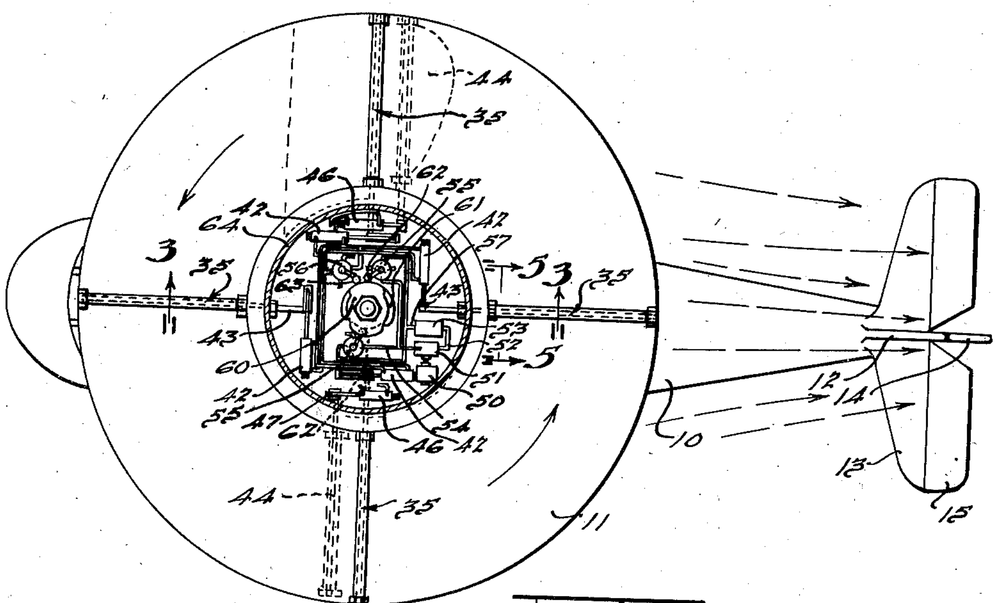


FIG. 1.

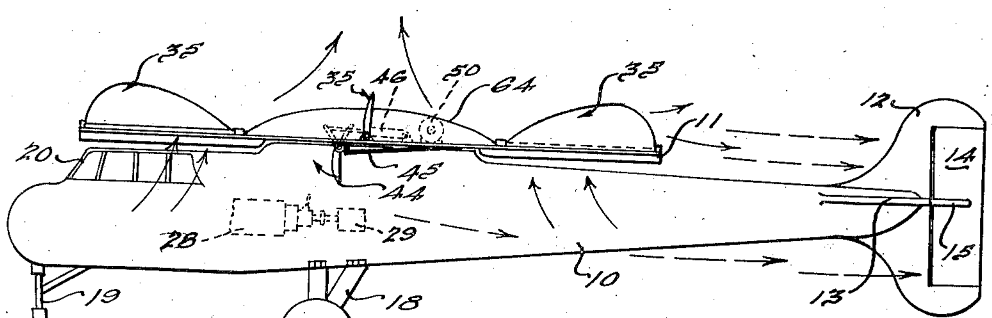


FIG. 2.

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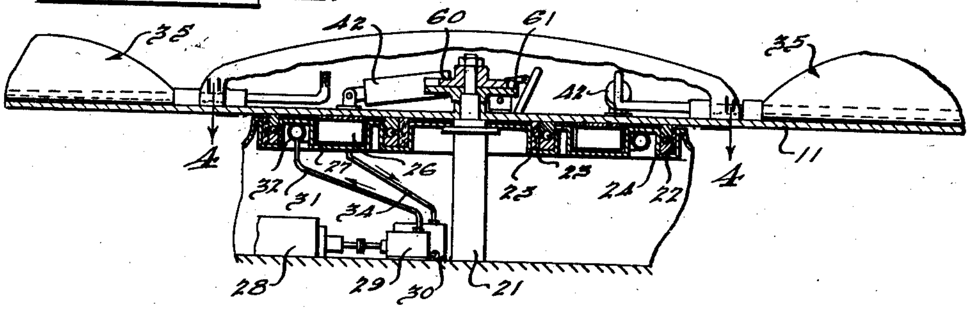
FIG. 3.



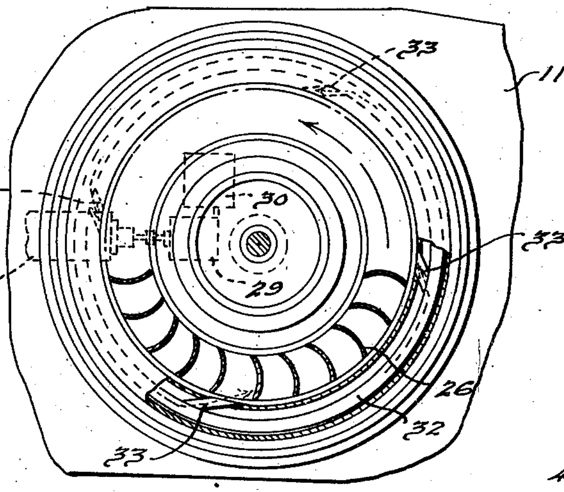


FIG. 4.

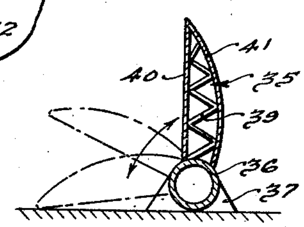


FIG. 5.

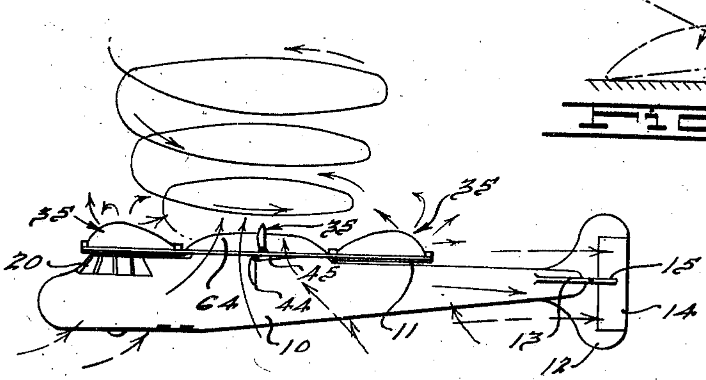


FIG. 6.

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2,432,775

# UNITED STATES PATENT OFFICE

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## ROTATING DISC TYPE AIRCRAFT

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Application June 9, 1943, Serial No. 490,171

3 Claims. (Cl. 244—17)

1

The present invention relates to improvements in aircraft and particularly to improvements in aircraft of the vertically rising, rigid rotating wing type.

The principal objects of the present invention are:

1. To provide an aircraft which is lifted in a vertical plane by means of a rotating disc or plate which upon rotation creates a differential air pressure on its upper and lower face surfaces, the lower pressure being adjacent the central portion of the upper face surface, thereby causing the aircraft to rise or descend if desired, in a substantially vertical plane with a minimum of movement in a horizontal plane.

2. To provide an aircraft of novel and distinctive design in which a rigid rotating plate is utilized to perform the combined functions of a lifting wing and a propeller or air screw.

3. To provide an aircraft particularly characterized by its relatively high lifting efficiency which is combined with an improved and efficient propulsion system by means of which high speeds in a horizontal plane are permitted.

4. To provide an aircraft in which the lifting and propulsion of the aircraft is accomplished by the rotation of a rigid disc member which, in addition to generating lifting forces exerted in a vertical direction and propulsion forces exerted in a longitudinal direction, also generates gyroscopic forces which impart stability to the said aircraft.

5. To provide an aircraft of the rotating rigid wing type in which a rotating plate is driven by hydraulically actuated driving mechanisms which transmit a driving force to a plurality of points on the rotating plate and thus provides a balanced mechanism in which the tendency of the rotating plate member to rotate in other than a horizontal plane is effectively neutralized.

6. To provide an aircraft designed to operate on a principle of flight based upon the creation of a conically shaped zone of disturbance having its central reduced pressure area surrounding its central vertical axis which is coincident with a vertical line which passes through substantially the center of gravity of the aircraft.

7. To provide an aircraft construction utilizing a rotating rigid disc type of lifting member in which provision is made for varying the lifting effect of the said disc by varying its effective air contacting surface area so as to provide the maximum vertical lifting effect during take-off and landing, and upon adjustment to provide lesser lifting forces which are sufficient to sustain

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the aircraft in the air during flight, the said adjustment also reducing resistance of the said disc to forward movement in a horizontal plane.

Other objects and advantages of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

Fig. 1 is a top plan view with parts broken away showing an aircraft embodying the principal features of the present invention.

Fig. 2 is a side elevation of the aircraft shown in Fig. 1.

Fig. 3 is an enlarged sectional view taken substantially on the line **3—3** of Fig. 1 looking in the direction of the arrows.

Fig. 4 is a sectional view with parts broken away taken substantially on the line **4—4** of Fig. 3 looking in the direction of the arrows.

Fig. 5 is a sectional view taken substantially on the line **5—5** of Fig. 1 looking in the direction of the arrows.

Fig. 6 is a side elevation with schematic indication of airflow and showing an aircraft of the present invention in flight.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Before describing the structural details of the present aircraft shown in the accompanying drawings, I desire to explain the theory of flight which is utilized therein. In view of the known tendency of science to re-examine its theoretical concepts in the light of the constantly accumulating scientific data, I do not desire to be limited strictly to the theory of flight herein outlined, inasmuch as there are a large number of physical forces of substantial magnitudes which are brought to bear upon the aircraft embodying the present invention, the exact nature of which can only be finally calculated and determined after exhaustive tests and careful study and correlation of the data so obtained.

The following theory and process is based upon basic observations and studies which I have made and from which I have formulated the general theory of flight which I shall now explain.

The aircraft herein disclosed embodying this theory has, it is believed, a higher efficiency in operation than previously known aircraft of comparable capacity and of conventional construction.

I have observed that when a flat disc is propelled through the air while rotating in a horizontal plane, it will travel a greater distance with the same propulsive force than if projected without rotation. I believe that this is due to the fact that the rotation of the mass utilizes in an efficient manner all the forces applied thereto which cause both its rotation and its propulsion through space. The mass, through its rotation, conserves the initial forces applied thereto and these conserved forces are made available to prolong its travel and overcome the inertia of the mass. This assists in maintaining the velocity of the mass so that it travels at a sufficient speed through the air for a greater horizontal distance before it is drawn to the earth by gravitational forces than is the case where an equal initial force is applied to the same disc which is propelled through space without rotation thereof.

The work required to set the disc in motion is partially stored in the disc as kinetic energy of rotation. The momentum of the rotating disc thus possesses a linear moment which is the product of its mass times its velocity, and an angular momentum which is the product of its rotary inertia and its angular velocity around a given axis. The propulsion force acting on the disc as a free mass changes its momentum and its rotary inertia in proportion to the mass and to the square of the distance of the mass from the axis of rotation. Thus a disc in rotation about an axis freely movable in either a horizontal or a vertical plane will continue in motion while a disc which is not so rotating will cease to continue in motion.

A familiar example of this principal is to be observed in the throwing of a discus. Here the discus is rotated in a substantially horizontal plane while it travels in an arcuate path through space. Another example of the principle is found in toy devices in which a high speed of rotation is imparted to a disc having vanes thereon and as the disc attains a sufficient velocity and is freed from a restraining axis, it will ascend vertically at a very high rate of speed and will descend slowly so long as there is a sufficient rotary motion in the member to exert a force which tends to retard the rate of descent under gravitational attraction.

In the aircraft of the present invention, I have utilized the principles of a rotating circular disc to provide for both vertical and horizontal movement of the airplane and I believe that the foregoing theories when applied to a structure as herein disclosed and claimed will result in an airplane having higher operating efficiencies than an aircraft of conventional design having a fixed rigid wing. I have increased the lifting and propulsive effect of this member by providing vanes at spaced points on the upper and lower surfaces of the disc so that I am enabled to cause such turbulence in the air as to create a conical zone of disturbance having its vortex and point of lowest pressure adjacent the point of the center of gravity of the aircraft of the present invention, and thus am enabled to impart efficiently a vertical lifting force to the aircraft. By my provision of movable vanes on the lower surface of the rotating disc I am enabled to control movement of the aircraft in a desired horizontal plane. The distance of such horizontal plane from the earth's surface is determined by adjustment of the movable vanes carried on the top surface of the rotating rigid disc and the speeds of rotation imparted thereto.



Referring to the drawings, the aircraft fuselage 10 is provided with a rotating disc 11, which will be hereafter more fully described, and which in the preferred embodiment of my invention takes place of both the wing construction and the air screw or propeller of conventional aircraft design. The fuselage 10 is provided with a vertical stabilizer 12, which extends a substantially equal distance above and below the center line of the fuselage 10, and acts to stabilize the movement of the aircraft in a horizontal plane. A horizontal stabilizer 13 is provided for stabilizing the movement of the aircraft in a vertical plane. The vertical stabilizer 12 is provided with a movable rudder section 14, which acts to guide the movement of the aircraft in a horizontal plane. The horizontal stabilizer 13 is provided with a movable rudder section 15 for directing movement of the aircraft in a vertical plane.

Body landing wheels 16 and a nose wheel 17 of any desired conventional construction are mounted respectively on the retractable landing members 18 and 19. The construction herein shown is that of a conventional "tricycle" type of landing gear, and while this is a preferred construction, it is to be distinctly understood that any suitable type of landing gear may be employed.

The fuselage 10 has a pilot compartment 20 which is located forward of the center of gravity of the aircraft. The center line of a rigid post or pillar 21, on which the rotating disc 11 is mounted for rotation is mounted so that the center of gravity of the aircraft falls on said center line. The rigid post or pillar 21 is secured to the structural framework of the aircraft fuselage and the lifting of the fuselage by forces transmitted through the rotating disc is accomplished through the said rigid post or pillar 21. The rotating disc 11 is mounted for rotation on the rigid post or pillar 21 by means of any suitable type of bearing construction and is locked against vertical movement relative thereto. Thus a lifting force exerted by the rotating disc 11 is transmitted through the rigid post or pillar 21 to the structural framework of the fuselage 10.

The rotating disc 11 is supported by bearing members 22 and 23 which are spaced concentrically with respect to the post or pillar 21 and with regard to each other. The bearing members 22 and 23 are rotatably retained in bearing races 24 and 25, which are formed in a structural portion of the fuselage 10 adjacent the top thereof. If desired, any suitable type friction reducing bearings may be employed in connection with these bearing members, such for example as ball or roller bearings, which are supplied with lubricant from any suitable source (not shown).

Rotation of the disc 11 may be accomplished by any desired means, such for example as electrical, mechanical or hydraulic transmission of power from a power source.

The preferred form of construction such as is here shown and will be now particularly described is a hydraulic transmission. In this instance the lower face of the disc 11 carries a plurality of arcuate turbine blades 26, which are mounted in the concentric race 27. Movement of the disc 11 is accomplished by fluid pressures generated by an engine 28 of any desired type and exerted on the turbine blades 26. The engine 28 is preferably a liquid cooled internal combustion engine connected in driving relation to a pressure pump 29, which draws the hydraulic fluid from a reservoir 30. The hydraulic fluid under pressure is supplied to the turbine blades 26 through a pressure line 31 to a concentric header 32 having a plurality of symmetrically disposed jets 33 discharging high pressure fluid for contact with the turbine blades 26. The spent hydraulic fluid is returned from the race 27 to the reservoir 30 through the return line 34.

The rotating disc 11 as previously mentioned acts both as the lifting medium for movement in a vertical plane and as an air screw for propulsion of the aircraft in a horizontal plane. The disc 11 is provided with a plurality of movable radial vanes 35, which are symmetrically disposed on the top thereof as shown in detail in Fig. 1. As shown in Fig. 5 each of the movable vanes 35 consists of a hollow tubular shaft 36, which is journaled for rotation in bearings 37 carried on the plate 11. A hollow fin 35 is secured to the tubular shaft 36 and has a suitable interior reenforcing frame member 39. The fin 35 is covered with a suitable air impermeable covering. The hollow fin 35 is so constructed as to provide a flat air engaging surface 40, and a curved air foil surface 41. Each of the movable radial vanes 35 may be rotated through an arc of approximately 90 degrees to the top surface of the plate 11. When rotated so that the center line of the vane 35 is approximately normal to the plane of the top surface of the disc 11, the disc and vanes will exert the maximum lifting effect on the aircraft. In this position upon rotation of the disc 11 a relatively large surface is brought in contact with the air and a turbulent condition is set up in the air immediately on top of the plate 11. After the aircraft is air borne and has attained a flying speed, the movable vanes 35 may be moved so that the center lines of the vanes extend at angles less than 90 degrees to the face of the top surface of the rotating disc 11.

In these positions shown by the intermediate dotted lines in Fig. 5, less of the surfaces of the members 35 is available for contact with the air, and the resultant lifting effect is less than the maximum lifting force exerted by the members when fully raised. If desired the members 35 may be rotated so that the center lines thereof lie in a plane substantially parallel to the top surface of the disc 11 as shown by the dotted line position. When in this position, the disc 11 and the vanes 35 are exerting their minimum lifting effect on the aircraft. In this position, the resistance to movement of the aircraft forwardly in a horizontal plane is decreased and the turbulent effect of the disc 11 on the air is at its minimum.

The movement of the vanes 35 relative to the disc 11 to vary the lifting force exerted by the disc 11, is actuated and controlled by any suitable means, such for example as a plurality of hydraulically actuated cylinders 42, having movable pistons therein, which are carried on the rotating disc 11. Each of these pistons is connected with a crank arm 43, which is connected operatively with each of the hollow tubular shafts 36, so that upon movement of the crank arms 43, the shafts 36 are rotated as may be desired for the positioning of the members 35 relative to the disc 11.

In order to provide for forward movement of the aircraft in a horizontal plane, a plurality of symmetrically disposed downwardly extending movable vanes 44 are provided on the lower face of the disc 11. These vanes may be constructed in a manner similar to that previously described in connection with the top movable vanes 35.

Adjacent each vane 44 is a stepped member 45 which is secured to the lower face of the disc 11, and acts to preliminarily baffle or direct the air currents as the disc is rotated so that the air currents are deflected in a downward direction prior to the time when they are contacted by the flat air engaging surface of the adjacent movable vane member 44. Each of the vane members 44 is moved from its open depending position as shown in Fig. 2, to a folded position so as to permit its movement over the top of the fuselage 10. It is held in the folded position as it travels through the arc of movement on the opposite side of the fuselage 10 so that the movement of the vane 44 for driving the aircraft forwardly in a horizontal plane occurs only on one side of the fuselage 10. The movement of the vanes 44 from their open to their closed position is accomplished by a plurality of hydraulically actuated cylinders 46, which are mounted on the rotating disc 11. Each of the cylinders is provided with a movable piston which is connected with a crank arm 47 connected to each of the movable vanes 44 for translating the linear movement of the piston into rotary movement of the connected vane 44.

Power for the movement of the vanes 35 and the vanes 44 is supplied by a suitable hydraulic power circuit which is a separate unit from the hydraulic circuit previously discussed, and which is mounted to rotate as a unit with the rotary disc 11 and the vanes 35 and 44. This hydraulic power circuit comprises a motor 50, which may be of any suitable type, which is connected in driving relation with the hydraulic pressure pump 51, which is connected by the supply duct 52 with a reservoir 53, from which hydraulic fluid is supplied to the said pressure pump 51. Power lines 54 lead to control valves 55, which control the flow of hydraulic fluid to the pistons 46, and to a control valve 56 which controls the supply of hydraulic fluid to the cylinders 42.

From the control valves 55 and 56 suitable hydraulic power supply lines lead to the respective cylinders and are arranged so as to discharge fluid under pressure selectively to the sides of the movable piston therein so as to cause its movement in a desired direction. From these cylinders suitable hydraulic lines 57 are provided and act as return lines for returning the fluid to the reservoir 53.

The valves 55 and 56 are separately controlled preferably by the separate control cam members 60 and 61, which are secured to the top of the post or pillar 21. Cam followers 62 and 63 are provided on valves 55 and 56 respectively, and operate the valves 55 and 56 when moved relative to the cams 60 and 61. The cam 60 is preferably a contour cam which is secured to the post or pillar 21 so that as the disc 11 rotates, the cam follower 62 is moved on the contour of the cam 60, and operates the valves 55 in a regular cycle so as to control the flow of hydraulic fluid to the pistons to raise and lower the vanes 44 at predetermined points in the rotation of the disc 11.

The cam 61 is an adjustable cam which may be adjusted as desired to vary selectively the opening and closing of the valve 56, or the holding of the valve in a predetermined position so as to lock the hydraulic fluid in the lines and thus to hold the fins 35 in any desired operating position relative to the top surface of the rotating disc 11.

The central portion of the disc 11 is provided with a hub-like covering 64, which not only encloses the operating mechanism previously described, but also acts as an overhead reenforcing member for the central portion of the disc 11 so as to counteract the tendency of the disc to be dished or bulged in its central portion. The hub-like member 64 also acts to transfer the loading uniformly over the central portion of the disc 11.

In the several views, I have indicated schematically by arrows the direction of the air currents which are generated by the aircraft in flight. As shown in Fig. 6, the rotation of the disc 11 creates a whirling turbulent condition of the air above the disc 11 in the form of a conical zone of disturbance, the vertical axis of which is located at the center of gravity of the aircraft. An area of diminished pressure is created inside the said conical zone of disturbance and the greatest pressure differential is in the area immediately adjacent the vertical axis thereof. Thus the air under pressure whirling in the spiral path indicated in the spiral line and arrows, surrounds an area of diminished pressure which causes an updraft and an upward rush of air into this zone of decreased pressure. Creation of this condition in the air is accelerated by the shape of the movable vanes 35, which as shown, have their greatest surface area adjacent the circumference of the disc 11 but tapers downwardly toward the hub portion 64 of the disc 11. Thus the greatest volume and area of air set in motion is that adjacent the outer circumference of the disc 11 and this volume and area decreases adjacent the hub portion 64. Thus the shape of the members 35 combined with the rotation of the disc 11, tend to move the greatest volume of air the greatest distance at the point of the greatest angular movement of the members 35 through the air, which is at a point lying adjacent the circumference of the disc 11. By this means the location of the turbulent zone is definitely maintained so that its maximum lifting force is exerted on the hub portion 64 at the center of gravity of the aircraft. Due to the shape of the members 35, the greatest volume and, therefore, the greatest weight of air is located adjacent the circumference of the rotating disc 11. The suspension of the fuselage 10 at its center of gravity from the axis of the disc 11 counteracts the forces which are created by the rotation of the disc and which would tend to cause the hub portion 64 to be pulled out of alignment in an upwardly direction due to the combined action of the air forces on the circumference of the disc 11 tending to deflect it downwardly and the diminished pressure zone created adjacent the top of the hub member 64 tending to deflect this portion of the disc upwardly. It will be seen that this construction thus utilizes the forces created by the rotation of the disc 11 to counteract the forces which otherwise would pull portions of the member 11 out of their alignment in a fixed horizontal plane.

The normal tendency of a rotating disc member, such as the disc 11, is to cause the fuselage 10 of the airpcraft to oscillate about the post or lifting pillar 21. To counteract this effect, I have provided a vertical stabilizer 12, which extends an equal distance above and below the longitudinal center line of the fuselage 10. Direction of the aircraft in a horizontal plane is accomplished by movement of the rudder portion 14 of the vertical stabilizing member 12.



Movement of the aircraft in a vertical plane is controlled by the vertical stabilizer 13 and the movable rudder portion 15 associated therewith.

In operation, the aircraft when in the landed position as shown in Fig. 2 is first caused to ascend substantially vertically by rotation of the disc member 11 with the top fin members 35 in their fully raised position. This creates the maximum condition of turbulence in the air above the disc 11 and the updraft thus created as indicated by the upwardly directed arrows in Fig. 2, exerts a lifting effect on the rotating disc 11 causing the plane to begin its vertical ascent. At the same time the movable vane 44 in the lowered position as shown in Fig. 2 has exerted a forwardly pushing effect on the air as indicated by the horizontally extending arrows in this figure. This causes a forward movement of the aircraft in a horizontal plane. The resulting movement of the aircraft is along an angular line which is not necessarily at right angles to the landing surface but is instead an intermediate line which lies between a horizontal and a vertical line. Thus the ascent of the aircraft may result from both the vertical lifting force and the horizontal impelling force, both of which are created by the rotation of the disc 11. If desired, provision may be made to hold the moveable vane 44 in its fully retracted position for the entire rotation of the disc 11. In this event, the ascent of the aircraft will be substantially on a vertically extending line. In either event, the angle of ascent is much steeper, that is, it lies nearer the vertical line, than is the case with conventional aircraft using a rigid wing and a rotating air screw or propeller for the lifting and propulsion of the aircraft. The lifting force and the angle of ascent or descent also is controlled in part by the horizontally extending rudder portion 15, which may be so adjusted as to increase or decrease, as may be desired, the angle of ascent or of descent of the aircraft.

If desired, a conventional type of propeller or air screw may be utilized in conjunction with the rotating disc member 11, in which event the disc member 11 would provide the lifting force for the aircraft while the air screw would provide for the propulsion of the aircraft in a horizontal plane. In this event, the moveable vanes 44 would be eliminated therefrom.

Also it is to be understood that the horizontal stabilizing member 12 extending above and below the horizontal center line of the fuselage 10, may be employed with other types of aircraft where it is desired to counteract a tendency of the aircraft to oscillate in a horizontal plane about its center of gravity. The stabilizing member 12, may if desired, extend only above the center line of the fuselage 10.

Any desired means may be employed to secure the rotation of the disc 11. The hydraulic construction herein disclosed has the desirable feature of providing a substantially uniform distribution of the driving forces so as to assure a balanced rotation of the disc 11. By this construction the power thrust on the vanes on one side of the disc is counteracted by an equal power thrust on the vanes on the opposite side. It is to be understood that any desired number of power jets may be utilized so as to provide a uniform and steady flow of power to the rotating disc 11.

While I do not desire to be limited to any dimensions or operational characteristics of a device embodying the present invention, I believe that a desirable combination is a disc approximately thirty feet in diameter, which will rotate at approximately 30 R. P. M. Due to the large circumference of such a rotating disc 11, the effect on the air of the movement of the disc at such a relatively slow rate is comparable to the lifting effect obtained by moving a smaller volume of air at a higher rate of speed.

The aircraft embodying the present invention is such that the fuselage portion 10 may be laid out to conform to the most efficient form of air flow so as thus to reduce to a minimum the resistance to horizontal movement. This also permits the most efficient utilization of the interior of the fuselage to secure a uniform distribution of the weight of the fuselage and its contents in relation to the center of gravity at the axis of the rotating lifting disc.

I claim:

1. An aircraft lifting and propulsion unit comprising a power driven rotating disc adapted to be secured to an aircraft fuselage with its axis located on a line passing through the center of gravity of the aircraft, and having a convex central hub portion, a plurality of radially disposed vanes pivotally mounted on the top surface of said disc for movement about their longitudinal axes, said vanes extending outwardly from the periphery of said convex central hub portion of said disc to points adjacent the circumference of said disc, power actuated means for moving said vanes about their longitudinal axes to control the amount of surface in contact with the air upon rotation of said disc, and power means for rotating said disc.

2. Aircraft propulsion means comprising a power driven rotating disc adapted to be secured to the fuselage of an aircraft with its axis located on a line passing through the center of gravity of said aircraft, a convex central hub housing secured to said disc, a plurality of radially disposed movable vanes pivotally mounted on the top sur-



face of said disc and extending radially outward from the periphery of said convex central hub housing to points adjacent the circumference of said disc, and power actuated means controlled manually for effecting and controlling the pivotal movement of the said radially disposed vanes relative to the top surface of said rotating disc to vary the effective air contacting surfaces thereof.

3. Aircraft propulsion means comprising a rotating disc adapted to be secured to the aircraft fuselage with its axis located on a line passing through the center of gravity of the aircraft, a convex central housing secured to said disc, means carried by said disc for controlling the forces generated by the rotation thereof to effect movement of the aircraft in both a horizontal and a vertical plane, said means comprising a plurality of radially disposed movable vanes pivotally mounted on the top surface of said disc and extending from the periphery of said convex housing to points adjacent the circumference of said disc, hydraulically actuated means for moving said vanes relative to the surface of said disc to vary the effective air contacting surfaces thereof, means for rotating said disc comprising an hydraulic power transmission system constructed and arranged to transmit a force to said disc to effect its rotation, a plurality of radially extending steps on the under side of said disc, an extensible and retractible vane secured on the underside of said disc adjacent each of said steps and hydraulically actuated means for extending and retracting said last named vanes in timed relation to the rotation of said disc.

CLARENCE D. LENNON.

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RADIAL FLOW GAS TURBINE ENGINE ROTOR BEARING

Filed April 18, 1955 3 Sheets-Sheet 1

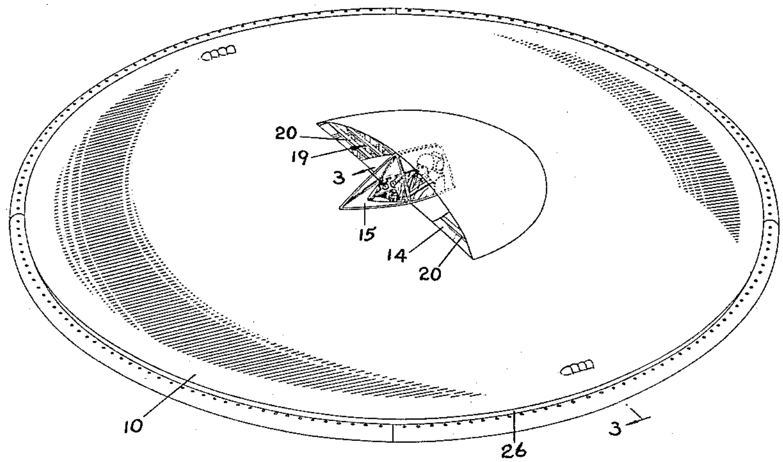
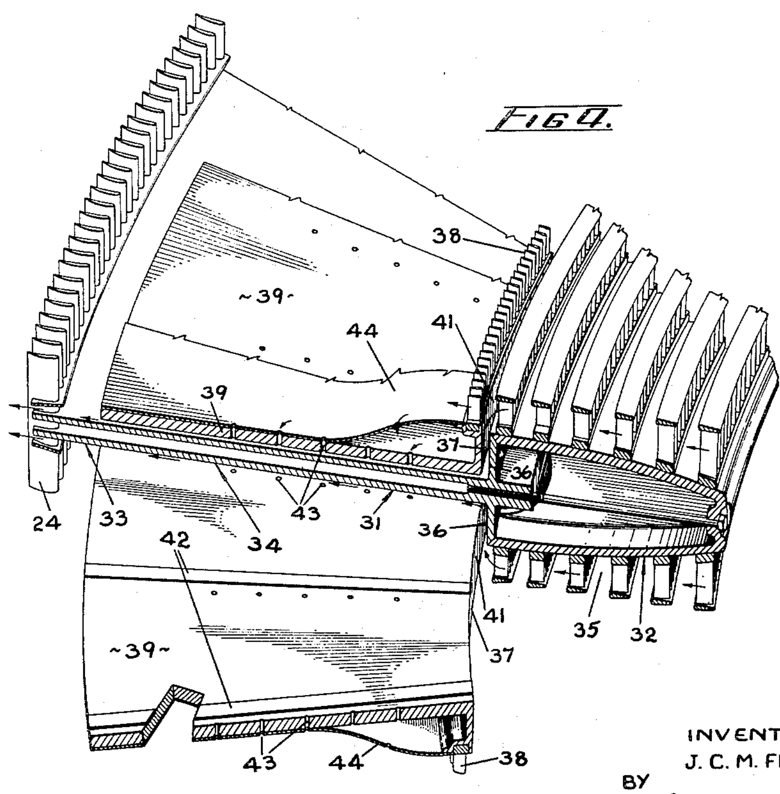



FIG. 1.

FIG. 4.

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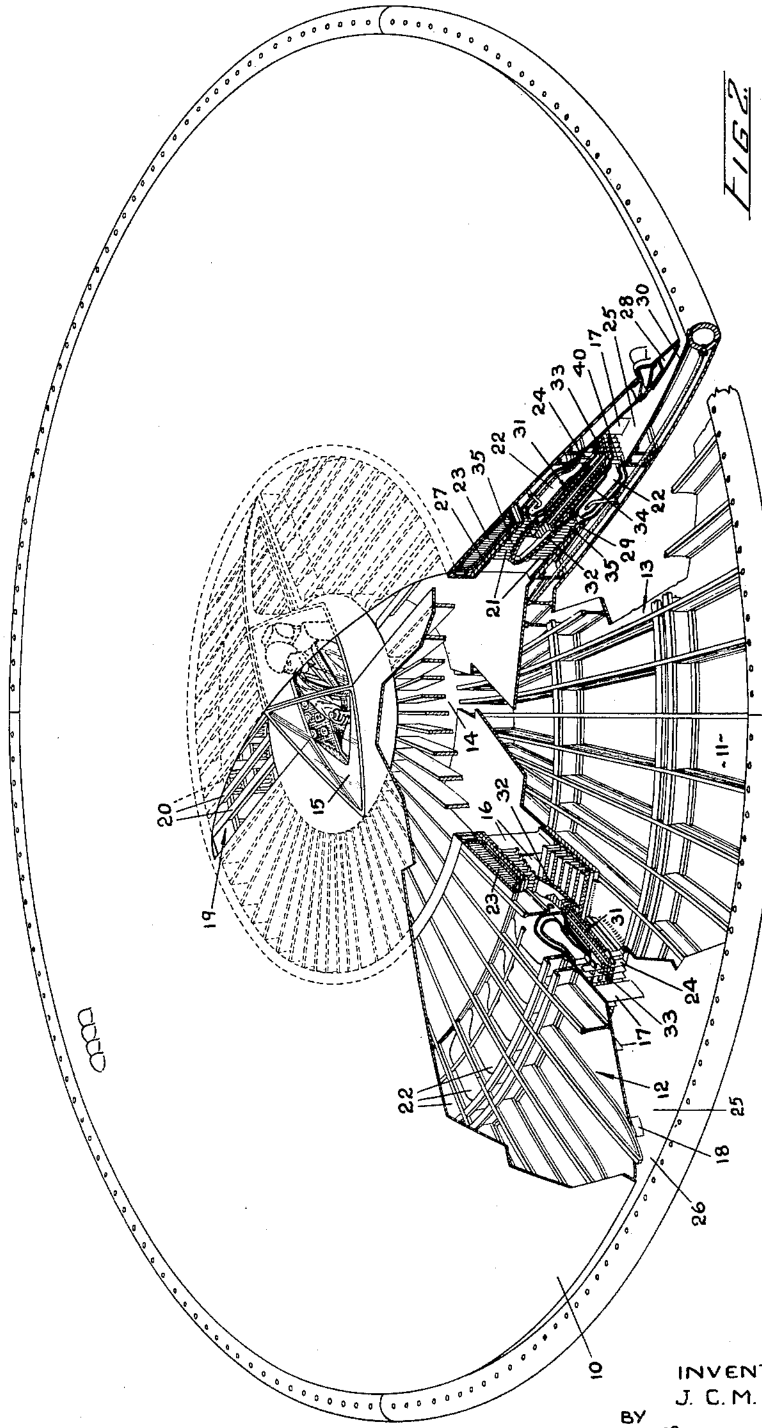


FIG. 2

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RADIAL FLOW GAS TURBINE ENGINE ROTOR BEARING

Filed April 18, 1955 3 Sheets-Sheet 3

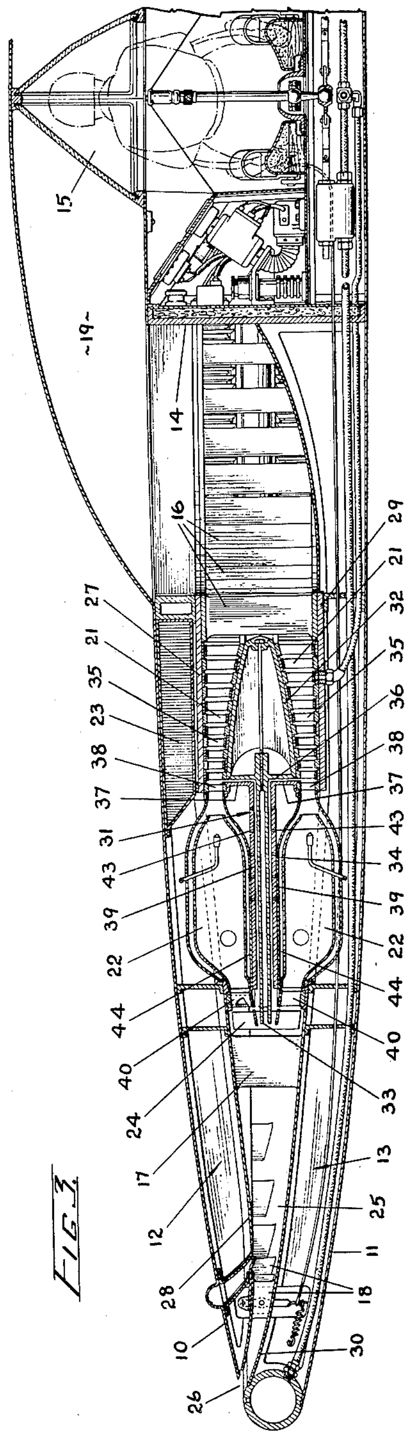


FIG 3

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United States Patent Office — 3,024,966 — Patented Mar. 13, 1962

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3,024,966

# RADIAL FLOW GAS TURBINE ENGINE ROTOR BEARING

John Carver Meadows Frost, Georgetown, Ontario, Canada, assignor, by mesne assignments, to Avro Aircraft Limited, Malton, Ontario, Canada, a corporation

Filed Apr. 18, 1955, Ser. No. 502,155
Claims priority, application Great Britain June 18, 1954
7 Claims. (Cl. 230—116)

This invention relates to the suspension of rotors in gas turbine engines and particularly to the suspension of rotors in gas turbine engines of the kind which form an integral part of aircraft of the general type disclosed in the co-pending patent application of John Carver Meadows Frost, Serial No. 376,320, filed on August 25, 1953.

As described in that application, the rotor is supported by roller bearings interposed between the rotor and the stator. However, due to the large area of the rotor and to its high speed of rotation and in order to avoid uneven running and vibration which may cause over-heating, it is necessary to work to very fine tolerances when machining and fitting the raceways and the bearing mountings. The high standard of workmanship, together with the large number of precision parts required, substantially increase production costs. By the present invention, the raceways and roller bearings are dispensed with.

It is the main object of the invention, therefore, to provide means for supporting the rotor of a radial flow gas turbine engine so that there is no metal-to-metal contact of bearing surfaces at the high linear velocities encountered during normal rotational speeds of the engine.

It is a further object of the invention to provide a rotor suspension which does not necessitate close manufacturing tolerances or unusual production methods and materials.

The invention is based on the principle that a fluid under pressure and constrained to flow through a pipe of constant cross-section experiences an increase in pressure and a decrease in velocity when it issues into a pipe the cross-sectional area of which is larger than that of the pipe in which it was originally constrained.

The foregoing and other objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, in which like reference characters indicate corresponding parts throughout the several views, and in which:

FIG. 1 is a perspective view of an aircraft of the kind which may be powered by an integral radial flow gas turbine engine incorporating a rotor suspension or bearing constructed in accordance with the invention;

FIG. 2 is a perspective view of the said aircraft, partly broken away to show particularly the internal construction of the engine;

FIG. 3 is a radial sectional view of the said aircraft, taken substantially transversely of the direction of flight, and more particularly as indicated by lines 3—3 of FIG. 1; and

FIG. 4 is an enlarged fragmentary perspective view of a sector of the rotor and showing some of the surrounding stator structure.

For greater convenience throughout the description and the claims certain terms of positional relationship are used; the terms "outboard" (or "outboardly") and "inboard" (or "inboardly") denote, respectively, greater and lesser distances from the axis of rotation of the rotor, and the terms "outer" and "inner" similarly denote greater and lesser distances from a medial plane of the aircraft coinciding with the plane of the rotor.

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The opposed aerofoil surfaces of an aircraft of the kind in which an engine embodying the invention may be used are constituted by upper skin **10** and lower skin **11**, supported respectively on the outer edges of an upper series of ribs and spacers generally indicated at **12** and a lower series of ribs and spacers generally indicated at **13**. The two series of ribs and spacers and the skins which they support are secured together in spaced relationship by a central cylindrical shell **14** within which is a pilot's compartment **15**, and by a circumferentially arranged group of inboard struts **16** and two circumferentially arranged groups of outboard struts **17** and **18**. Air enters an inlet **19** which is provided by a central protuberance in the upper skin, is deflected downwardly by cascades **20**, then after passing through a central plenum chamber it flows radially outboardly through a double-sided multi-stage compressor generally indicated at **21**, then into an annularly disposed combustion system **22** where it supports combustion of the fuel supplied from an annular fuel tank **23**. The products of combustion expand through a single stage radial flow turbine **24** into a peripheral passage **25** whence they flow radially outboardly through a perimetrical orifice **26** which forms a constituent part of a Coanda nozzle. To propel and stabilize the aircraft the direction of flow of the ejected air may be controlled selectively by the pilot through the operation of his controls which alter the operating characteristics of the Coanda nozzle, in the manner described in the co-pending United States patent application of John Dubbery, John Carver Meadows Frost and Thomas Desmond Earl, Serial No. 502,156, filed on April 18, 1955, now abandoned, but superseded by continuation application Serial No. 684,615, filed on September 17, 1957.

Secured to the inner edges of the upper series of ribs and spacers **12** are inboard disc **27** and outboard disc **28**, and secured to the inner edges of the lower series of ribs and spacers **13** are inboard disc **29** and outboard disc **30**; the inboard discs together with the ribs and spacers and also the struts in effect constitute the stator casing of the engine.

A rotor generally indicated at **31** and which in plan form is an annular disc is rotatably mounted within the stator casing, its plane of rotation approximately coinciding with the medial plane of the opposed aerofoil surfaces of the aircraft. For convenience, the rotor may be considered as consisting of three concentric ring portions, namely an inboard or compressor portion **32**, an outboard or turbine portion **33**, and an intermediate portion **34**.

In radial cross-section the compressor portion **32** of the rotor is generally wedge-shaped, the thin edge of the wedge being substantially in line with a circumferential compressor inlet defined by the struts **16** and the thicker edge being substantially in line with the circumferential compressor outlet. The surfaces of the compressor portion of the rotor are spaced from the opposed surfaces of the stator casing, thus providing outboardly converging annular passages **35** at each side of the rotor. Concentric rings of blades of aerofoil cross-section with their longitudinal axes substantially parallel to the axis of rotation of the rotor are mounted in the annular passages, alternately on the compressor portion of the rotor and on the opposed portions of the stator casing, to form a double-sided multi-stage radial flow air compressor. Since the passages converge from their inboard periphery to their outboard periphery, the blades of each succeeding row decrease in length accordingly.

Immediately outboard of the last stage of the compressor there is a discontinuity in each of the heretofore continuous surfaces of the compressor portion **32** of the rotor, and the rotor suddenly becomes a disc of comparatively thin cross-section, which thin portion is the previously mentioned intermediate portion 34 of the rotor. The discontinuity in each of the surfaces of the compressor portion of the rotor is defined by a cylindrical surface or cylinder 36 which is coaxial with the axis of rotation of the rotor; this cylindrical surface provides the radial load bearing of the rotor. The axial load bearing of the rotor is provided by the annular surfaces of the intermediate rotor portion 34. The cylindrical surfaces 36 and the contiguous annular bearing surfaces of the rotor portion 34 together provide a stepped rotor wall.

Encompassing the cylinders 36 of the rotor and spaced therefrom very slightly are two cylindrical rings 37, one at each side of the rotor. The outer edge of each ring is secured firmly to the opposed portion of the stator casing by means of spaced circumferentially arranged vanes 38, which vanes extend across the circular zones which provide entrances to the combustion system 22. To the inner edges of the two rings 37 are firmly secured the contiguous inboard peripheries of annular bearing plates 39 located opposite the annular bearing surfaces of the rotor. The outboard peripheries of the bearing plates 39 are supported by circumferentially spaced fixed hollow vanes 40 located in the circumferential outlets of the combustion system 22. The cylindrical rings 37 and the contiguous annular bearing plates 39 together provide a stepped stator wall. The spacing between the two bearing plates is slightly greater than the spacing between the annular bearing surfaces of the rotor, so that when the rotor is located medially between the bearing plates (when the rotor is in operation) thin annular passages are provided between the bearing plates and the opposed annular bearing surfaces of the rotor.

Thus, the two annular bearing plates 39 in association with the opposed annular bearing surfaces of the rotor provide bearings which carry the axial load of the rotor on the stator casing, and the cylinders 36 of the rotor in association with the cylindrical rings 37 of the stator casing provide bearings which carry the radial load of the rotor on the stator casing. The spaces between the previously mentioned stepped walls provide continuous air passages having circumferentially arranged inlets 41 registering with the last stage of the compressor and having circumferential outlets whereby the air flowing through the passages may be exhausted to atmosphere through the turbine 24 and through the passages in the hollow vane 40.

Thin bars 42 are equiangularly arranged on the bearing plates 39 and are disposed radially on it. The bars project slightly above the surfaces of the bearing plates and provide rubbing strips for the rotor. The rubbing strips 42 are approximately ¼" in width and preferably are set in retaining grooves provided in the bearing plates and which are of the order of ⅛" in depth. The thickness of each rubbing strip is such that it projects above the surface of the bearing plate about .020". Any material which has a low coefficient of friction and can withstand high temperatures and high bearing loads may be used for the rubbing strips, and it would appear from experiment that bars of solid carbon give the best results. A series of holes or ports 43 in direct communication with the air supply in flame tube jackets 44 of the combustion system 22 is provided in the bearing plates 39 adjacent the trailing edge of each rubbing strip, that is, on the side of the rubbing strip which may be said to represent the lee when taken in the direction of rotation of the rotor; each series of holes is arranged in a direction substantially parallel to the adjacent rubbing strip.

In operation, air is diverted from the last stage of the compressor 21 into the cylindrical passages between the cylinders 36 of the rotor and the opposed cylindrical rings 37 of the stator casing, and thence flows into the annular passages between the annular bearing plates 39 and the opposed annular bearing surfaces of the rotor. The air when flowing in the said annular passages initially flows radially outboardly, but this radially outboard flow has added to it a centrifugal component of motion due to the rotational forces of the rotor. The rotor is supported radially and axially by the cushion of air under pressure supplied by the compressor. The supply of air from the compressor is augmented by air fed from the flame tube jackets through the holes 43 in the bearing plates 39. This secondary air supply, although not essential during the running of the engine, is a useful additional source of pressure which becomes especially important during the starting and stopping operations.

The rubbing strips 42 which project above the surfaces of the bearing plates 39 in effect restrict the passages between the bearing plates and the opposed annular bearing surfaces of the rotor. Such restriction of the passages causes an increase in the air pressure in the passages beyond the leading edges of the rubbing strips, to the extent that a pressure of say 1 lb./sq. in. at the holes in the bearing plates is multiplied about six times under the action of the imparted rotational velocity within the bearing passages. The rotational velocity is reduced as the air approaches the narrow gaps formed by the rubbing strips in the bearing surfaces of the rotor, thereby causing an increase in pressure.

By the aforedescribed construction mechanical friction is reduced to a minimum when starting or stopping the engine, as the combination of a large bearing area with the pressure build-up caused at the rubbing strips enables the rotor to be "airborne" within one revolution. Except during the first revolution of starting and the last revolution of stopping there is no rubbing contact between the rotor and the stator, the entire load being carried by the cushion of air between the rotor and the stator, as described.

The forms of the invention herein shown and described are to be considered merely as examples, and various changes in the shape, size and arrangement of the parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims. For convenience the invention has been described as embodied in the particular engine from the design of which the invention resulted, and which engine forms an integral part of the air-frame of an aircraft, but obviously the invention could be incorporated in other gas turbine engines.

What I claim as my invention is:

1. In a radial flow gas turbine engine having a compressor including an annular disc-like rotor mounted for rotation between two opposed members which provide a stator casing, a cylindrical surface of the rotor concentric with the rotor's axis of rotation, a complementary cylindrical surface of the stator casing slightly spaced from the rotor's cylindrical surface, means introducing air under pressure into the space between the two cylindrical surfaces for radially supporting the rotor when it rotates, annular bearing surfaces of the rotor at each side thereof, annular plates of the stator casing on each side of the rotor, the spacing between the said plates being slightly greater than the spacing between the rotor bearing surfaces so that when the rotor bearing surfaces are centred relative to the annular plates spaces are provided between the rotor bearing surfaces and the opposed bearing plates, and means introducing air under pressure into the spaces between the rotor bearing surfaces and the opposed annular plates for axially supporting the rotor when it rotates.

2. In a radial flow gas turbine engine having a compressor including an annular disc-like rotor mounted for rotation between two opposed members which provide a stator casing, a cylindrical surface of the rotor concentric with the rotor's axis of rotation, a complementary cylindrical surface of the stator casing slightly spaced

from the rotor's cylindrical surface, annular bearing surfaces of the rotor at each side thereof, annular plates of the stator casing on each side of the rotor, the spacing between the said plates being slightly greater than the spacing between the rotor bearing surfaces so that when the rotor bearing surfaces are centred relative to the annular plates spaces are provided between the rotor bearing surfaces and the opposed bearing plates, the spaces between the opposed cylindrical surfaces and the spaces between the opposed rotor bearing surfaces and annular plates providing continuous passages, and means introducing air under pressure into the said passages for radially and axially supporting the rotor when it rotates.

3. In a radial flow gas turbine engine having a compressor including an annular disc-like rotor mounted for rotation between two opposed members which provide a stator casing, a cylindrical surface of the rotor concentric with the rotor's axis of rotation, a complementary cylindrical surface of the stator casing slightly spaced from the rotor's cylindrical surface, annular bearing surfaces of the rotor at each side thereof, anular plates of the stator casing on each side of the rotor, the spacing between the said plates being slightly greater than the spacing between the rotor bearing surfaces so that when the rotor bearing surfaces are centred relative to the annular plates spaces are provided between the rotor bearing surfaces and the opposed bearing plates, the spaces between the opposed cylindrical surfaces and the spaces between the opposed rotor bearing surfaces and annular plates providing continuous passages, and ducts connecting the passages to a supply of air compressed by the compressor, the said compressed air in the passages radially and axially supporting the rotor when it rotates.

4. In a radial flow gas turbine engine having a compressor and a turbine which include an annular disc-like rotor mounted for rotation between two opposed members which provide stator casings, the inboard portion of the rotor providing a rotor for the compressor and the outboard portion providing a rotor for the turbine, a cylindrical surface of the rotor at each side thereof and adjacent the outboard periphery of the compressor portion and concentric with the rotor's axis of rotation, complementary cylindrical surfaces of the members of the stator casing and encompassing the rotor's cylindrical surfaces while being slightly spaced therefrom, annular bearing surfaces of the rotor at each side thereof and intermediate the compressor portion and the turbine portion, and annular plates of each of the members of the stator casing and opposite the rotor bearing surfaces, the said plates being slightly spaced from the opposed bearing surfaces when the rotor is located medially between the said bearing surfaces, each rotor cylindrical surface with the contiguous annular bearing surface defining a rotor wall, each stator casing cylindrical surface with the contiguous annular plate defining a stator wall, the rotor walls and the opposed stator walls together providing passages therebetween, the passages having circumferentially arranged inlets connected to a supply of compressed air from the compressor and having circumferentially arranged outlets at their outboard peripheries, the compressed air blowing through the passages radially and axially supporting the rotor when it rotates.

5. In a radial flow gas turbine engine having a compressor and a turbine which include an annular disc-like rotor mounted for rotation between two opposed members which provide stator casings, the inboard portion of the rotor providing a rotor for the compressor and the outboard portion providing a rotor for the turbine, a cylindrical surface of the rotor at each side thereof adjacent the outboard periphery of the compressor portion and concentric with the rotor's axis of rotation, complementary cylindrical surfaces of the members of the stator casing and encompassing the rotor's cylindrical surfaces while being slightly spaced therefrom, annular bearing surfaces of the rotor at each side thereof and intermediate the compressor portion and the turbine portion, annular plates of each of the members of the stator casing and opposite the rotor bearing surfaces, the said plates being slightly spaced from the opposed bearing surfaces when the rotor is located medially between the said bearing surfaces, each rotor cylindrical surface with the contiguous annular bearing surface defining a rotor wall, each stator casing cylindrical surface with the contiguous annular plate defining a stator wall, the rotor walls and the opposed stator walls together providing passages therebetween, the passages having circumferentially arranged inlets connected to a supply of compressed air from the compressor and having circumferentially arranged outlets at their outboard peripheries, and radially disposed rows of ports in the annular plates and having their inlet ends connected to a supply of compressed air and their outlets connected to the passages, the said ports supplying additional compressed air to the passages.

6. In a radial flow gas turbine engine having a compressor and a turbine which include an annular disc-like rotor mounted for rotation between two opposed members which provide stator casings, the inboard portion of the rotor providing a rotor for the compressor and the outboard portion providing a rotor for the turbine, a cylindrical surface of the rotor at each side thereof adjacent the outboard periphery of the compressor portion and concentric with the rotor's axis of rotation, complementary cylindrical surfaces of the members of the stator casing and encompassing the rotor's cylindrical surfaces while being sligthly spaced therefrom, annular bearing surfaces of the rotor at each side thereof and intermediate the compressor portion and the turbine portion, annular plates of each of the members of the stator casing and opposite the rotor bearing surfaces, the said plates being slightly spaced from the opposed bearing surfaces when the rotor is located medially between the said bearing surfaces, each rotor cylindrical surface with the contiguous annular bearing surface defining a rotor wall, each stator casing cylindrical surface with the contiguous annular plate defining a stator wall, the rotor walls and the opposed stator walls together providing passages therebetween, the passages having circumferentially arranged inlets connected to a supply of compressed air from the compressor and having circumferentially arranged outlets at their outboard peripheries, radially disposed rows of ports in the annular plates and having their inlet ends connected to a supply of compressed air and their outlets connected to the passages, the said ports supplying additional compressed air to the passages, and raised radially disposed elements on the bearing plates, the radially disposed rows of ports being located adjacent the edges of the aforesaid elements which are the trailing edges with relation to the direction of rotation of the rotor.

7. In a radial flow gas turbine engine having a compressor and a turbine which include an annular disc-like rotor mounted for rotation between two opposed members which provide stator casings, the inboard portion of the rotor providing a rotor for the compressor and the outboard portion providing a rotor for the turbine, a cylinder secured to each side of the rotor adjacent the outboard periphery of the compressor portion and concentric with the rotor's axis of rotation, complementary cylindrical rings secured to each of the opposed stator casing members and having inner edges disposed adjacent each side of the rotor, the said rings encompassing respectively the rotor cylinders while being slightly spaced therefrom, annular rotor discs intermediate the compressor portion and the turbine portion, annular plates at each side of the rotor and opposite the rotor discs, the outboard peripheries of the plates being supported by the respective stator casing members, the inboard peripheries of the plates being fast on the inner edges of the cylindrical rings which are contiguous thereto so that

each plate and the contiguous ring define a stepped stator wall, the plates being slightly spaced from the opposed rotor discs when the rotor is located medially between the plates, each rotor cylinder and the annular rotor disc which is contiguous thereto defining a stepped rotor wall, the aforesaid stepped rotor walls and the said stepped stator walls together providing passages therebetween, the said passages having circumferentially arranged inlets connected to a supply of air from the compressor and having circumferentially arranged outlets at their outboard peripheries, the compressed air in the passages radially and axially supporting the rotor when it rotates.

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LOW ASPECT RATIO AIRCRAFT

Filed Aug. 25, 1948 — 3 Sheets-Sheet 1

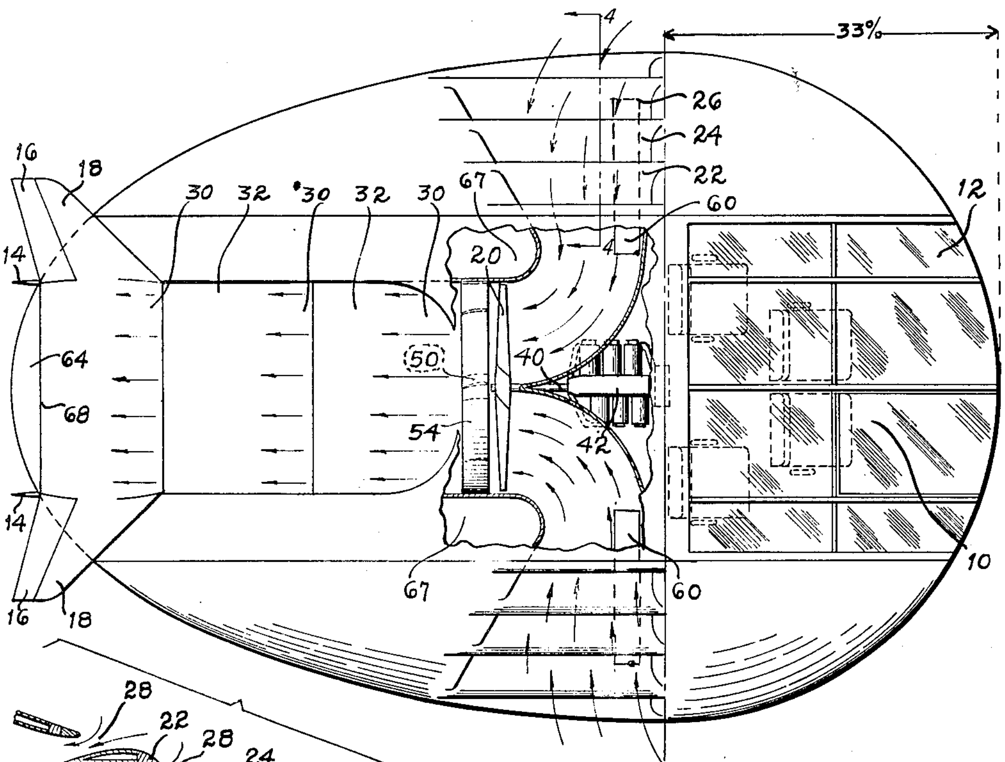


FIG. 1

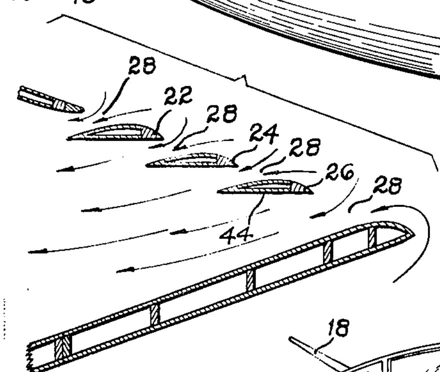


FIG. 4

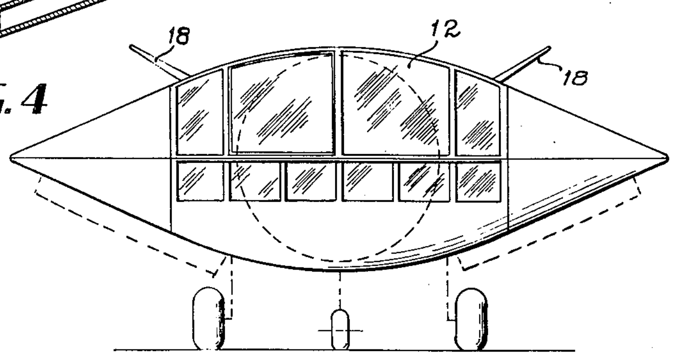


FIG. 2

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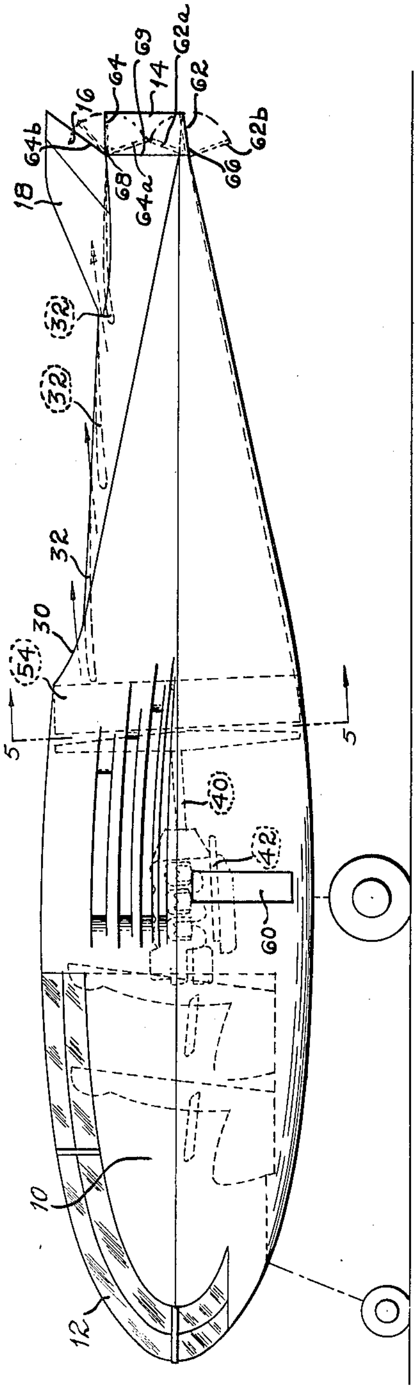

FIG. 3

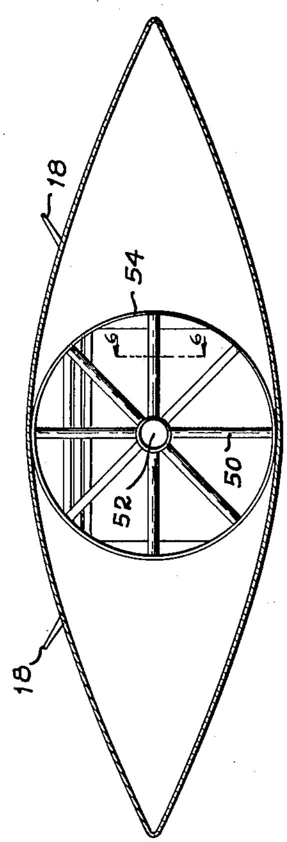


FIG. 5

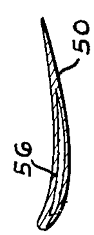


FIG. 6

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LOW ASPECT RATIO AIRCRAFT

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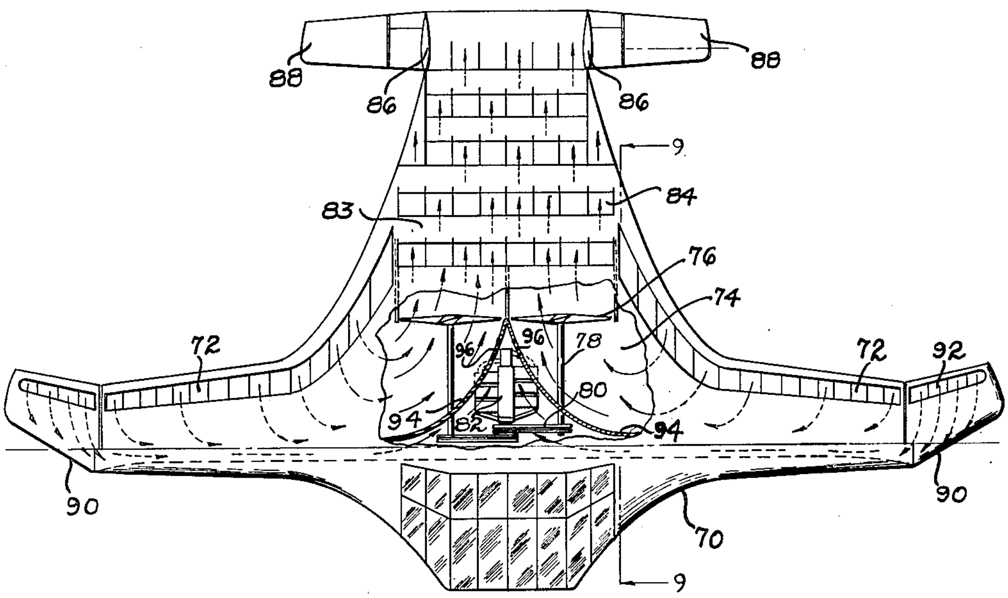


FIG. 7

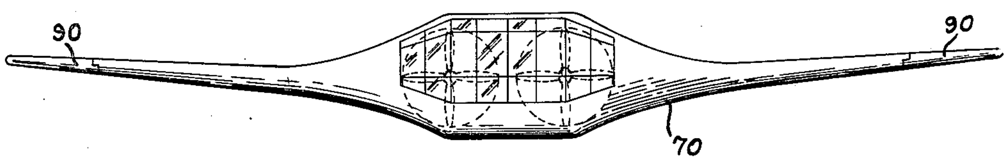


FIG. 8

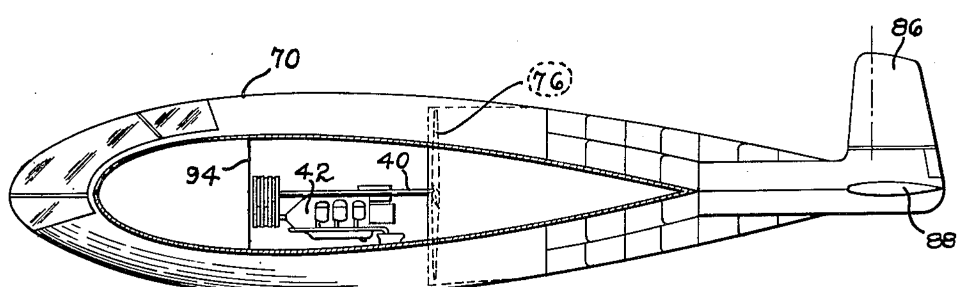


FIG. 9

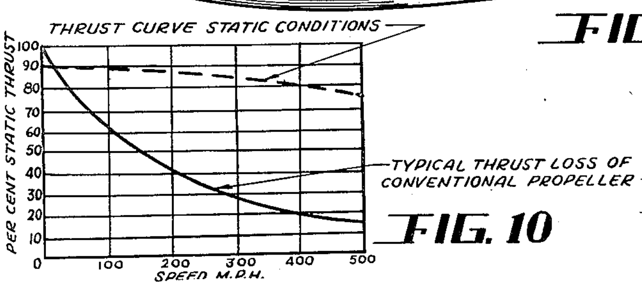


FIG. 10

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Patented Nov. 25, 1952 2,619,302

# UNITED STATES PATENT OFFICE

2,619,302

## LOW ASPECT RATIO AIRCRAFT

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Application August 25, 1948, Serial No. 45,992

3 Claims. (Cl. 244—15)

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This invention relates to an aircraft and more particularly to an aircraft having a low aspect ratio.

In the conventional airplanes of both the propeller and jet propelled type, there is usually provided two, or a multiple of two, laterally extending well defined wings forming a part of an airplane having a comparatively high aspect ratio. As is well known to those skilled in the art, in the conventional airplanes now in use the thrust of the propeller decreases very rapidly from a static aircraft at rest condition to one where the airplane travels at a high rate of speed. In other words, the thrust of the propeller goes down as the velocity of the airplane increases. Furthermore, the airfoil in passing through air produces a well known boundary layer of relatively stagnant air near the upper trailing portion of the airfoil, which stagnant air has a detrimental aerodynamic effect. Various methods have been proposed for overcoming this objectionable feature. For example, in the patent to Jones No. 1,980,140 dated November 6, 1934, there is shown slots extending through the wings functioning as air passages. Other methods have been proposed for eliminating the accumulation of such stagnant air or boundary layer.

An object of my invention is to provide a low aspect ratio airplane that has great stability, high lift characteristics that can be efficiently utilized for vertical or near vertical take-off and rapid climb and at the same time adapted for high speed propulsion.

Another object of this invention is to provide an airplane which might be referred to as an airplane of the flying wing type, wherein the wing and housing portion cooperate to form a continuous gradually curving periphery.

Another object of this invention is to provide a propeller that is housed within the airplane that has the characteristics simulating a static condition even though the airplane travels at high velocity through the air.

Another object of this invention is to provide a mode of propulsion wherein the propeller is mounted within the aircraft, drawing the air in laterally, so as to produce resultant lower drag components normal to the direction of flight, equal and opposite to each other to thereby cancel each other, the propeller while actually propelling the air operating over a much larger area than the cross sectional area of the exit port of the air flow, thereby permitting the propeller to propel the air at a much lower velocity in the vicinity of the propeller than the velocity of the

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air that is being expelled through the air expulsion port.

Another object of this invention is to provide a mode of propulsion wherein the boundary layer air is drawn into the airplane laterally and expelled to the rear in a direction parallel to the direction of flight. The air upon being acted upon by the propeller results in a turbulent and rotary motion generally referred to as a slip stream which is later removed so as to cause the air being expelled through the exhaust port and louvers on the upper surface of the aircraft to travel in a substantially straight path parallel to the direction of flight.

Another object of this invention is to provide hollow airfoils or louvers around which the air used in propelling the airplane passes while flowing towards the propeller and also from the propeller, the passages through the airfoils being used as heat transfer elements.

Another object of this invention is to provide an aircraft that has ample ruggedness and rigidity; excellent visibility; structural simplicity; roominess; unrestricted disposition of load in spanwise direction; a minimum of protuberances (that is, absence of fuselage, nacelles, wing tanks, et cetera); low wing loading; high obtainable lift; positive control to maintain almost any flight attitude, particularly at very low speeds and also very high altitudes; low percent thickness of airfoil sections to meet high speed requirements and still provide adequate depth for complete housing of all components due to the fact that the length is greater than the span; practical solution to mechanical problem for efficient utilization of boundary layer removal and obtaining a so-called flow control of the free air displaced by the aircraft; and large mean aerodynamic chord relative to span to obtain large Reynolds' number and hence, large scale effect, particularly for small sized aircraft.

Another object of this invention is to utilize the entire primary power plant in conjunction with a comparatively large fan disc area for the production of boundary layer removal and free air stream flow control.

Another object of this invention is to provide suction for removing boundary layer air at the tip portions as well as utilizing the wing tip vortex flow to simulate static thrust conditions, besides preventing its normal adverse aerodynamic effect, so as to greatly reduce drag by a co-action of suction and partial consumption of tip vortex or spanwise flow, which causes free air to flow in a controlled manner from the tip through the entrance louvers towards the center and thence rearwardly, which, in effect, turns the lift component of the louver portions towards the center, which tends to produce a spanwise compression load on the aircraft instead of a drag fore and aft force.

Other objects and advantages reside in the construction of parts, the combination thereof and the mode of operation, as will become more apparent from the following description.

In the drawings, Figure 1 is a top plan view of my preferred embodiment of a low aspect ratio airplane.

Figure 2 is a front elevational view of the airplane shown in Figure 1.

Figure 3 is a side elevational view thereof.

Figure 4 is a fragmentary, cross sectional view, taken substantially on the line **4—4** of Figure 1.

Figure 5 is a transverse, cross sectional view, taken substantially on the line **5—5** of Figure 3.

Figure 6 is a cross sectional view of an air straightener, taken substantially on the line **6—6** of Figure 5.

Figure 7 is a top plan view of a modification.

Figure 8 is a front elevational view of the airplane shown in Figure 7.

Figure 9 is a cross sectional view, taken substantially on the line **9—9** of Figure 7.

Figure 10 is a graphic illustration of thrust losses of a conventional propeller compared to a theoretical thrust curve of a propeller functioning as a pump simulating the static condition.

Certain aerodynamic improvements due to boundary layer removal have been recognized and appreciated by many aeronautical scientists for years. Its full utilization is mainly a mechanical problem, which, prior to my invention, has remained without a practical solution. In my invention all the primary power energy is devoted to the removal of boundary layer and to provide proper external flow control. The arrangement is such that the mass flow is sufficiently large to provide the required propulsion for at least all subsonic flight conditions. An ideal configuration is provided which will allow its use efficiently, both from the standpoint of external and internal air flows. The total horsepower available can be employed to produce a high aspect ratio effect. Empirically, in the absence of an exact theory, the thrust which is the product of unit air mass flow and velocity and therefore a direct measure of air flow energy devoted to such control and effect may be used to replace the aspect ratio factor A in the well known induced drag formula

$$C_{D_i}=C_L^2/\pi A$$

Where

$C_{D_i}$ represents the usual non-dimensional induced drag coefficient;

$C_L$ represents the usual non-dimensional lift coefficient; and

$A$ represents aspect ratio, which is the span squared divided by area.

This empirical substitution may prove valid if expressed as thrust in terms of propeller or fan disc area and wing area adjusted by a constant (C) to be determined by actual tests. The formula would now read:

$$C_{D_i}=\frac{C_L^2}{\pi K}XC$$

Where

$K$=fan disc area times thrust divided by wing area.



Then

$$\frac{1}{K}$$

=wing area (sq. ft.) divided by fan disc area (sq. ft.)×thrust (lbs.) at given flight conditions.

As an example, assume wing area 300 sq. ft. Disc area of propeller is 20 sq. ft. and maximum thrust is 600 lbs. at a specific flight condition.

Then

$$K=\frac{20\times 600}{300}=40 \text{ (neglecting units)}$$

Aspect ratio factor A therefore would change from 0.85 to 40 provided C=1. It is anticipated that C would have practical values from .3 to unity. Thus, such a low aspect ratio arrangement would compare favorably with present-day long range type conventional aircraft for a C value of only 0.3. The effect would be astounding and result in aircraft performance several times better than the best conventional aircraft by use of adequate power and good design of air duct system and fan or blower.

The airplane disclosed in the preferred embodiment is substantially oval; thereby having an extremely low aspect ratio and at the same time great stability and maneuverability. Instead of having an externally located propeller, as now in general use, the propeller is located within the airplane and so arranged that the boundary layer and spanwise flow induced by tip vortex effect is drawn in laterally, then propelled rearwardly by a fan or blower or propeller, straightened and expelled through suitable openings located in the rear upper portion and aft of the airplane.

As best viewed in Figure 1, the horizontal peripheral outline of the preferred embodiment is substantially oval. Furthermore, as best seen in Figure 3, the peripheral appearance, as viewed from the side, is substantially tear-shaped. This arrangement eliminates the use of the conventional fuselage or cabin, in that, as best seen in Figures 1 and 3, the seats for the pilot, et cetera, are located in the forward portion **10** of the main body of the airplane. Suitable portions of the outer surface, as illustrated at **12**, may be provided with a translucent covering to provide the necessary visibility.

A pair of rudders **14** are used in steering the airplane, particularly at slow speed and transonic speed ranges. The angle of incidence, as well as direction, is controlled by elevons **16** attached to stabilizers **18**. As may best be seen by referring to Figures 2 and 5, the stabilizers **18** form dihedral angles with the adjacent portion of the main body, to thereby give the airplane adequate lateral stability.

In conventional propellers the thrust decreases very rapidly as the speed of the airplane increases. For example, using a static thrust as 100%, the thrust at 500 miles per hour would be approximately 15%, as illustrated by the full line curve shown in Figure 10. If a propeller could be produced such that it would operate under conditions simulating static conditions, the thrust curve would probably simulate the dotted curve shown in Figure 10.

Furthermore, in conventional airplanes separation of the boundary layer creates a drag, which, of course, is objectionable.

In the device disclosed herein, the propeller **20** is mounted within the outside surface of the airplane. A plurality of louvers 22, 24 and 26 cooperate to form openings 28 in the sides of the airplane, so that the propeller 20 withdraws the boundary layer air as well as air flowing laterally from the tips and utilizes this air in propelling the airplane. Furthermore, the velocity of the air in the vicinity of the propeller is less than the velocity of the air passing through the openings 28 and is less than the velocity of the air exhausted or propelled through the openings 30 located in the vicinity of the louvers 32 positioned immediately in front of and above the tail. It is a well established phenomenon that a propeller has greater efficiency at lower velocity levels where the compressibility effects are less. When approaching the well known Mach number of 1 (M=1.0), the ratio of speed or local flow velocity to the speed of sound, the effect of compressibility becomes very serious. Shock waves are evidenced and the drag increases at an abnormally high rate. When the local velocity is approximately 520 miles per hour at seat level, M is then only 0.7, and compressibility is just beginning to be evidenced.

The propeller 20 is mounted on the propeller shaft 40 driven by any suitable type of engine 42 mounted within the airplane. A liquid-cooled type engine 42 may be efficiently employed. The liquid coolant used in cooling the engine may be circulated through the ducts 44 in the louvers 26, as best seen in Figure 4. Thus, the louvers 26 may function as radiators for the coolant. Some of these louvers may be used as radiators for the oil. By mounting the engine or the power plane entirely within the airplane, a practical solution of coping with extremely low temperature operations, as for example, in the Arctic regions or at very high altitudes, is thereby attained. Furthermore, it is a comparatively easy matter to pre-heat the air used in carburetion.

When a single propeller is used, rotating in one direction, the propelled air creates a vortex, that is, a twisting effect. This is an undesirable movement of the air for the proper flight of the airplane disclosed herein. That being the case, a plurality of straightener vanes 50 mounted between the hub 52 and the rim 54 are positioned near the propeller 20. The vanes 50 are preferably hollow, so as to form ducts 56 that may be used as a heat exchanger, either for the coolant or for the crankcase oil. The air, in passing from the propeller through the straightener, increases in velocity, due to the tapering contour of the air exhaust passage. The air escapes between the louvers 32, so as to propel the aircraft in a manner similar to jet propulsion. Arrangements employing counter-rotating dual propellers may eliminate entirely the need for the vanes 50.

Suitable trap doors 60 may be opened in the event the engine stalls. These doors could then be opened, as shown in dotted lines in Figure 2, dropping down, so that if the engine stalls, air can rush in, due to natural pressure differentials between the lower and upper surfaces. The doors will also serve as air brakes to increase the drag, thereby slowing down the airplane to effect a slow, safe landing. These doors have been shown as extending in a direction substantially normal to the longitudinal axis of the airplane. These doors could be diagonally disposed or angularly disposed with respect to the longitudinal axis of the aircraft, to thereby aid in the control of the aircraft.

The top part of the airplane could be made from porous material. Portions of the upper and lower wing surfaces may be porous to permit efficient entrance of air to the interior in conjunction with the openings shown or without them. The porous material should be so selected that it is possible to maintain surface continuity and smoothness. Furthermore, these porous areas should be so selected as not to interfere with the internal and external air pressures in areas of the plane where changes in air pressure are objectionable. At the same time, the porous areas should offer a minimum resistance to air entering into the ducting system, so as to maintain high thrust of the propeller.

The aircraft, both in flight and while landing or hovering, may be controlled by trim and thrust control members 62 and 64 pivoted along the lines 66 and 68 respectively to the main body of the tail portion. These trim and thrust members 62 and 64 subtend an opening 69, which forms a rather large opening in the rear end of the tail of the airplane. This large opening functions as an exhaust passage for the air propelled by the propeller. By actuating members 62 and 64 into the dot dash position 62*a* and 64*a*, the flow of air through the opening 69 is greatly restricted. This shifts the angle of the effective thrust created by the propellers exhausting the air. It also produces the greatest lift for possible hovering by forcing the air out through the openings 30. Furthermore, immediate high thrust is also possible by suddenly adjusting the surfaces from a restricted position into the full line positions 62 and 64, that is, into their neutral positions, without increasing the engine speed. By actuating the thrust control members into the position 62*b* and 64*b*, these trim and thrust control members function as drag elements. Furthermore, these members may be used in controlling the angle of incidence by adjusting one or the other out of the horizontal plane.

The load or cargo in this type of airplane is preferably carried ahead of the 33% point, as measured from the front of the airplane. Everything to the rear of the 33% point, or substantially so, is used as a space for the power plant, the propeller or fan arrangement and the air passages, to thereby secure adequate air flow through the airplane. The configuration is substantially oval, or tear-shaped, as viewed from the top or upwardly from the bottom. The side of the airplane also is what might be referred to in general as an oval contour or a tear-shaped contour.

The propulsion of the airplane may be accomplished by or aided by the use of turbo-jet engines that could be located in the space 67 on either side of the air passage conduit or channel. By locating the turbo-jet engines, not shown, in this space, the flow of the air could be accelerated and also the flow of the air around the rather abrupt corners adjacent this space could be facilitated.

These turbo-jet engines can be used either as a sole source of power or as an auxiliary source of power. If used as an auxiliary source of power, they could, in case of emergency, be used as the sole source of power or they could be used to augment the internal combustion engines for super-performance. In the event the turbo-jet engines are used as a sole source of power and the only source of power, the engine 42 would be eliminated; but not necessarily the propeller

20 and the straighteners 54. These parts could be retained. The turbo-jet engine exhaust is preferably directed out through the center of the channel.

The removal of the boundary layer air and the enclosed power plant are adaptable for universal use.

The modification disclosed in Figures 7, 8 and 9 disclose a wing type airplane 70 that is similar in contour to the airplane disclosed in my Patent No. 2,118,254, patented May 24, 1938. The main body portions of the wings have been provided with slots or openings 72 along the top rear edge, communicating with a pair of air passages 74, there being one air passage in each wing. A pair of propellers 76, mounted within the airplane and upon the shafts 78 driven through V-belts 80 from a motor 82, are used in drawing air in through the openings 72 and exhausting the air between suitable louvers 83 or through openings 84 located towards the rear and upper surface of the main body of the airplane. The air exhausted from the rear of the airplane flows out in the vicinity of a pair of rudders 86 and the elevators 88. Control members 90, which have been described in my Patent No. 2,118,254, form wing tips. These control members 90 are provided with openings 92 located in the rear upper surface thereof. Air is drawn in through the openings 92 ahead of a partition member 94. Thus, air is supplied to the motor 82 to cool the same. Suitable vents or openings 96 in the curved portion of the partition member 94 cause the air drawn in through the openings 92 to be discharged through the apertures in the rear of the airplane. This arrangement disclosed herein removes the boundary layer air, the propellers operating so as to develop a high thrust. By utilizing two propellers driven through a suitable gear mechanism, so as to rotate in opposite directions, the torque resulting from the vortex generated by one propeller is cancelled or equalized by the torque resulting from the vortex generated by the other propeller.

The space in the airplane in front of the 33% line in the preferred embodiment and the space in the main body of the airplane in front of the partition 94 disclosed in the modification are each available as a load carrying space. In the preferred embodiment a large space is available for the load without increasing the overall height of the airplane beyond optimum efficiency. In the modification disclosed in Figures 7, 8 and 9, there may be a double partition, one for dividing the wing-like extensions into two passages, the rear passage for the flow of the air drawn in through the openings 72 and the leading passage for the flow of the air passing through the openings 92. The second partition could extend across the main body of the fuselage-like portion of the airplane in front of the leading passage, so as to prevent the cargo from obstructing the flow of air used in cooling the engine.

Although the preferred embodiment of the device has been described, it will be understood that within the purview of this invention various changes may be made in the form, details, proportions and arrangement of parts, the combination thereof and mode of operation, which generally stated consists in a device capable of carrying out the objects set forth, as disclosed and defined in the appended claims.



Having thus described my invention, I claim:

1. In a low aspect ratio airplane, the combination of an outer surface having a substantially continuous curvature provided with laterally disposed openings for removing boundary layer air, and provided with openings in the rear, said airplane having air passages extending from the lateral openings to the rear openings, with propeller means mounted within the airplane for drawing the air in through the lateral openings and exhausting it through the rear openings to thereby propel the airplane, and doors providing closures for auxiliary intake openings in the under side of the airplane, said doors being adapted to drop downwardly to provide drag elements for suddenly slowing down the airplane and for providing sufficient airflow through the air passages to maintain control to effect a slow safe landing.

2. In an airplane having a curved surface terminating in a pair of laterally disposed wing-like extensions, said wing-like extensions being provided with openings in the upper rear surface thereof, a partition through the wing-like extensions forming a portion of each of a pair of air passages, said passages communicating with the openings in the upper surface of the wing-like extensions and terminating in a common passage communicating with openings in the upper rear surface of the main body of the airplane, control tips extending outwardly from said wing-like extensions, openings in the upper rear surface of the control tips, said openings communicating with the first mentioned passages in the wing-like extensions, an engine located in front of the partition, and means driven by the engine located to the rear of the partition for removing the boundary layer air overlying the rear surface of the wing-like extensions and exhausting this air through the openings in the upper rear surface of the airplane to create a thrust for propelling the airplane, said partition having vent openings in the vicinity of the engine so as to draw the air overlying the rear portion of the control tips through the leading passage in the wing-like extensions to cool the engine.

3. In an airplane having a curved surface terminating in a pair of laterally disposed wing-like extensions, said wing-like extensions being provided wth openings in the upper rear surface thereof, a partition through the wing-like extensions forming a portion of each of a pair of air passages, said passages communicating with the openings in the upper surface of the wing-like extensions and terminating in a common passage communicating with openings in the upper rear surface of the main body of the airplane, control tips extending outwardly from said wing-like extensions, openings in the upper rear surface of the control tips, said openings communicating with the first mentioned passages in the wing-like extensions, an engine located in front of the partition, and a pair of propellers located to the rear of the partition and driven by the engine, said propellers removing the boundary layer air overlying the rear surface of the wing-like extensions and exhausting this air through the openings in the upper rear surface of the airplane to create a thrust for propelling the airplane, said partition having vent openings in the vicinity of the engine so as to draw the air overlying the rear portion of the control tips through the leading passage in the wing-like extensions to cool the engine.

ALFRED C. LOEDDING.

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Jan. 10, 1956 E. R. DOAK 2,730,311

IMPELLER PROPELLED AERODYNAMIC BODY

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Fig. 3.

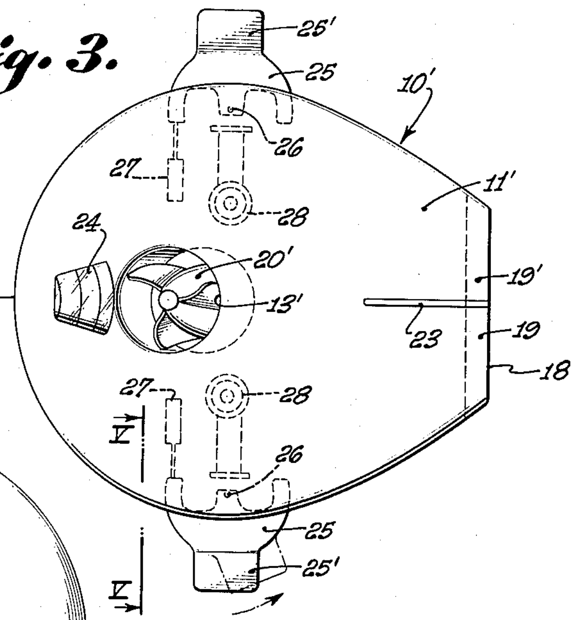



Fig. 1.

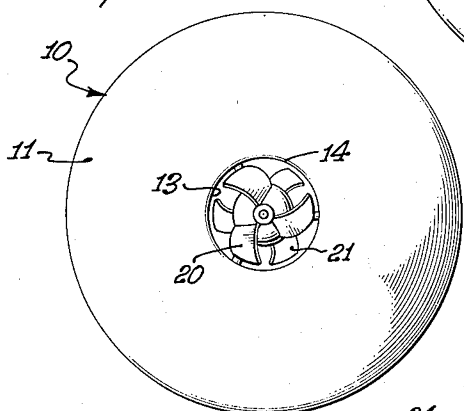



Fig. 4.

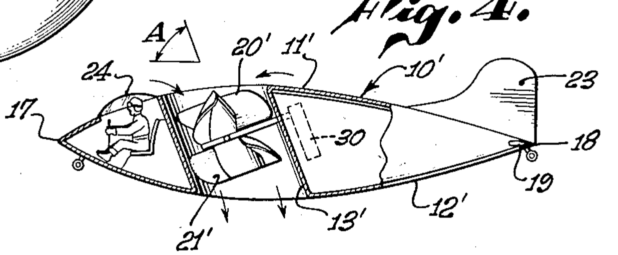



Fig. 2.

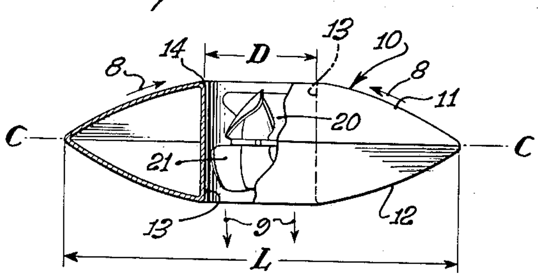
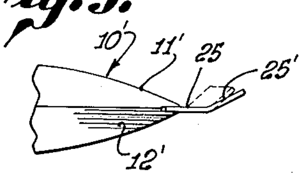



Fig. 5.

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IMPELLER PROPELLED AERODYNAMIC BODY

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Fig. 6.

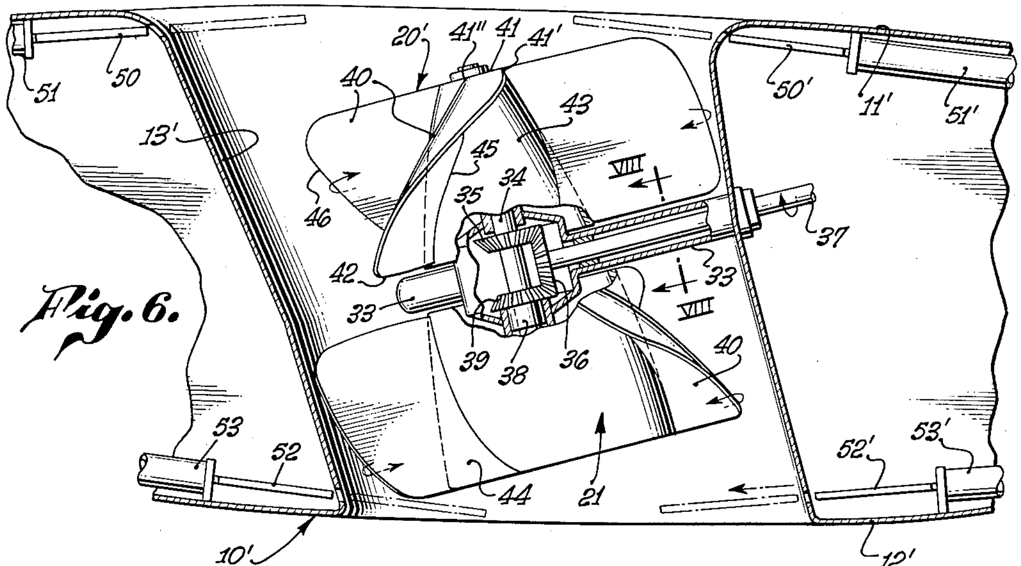



Fig. 7.

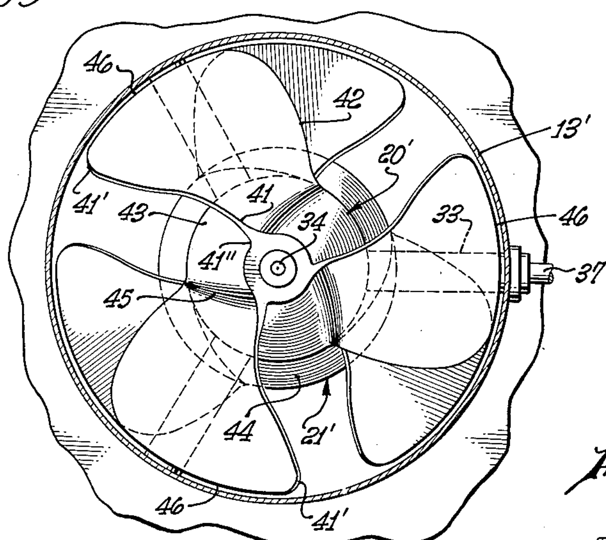



Fig. 8.

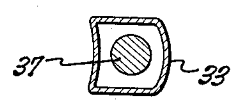
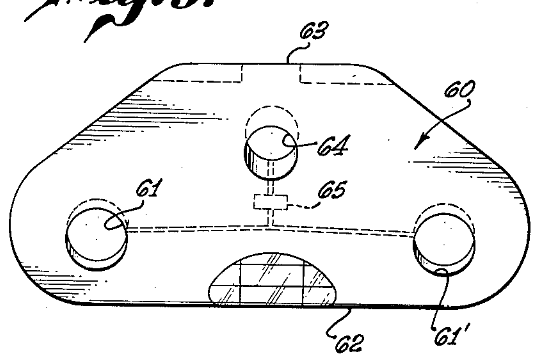



Fig. 9.

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ATTORNEY.

# United States Patent Office

2,730,311

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2,730,311

## IMPELLER PROPELLED AERODYNAMIC BODY

Edmond R. Doak, Los Angeles, Calif.

Application July 1, 1950, Serial No. 171,705

20 Claims. (Cl. 244—12)

This invention relates to means for aerial propulsion and is particularly directed to aerodynamic units which may be employed singly or in combination in the construction of aircraft having novel characteristics. The invention pertains to means and methods whereby compact, highly maneuverable aircraft may be constructed, such aircraft being characterized by freedom from normal propellers or airscrews. The invention also relates to aerodynamic units and component parts whereby high lifting forces may be generated by the passage of air over airfoils, such air being also converted into thrust jets which, properly directed and controlled, impart both lift and a forward velocity component.

Since the aerodynamic unit results in an aircraft having relatively low landing speeds and capable of rising in a substantially vertical manner, the aerodynamic unit of this invention may be compared with helicopters. Prior helicopters do not compare favorably with their airplane counterparts, since the maximum lift-drag ratio of a contemporary helicopter varies from about 5 to 8 and has not been known to exceed 10, whereas the lift-drag ratio of an airplane may be of the order of 12 to 22. However, in many instances, it is desirable to have an aircraft capable of substantially vertical ascent and descent.

Prior helicopter design (and by this term there are included the so-called gyroplane and autogiro) was beset with many problems both mechanical and physical. The necessity of hinging the blades in such manner as to allow them a certain freedom of movement in a flapping plane as well as the provision of vertical hinges or articulations permitting some movement of the rotor blade about a substantially vertical axis has given rise to numerous mechanical problems. The coriolis effect produced by the upward movement of the blade during rotation gives rise to vibrations of a destructive nature and requisite care must be taken in order to minimize the hunting oscillation of a blade about the vertical hinge, to increase the natural frequency of the blade in the plane of rotation, to minimize the violent rocking of a helicopter during the starting or stopping of the rotor and other resonance conditions of hazardous character. Moreover, large diameter helicopter blades cannot be employed and blade-tip speeds must be kept within reasonable limits.

The present invention obviates all of the difficulties encountered with contemporary helicopters and permits the construction of aircraft having the hovering characters of the helicopter without the use of rotor blades, the mechanical constructions which characterize helicopters, and without the mechanical and physical limitations of contemporary helicopters. Generally stated, the aerodynamic unit of the present invention comprises a body having airfoil attributes in that it has an upper, generally convex surface and a lower, generally convex surface, said surfaces meeting, in part at least, to form entering and trailing edges. Such body of airfoil characteristics is provided with one or more ports extending



from the upper surface through the body and discharging at the lower surface, thereby forming passageways provided with virtually imperforate walls and preferably inclined, downwardly and rearwardly, at an angle of between about 30° and 85° to a plane passing through the entering and trailing edges of the body. Such a passageway is in confluent, smooth, transitional relation to the upper surface of the body so as to permit smooth flow of air over such upper surface and into the passageway. Positioned in such passageway are means for inducing flow of air over the adjacent convex surfaces and into the passageway, such means preferably including devices or means for compressing the air and discharging the air at high velocity and considerable pressure as a jet at a desired angle to the plane connecting the entering and trailing edges. The means for inducing flow of air and generating high velocity fluid flow through each passageway preferably includes bladed elements of novel design, said blended elements preferably consisting of adjacent sections rotating in opposite directions and at controllable speeds, thereby controlling rotational torque and permitting such thrust-generating elements to be used, in part at least, as means for controlling the direction of flight. The invention further coatemplates the provision of starvers and other control elements whereby rolling, turning and pitching may be regulated and controlled.

It is an object of the present invention, therefore, to disclose and provide novel aerodynamic units.

Another object of the invention is to disclose and provide an aerodynamic unit embodying impellers and vertical reaction generators positioned wholely within passageways extending through an airfoil structure.

A still further object of the invention is to disclose and provide an aerodynamic unit including means which overcome the normal differential pressure between the upper and lower surfaces and generate sufficient lift to permit vertical flight without need of forward motion, the unit or airfoil body being capable of gliding flight, when desired.

Again, an object of the present invention is to disclose and provide improved thrust-generating means which are compact and are adapted to produce a vertical reaction in excess of 30 lbs. per square foot of cross-sectional area of such impeller means.

A still further object of the invention is to disclose and provide various controls and methods of control whereby pitching, rolling, turning and direction of flight may be adequately and simply regulated.

These and various other objects, uses and advantages of the present invention will become apparent to those skilled in the art from the following, more detailed description of exemplary forms embodying the invention, it being understood that the aerodynamic unit and its various appurtenances and auxiliary means may be embodied in a great variety of aircraft, depending upon the requirements of such aircraft. In the appended drawings:

Figs. 1 and 2 are diagrammatic representations of a simple aerodynamic unit embodying the present invention, Fig. 1 being in plan and Fig. 2 being in side elevation partly broken away.

Fig. 3 is a plan view, partly diagrammatic, of the aerodynamic unit of the present invention in the form of an aircraft.

Fig. 4 is a longitudinal section through the aircraft of Fig. 3.

Fig. 5 is a transverse section taken approximately along the plane V—V in Fig. 3.

Fig. 6 is an enlarged view through a passageway in an aerodynamic unit of the present invention, illustrating one form of thrust-generating means and control elements.

Fig. 7 is an end view of the passageway and thrust-generating means illustrated in Fig. 6.

Fig. 8 is a section taken along the plane VIII—VIII in Fig. 6.

Fig. 9 is a plan view, partly diagrammatic, of a modified form of aircraft embodying the present invention.

The elementary form of aerodynamic unit illustrated in Figs. 1 and 2 comprises a body, generally indicated at **10**, which has a discus-like form including an upper, generally convex surface **11** and a lower, generally convex surface **12**, the margins of the upper and lower surfaces being connected so as to form entering and trailing edges. The chord or plane connecting such entering and trailing edges is indicated at C—C, the length of the body between the entering edge and trailing edge being indicated at L (Fig. 2).

A passageway **13** extends through the body **10**, said passageway being provided with virtually imperforate walls and with gradually rounded, smooth, contiguous portions **14** merging the upper surface **11** into the walls of the passageway **13**, such smooth, confluent relationship between the passageway and such upper surface being hereinafter referred to as an anastomotic relation.

Preferably, the axis of the passageway **13** passes through the chord C—C at a point located between 0.3 and 0.5 of the length of such chord from the leading edge. Furthermore, it may be stated that the average diameter of such passageway **13**, indicated at D, comprises between about 0.1 and 0.4 of the length of the chord C—C between entering and trailing edge. These relationships are of particular importance when the aerodynamic unit is embodied in a complete aircraft.

Mounted within the passageway **13** are power-driven means for drawing large volumes of air into the passageway along the upper surface **11**, as indicated by the arrows **8**, and discharging such air at high velocity downwardly in a direction parallel to the axis of the passageway, as indicated by the arrows **9**, thereby forming a downwardly directed jet and creating lift along the upper surfaces.

Such thrust-generating and lift-producing means may comprise two or more impeller sections, generally indicated at **20** and **21**, mounted coaxially and provided with means for rotating such sections in opposite directions. Each of said sections **20** and **21** is provided with a plurality of blades specifically designed (as will become apparent hereafter) to efficiently draw in air, compress the same and eject the air in the form of a thrust-jet in a direction parallel to the axis of rotation of the impellers and impeller sections. By employing counter-rotating impeller sections, torque is counteracted and no auto-rotational effect is imposed upon the body **10**.

It may be noted here that each of the impeller sections **20** and **21** preferably has an axial length in excess of 20% of its diameter. The blades carried by each section are provided with outer margins which are in proximity to the wall **13** of the passageway for a distance not materially shorter than the axial length or height of the blades of the impeller section. The blades of each impeller section are carried upon a hub portion and each of the blades is preferably provided with a front face concave in section taken perpendicular to the shaft, as will be described in greater detail hereinafter.

Figs. 1 and 2 therefore disclose the general relationships of the parts and the mode of operation of the aerodynamic unit. The application of these general principles to an aircraft is exemplified by Figs. 3–5. As there shown, the aircraft comprises a body portion **10'** which is generally discus-like in shape. The upper, convex surface is indicated at **11'**; the lower convex surface is indicated at **12'**. These surfaces meet at a leading edge generally indicated at **17**; a trailing edge is indicated at **18**. Portions of the body adjacent the trailing edge **18** may include flaps or pivoted, virtually horizonal elevator planes **19** and **19'**. A vertical rudder fin is indicated at **23**. A bubble-like canopy **24** is indicated in the forward part of the aircraft for pilot and copilot. The sides of the craft may be provided with stabilizers such as the fin-like members **25** provided with upwardly inclined outer portions **25'**. These stabilizers may be mounted for pivotal movement upon substantially vertical axis **26** and means may be provided for controllably positioning said stabilizers at various angles around such axis, such means being diagrammatically illustrated at **27**.



The operating and control means may be hydraulic or electrical and are not shown in detail since servo mechanisms of any well-known type may be used in adjustably and controllably positioning such stabilizers **25**. It is to be understood that such stabilizers **25** extend through suitable tlits or openings formed adjacent or in the edge of the aircraft for movement therein. Suitable landing gear, diagrammatically indicated at **28**, and capable of being retracted into the body **10'** are also provided, such landing gear being again operated by any desired type of servo mechanism.

A passageway **13'** extends through the body **10'**, the relationship between the diameter of the body and the chord length being within the limits stated hereinbefore during consideration of Figs. 1 and 2. The axis of the passageway **13'** is preferably inclined downwardly and rearwardly at an angle of between 30° and 85° to the plane passing through the entering and trailing edges of the body **10'**, such angle being indicated as the angle A in Fig. 4. The axis of the passageway passes through the body at a point located between 0.3 and 0.5 of the length of the chord from the leading edge **17** and such position is also correlated at the center of gravity of the unit and the center of pressure of the surfaces of the unit. This requires that consideration be had of the weight of the entire body, including its various accessories and appurtenances (such as the landing gear **28**) and of a motor, generally indicated at **30**, positioned within the body and used in driving the impeller sections **20'** and **21'** which are positioned within the passageway and conform in general to the description given hereinbefore of the sections **20** and **21**.

It will be evident that by reason of the inclination of the passageway **13'**, a forward component is generated by the downwardly and rearwardly directed thrust of the air jet. In forward flight, the chord C—C assumes a virtually horizontal plane; when landing, the forward portion of the craft and the leading edge assume an angle of attack wherein the chord is inclined downwardly and rearwardly, this attitude characterizing the position of the aircraft when at rest, when hovering, and when rising vertically.

It will be noted that in all instances large volumes of air are drawn over the upper surface of the aerodynamic unit, thereby generating lift; in all instances a downwardly directed jet imparts upward and forward thrust.

By referring to Figs. 6 and 7 which are, in effect, a vertical enlarged section taken along the plane VI—VI in Fig. 5 and an enlarged view, in plan, in a direction parallel to the axis of the passageway, it will be seen that the walls of the passageway **13'** can be contoured somewhat so that the passageway is of varying diameter. In the example given, the inlet portion of the passageway is larger than the discharge area, the walls of the passageway converging for a portion of their length and then becoming parallel. Extending transversely across such passageway is a spider having arms, such as the arm **33**, such spider supporting a centrally disposed bearing assembly for a vertical shaft **34** upon which there is mounted the upper impeller assembly **20'**. It is desired that this upper impeller assembly rotate in one direction, whereas the lower impeller assembly **21'** rotate in the opposite direction. Although various forms of drives may be employed, a simple exemplary drive is shown in the drawings and includes a bevel gear **35** mounted upon the shaft **34**, such bevel gear being in engagement with gear **36** mounted upon the end of drive shaft **37** extending through the hollow arm **33** of the spider. The shaft **37** is suitably connected to a motor, not shown. The lower portion of shaft **34** has a sleeve **38** journaled therein, such sleeve carrying a bevel gear **39** which is also in engagement with gear **36**. It will be evident that by this arrangement shaft **34** is rotated in one direction, whereas the sleeve **38** is rotated in the opposite direction. The lower impeller assembly **21'** is mounted upon sleeve **38**.

It is to be remembered that the thrust-generating means, such as the impeller sections **20'** and **21'**, needs induce flow of air along the upper surfaces **11'**, compress such air and eject it forceably downwardly, preferably in a direction substantially parallel to the axis of the passageway **13'**. In order to develop utilizable thrust in excess of 30 lbs. per square foot of cross-sectional area of the passageway, it is impracticable to use normal blower or propeller assemblies and instead, it is necessary to use carefully designed bladed elements of the character to be described in detail at this point. As shown in Figs. 6 and 7, each of the impeller sections carries a plurality of blades, such as the blade **40**. Each blade has a front face which is concave in section taken perpendicular to the shaft and such concavity extends from the upper, generally radial inlet edge identified at **41** to the generally radial outlet edge identified at **42**. It may be noted that the blades are preferably mounted upon a hub or hub section of varying diameter from inlet to outlet end. These hubs, such as the hub portions **43** and **44**, form a core which, in combination with the varying diameter of the walls of the passageway **13'**, cooperate with the blades of each impeller section in facilitating compression of air and its discharge as an axial thrust jet. It may be noted at this time that at the discharge port of the entire passageway, the cross-sectional area of the hub in that zone preferably comprises 15% or more of the total cross-sectional area defined by the walls of the passageway and preferably ranges from between about 20% of such passageway to approximately 35% thereof. Differently stated, the ratio of hub area to total passageway area in a transverse plane adjacent the outlet is not less than 0.15 to 1.0.

Each of the blades, such as the blade **40**, may also be defined by a root line adjacent the shaft, such as the root line **45** at the surface of the hub **43** and an outer edge, indicated at **46**, which is arranged to come into proximity with the wall of the passageway **13'** from substantially the upper radial edge **41** to the plane of the lower radial edge **42**, due regard being given to rounding of sharp corners and mechanical considerations. The outer edge **46** of each blade is preferably between an angle of 35° and 60° to the shaft axis and approximates a portion of a helix. The outer margin of each radial edge, such as the point **41'**, is angularly in advance of the root margin of such edge, such as the point **41''**, by a radial angle of between about 5° and 50°. These requirements insure the formation of blades having concave surfaces adapted to scoop in large volumes of air and rapidly, with a minimum expenditure of energy, impart axial movement to such air. The number of blades carried by an impeller section may be varied; three-bladed impellers are shown in the drawings for illustrative purposes only, and in actual practice a larger number, say six, is commonly employed. As shown by the drawings, the use of three or more blades of high angle (35° to 60°) to the axis of rotation produces an impeller of high solidity (i. e. when viewed axially a high proportion of the total transverse area is intercepted by the impeller) and this insures the generation of exceptionally high axial reaction or thrust obtained by this invention. In practice, it has been found that the axial height of the blades, that is the distance between the plane of the radial inlet edges **41** and the radial outlet edges **42**, should be in excess of 20% of the outer diameter of such blade assembly, thereby permitting the formation of smooth air flow without excessive turbulence within the passageway. The various impeller sections may operate at equal speeds or at different speeds and turning movement of the entire aircraft may be obtained by controllably varying the relative speeds of the impeller sections.



It may also be noted that by reason of the fact that the outer margins of each radial edge are in advance of the root margin of such edge by an appreciable angle, the transition of air from one impeller section to another impeller section is obtained very effectively without the creation of resonant vibrations, a slip stream of air discharged by impeller section **20'** being, in effect, gradually sheared and received by the succeeding impeller section **21'**, and not chopped off in toto in a single instant of time. The impeller sections such as **20'** and **21'** should be as close together as possible. When a spider is used therebetween (as in Fig. 6) the arms of such spider, such as the arm **33**, are preferably contoured, as best shown in Fig. 8, in order to facilitate the translation or change in direction of the air stream, thereby minimizing sonic or ultrasonic vibrations.

It is to be understood that although specific reference has been made in the description given hereinabove to a blade such as the blade **40** in the upper impeller section **20'**, the same considerations apply to the blades used in the lower impeller section **21'**. Some increase in the root angle of the discharge stage or stages of the impeller over the root angle employed on the blades of the initial section or sections of the impeller is indicated.

In order to facilitate control of an aircraft employing the aerodynamic units of this invention, vanes or deflectors are preferably employed adjacent inlet and outlet ports of the passageway. Variations in the direction of thrust may thus be attained, and horizontal stability, banking and turning are facilitated. Such deflectors may take the form of blades or deflectors which can be controllably introduced into the stream of air passing through the passageway. For example, as illustrated in Figs. 6 and 7, vanes such as **50** and **50'** in the form of blades may be positioned at a plurality of points around the inlet port of the passageway, each of said vanes being controllably operated by suitable servo mechanism, such as for example, the hydraulic cylinders **51** and **51'**. If, for example, the deflector **50** is moved into the dash line position, the quantity of air admitted to the forward part of the passageway facing the entering edge of the unit is reduced, thereby changing the characteristics and the effectiveness of the resulting jet, as well as influencing the amount of lift which is developed along the forward portion of the upper surface **11'**. The various deflectors may be operated independently or in unison.

Similarly, vanes, such as the vanes **52** and **52'**, under the controllable actuation of suitable servo mechanisms, such as the hydraulic cylinders **53** and **53'**, may be caused to extend into the jet and produce resultant forces which affect the attitude of the entire aircraft. Such vanes are particularly effective in facilitating vertical ascent of the aircraft from the ground and are also of value in facilitating gliding descent and landings. It is to be understood that certain of the vanes and deflectors may be interconnected or operated in unison so as to accentuate the effect, as for example, by concurrently operating an aft deflector such as **50'** and a forward vane such as **52**. It may be noted at this time that by selecting and impeding a segmental portion of airflow through said passageway an unbalance in airflow velocity is produced with resultant unbalance in air reaction, thereby permitting lateral or longitudinal control of the aircraft.

Tests conducted with the construction described hereinabove show that more than 25 lbs. lift per square foot of the impeller disc area (swept area) or passageway can be readily attained, with lifts of 40 lbs. per square foot not unusual. In comparison, the conventional helicopter generates a lift of approximately 2–4 lbs. per square foot of the rotor blade diameter (swept area) and for reasons of solidity, tip speed, etc., these figures cannot be materially increased by the use of conventional helicopter design. By reason of the compact character of the means employed herein, lift per square foot can be materially increased without difficulties. Similarly, the aerodynamic unit of the present invention generates approximately 2–3 times as much lift per horse power as is possible with conventional helicopter design.

It is to be understood that the invention is not limited to the utilization of but a single passageway in an aircraft. Fig. 9 diagrammatically shows, in plan form, an aircraft provided with a body **60** provided with two passageways **61** and **61'** extending therethrough, the axes of such passageways being slightly inclined, say at an angle of 85° to a plane passing through the entering and trailing edges of the body, such edges being indicated at **62** and **63**, respectively. These two passageways may be spaced from the longitudinal axis of symmetry of the body **60**. In alignment with such longitudinal axis of symmetry is another passageway **64** which is downwardly and rearwardly inclined at a material angle to the chord, say at an angle of 30° to such chord. Each of such passageways may be provided with means for producing flow of air over the upper convex surface of the body **60** and discharging such air in the form of downwardly and rearwardly directed, high velocity jets. Vertical ascent and hovering may be controlled by passageways **61** and **61'**; increased high forward velocity may be attained by the energization of the jet-creating means in passageway **64**. All of the means (such as, for example, the impellers of the character described hereinbefore) may be driven from a common motor indicated at **65**, suitable clutch or other selective means being employed for controllably actuating the impellers in passageway **64**.

Those skilled in the art will readily appreciate that the aerodynamic unit of the present invention may be embodied in various forms of aircraft and one or more of the lift-generating and thrust-producing means may be embodied in an aircraft. Furthermore, the impellers of the present invention need not be employed as the sole means for generating lift and thrust; such impellers may be used in combination with turbo-jet or ram-jet engines as a means of feeding large volumes of air into the combustion chambers of engines, the exhaust from such engines being utilized in producing added thrust.

All changes and modifications coming within the scope of the appended claims are embraced thereby.

I claim:

1. An aerodynamic unit comprising, in combination with a body having an upper, generally convex surface and a lower, generally convex surface and having air foil characteristics in longitudinal section, margins of said upper and lower surfaces being connected, in part at least, to form entering and trailing edges: a port in the upper surface and an outlet port in the lower surface, said lower port being rearwardly displaced with respect to the upper port; an inclined passageway extending through the body and connecting said ports, said passageway being provided with a smooth, virtually imperforate wall, said wall being in continuous, curved, confluent, anastomotic relation to the upper surface of the body; a power-driven impeller mounted for rotation within said passageway about an inclined axis coincidental with the axis of said passageway, said impeller including counter-rotating, torque-counteracting impeller sections, each impeller section carrying blades mounted upon a hub portion, said hub portion being correlated to the walls of the passageway to provide an annular air duct, each blade having a concave front face defined by a root line adjacent the hub, a generally radial inlet edge, a generally radial outlet edge, and an outer margin; the outer margin of each blade being at an angle of between 35° and 60° to the axis of rotation, such outer margin being in proximity to the wall of the passageway for a distance not materially shorter than the effective axial height of



the air-moving impeller blades; said impeller being adapted to produce a vertical reaction in excess of 30 lbs. per square foot of area swept by the impeller.

2. An aerodynamic unit of the character stated in claim 1, wherein the outer margin of each blade is in advance of the root line by a radial angle of between 5° and 50°.

3. An areodynamic unit of the character stated in claim 1, wherein the axis of said passageway is inclined downwardly and rearwardly at an angle of between 30° and 85° to a plane passing through the entering and trailing edges of the body.

4. An aerodynamic unit of the character stated in claim 1, wherein the ratio of hub area to total passageway area in a transverse plane adjacent the outlet is not less than 0.15 to 1.0.

5. An aerodynamic unit of the character stated in claim 1, wherein the axial height of each impeller section is in excess of 20% of its diameter.

6. An aerodynamic unit of the character stated in claim 1, including vanes adjustably and selectively positionable adjacent the port in the upper surface of the body.

7. An aerodynamic unit of the character stated in claim 1, including deflectors adjustably and selectively positionable adjacent the port in the lower surface of the body.

8. An aerodynamic unit of the character stated in claim 1, wherein the axis of the passageway is inclined downwardly and rearwardly at an angle of between 30° and 85° to a plane passing through the entering and trailing edges of the body and said axis passes through the center of gravity of the unit.

9. An aerodynamic unit of the character stated in claim 1, wherein the axis of the passageway is inclined at an angle of between 30° and 85° to a plane passing through the entering and trailing edges of the body and intersects such plane at a point located between 0.3 and 0.5 of the length of such plane from the leading edge.

10. An aerodynamic unit of the character stated in claim 1, wherein the axis of the passageway is inclined downwardly and rearwardly at an angle of between 30° and 85° to a plane passing through the entering and trailing edges of the body and the average diameter of said passageway comprises between about 0.1 and 0.4 of the length of the body between trailing edge and entering edge.

11. An aerodynamic unit of the character stated in claim 1, wherein the space within the body contains motor means and means for operatively and controllably connecting said motor means and impeller.

12. An aerodynamic unit of the character stated in claim 1, wherein the unit is provided with pitching, rolling, and directional controls independent of the impeller, comprising control surfaces at the trailing edge of the unit and means for selectively actuating said control surfaces.

13. An aerodynamic unit of the character stated in claim 1, wherein the hub portions are of a contour correlated with the walls of the passageway to produce an annular air duct of progressively decreasing area from the upper intake port to a zone adjacent the lower edge of the passageway.

14. An aerodynamic unit comprising, in combination with a body having an upper, generally convex surface and a lower, generally convex surface and having air foil characteristics in longitudinal section, margins of said upper and lower surfaces being connected, in part at least, to form entering and trailing edges: a port in the upper surface and an outlet port in the lower surface, said lower port being rearwardly displaced with respect to the upper port; a passageway extending through the body and connecting said ports, the axis of said passageway being inclined downwardly and rearwardly at an angle of between 30° and 85° to a plane passing through entering and

trailing edges of the body, said passageway being provided with a smooth, virtually imperforate wall, said wall being in continuous, curved, confluent, anastomotic relation to the upper surface of the body; a power-driven impeller mounted for rotation within said passageway about an inclined axis coincidental with the axis of said passageway, said impeller including counter-rotating, torque-counteracting impeller sections, each impeller section carrying blades mounted upon a hub portion, said hub portions being correlated to the walls of the passageway to provide an annular air duct, each blade having a front face defined by a root line adjacent the hub, a generally radial inlet edge, a generally radial outlet edge, and an outer margin; the outer margin of each blade being at an angle of between 35° and 60° to the axis of rotation, such outer margin being in proximity to the wall of the passageway for a distance not materially shorter than the effective axial height of the air-moving impeller blades; the space within the body containing motor means and means for operatively and controllably connecting said motor means and impeller; said impeller being adapted to produce a vertical reaction in excess of 30 lbs. per square foot of area swept by the impeller; said unit being provided with pitching, rolling and directional controls independent of the impeller, comprising control surfaces at the trailing edge of the unit, and means for selectively actuating said control surfaces.

15. An aerodynamic unit of the character stated in claim 14, wherein the outer margin of each blade is in advance of the root line by a radial angle of between 5° and 50°

16. An aerodynamic unit of the character stated in claim 14, wherein the axial height of each impeller section is in excess of 20% of its diameter.

17. An aerodynamic unit of the character stated in claim 14, wherein the axis of the passageway passes through the center of gravity of the unit and the ratio of the hub area to total passageway area in a transverse plane adjacent the outlet is not less than 0.15 to 1.0.

18. An aircraft comprising: a body having an upper, generally convex surface and a lower, generally convex surface imparting airfoil characteristics thereto; a plurality of intake ports in the upper surface, said ports being in spaced relation, and a plurality of outlet ports in the lower surface, each of said outlet ports being correlated to one of the intake ports; a passageway provided with a virtually imperforate wall, extending through the body and connecting each of said intake ports with its correlated outlet port, the walls being in an anastomotic relation to the upper surface to form curving, confluent intakes, the axes of said passageways being downwardly and rearwardly inclined at an angle of between 30° and 85° to a plane passing through the entering and trailing



edges of the body, the distance between adjacent passageways being not less than three times the minimum diameter of a passageway; a power-driven impeller mounted for rotation in each passageway, each impeller carrying blades, the outer margins of each blade being rotationally in advance of the root of the blade, said outer margins being at an angle of between 35° and 60° to the axis of rotation and in proximity to the wall of the passageway; motor means mounted within the body and operably connected to said impellers; and control surfaces at the trailing edge of the unit for controlling pitching, rolling and direction of flight of the aircraft.

19. A device for generating high velocity fluid flow comprising: a driven shaft provided with a plurality of angularly extending blades in spaced relation, each blade having front face concave in section taken perpendicular to the shaft, each such face being defined by a root line adjacent the shaft, a generally radial inlet edge, a generally radial outlet edge and an outer edge, the inlet and outlet edges lying in planes perpendicular to the shaft axis, the outer edge of each blade being at an angle of between 35° and 60° to the shaft axis, the outer margin of each radial edge being in advance of the root margin of such edge by radial angle of between about 5° and 50°, the outer margins of the blades lying virtually in an imaginary cylinder, the axial height of the blades being in excess of 20% of the outer diameter of said blade assembly.

20. A device of the character stated in claim 19, in combination with a similar bladed assembly mounted upon a second shaft and assembly carried thereby being arranged for rotation in the opposite direction, with said second assembly in proximity to the first assembly and acting upon fluid discharged by the first assembly.

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CIRCULAR AIRCRAFT AND CONTROL SYSTEM THEREFOR.

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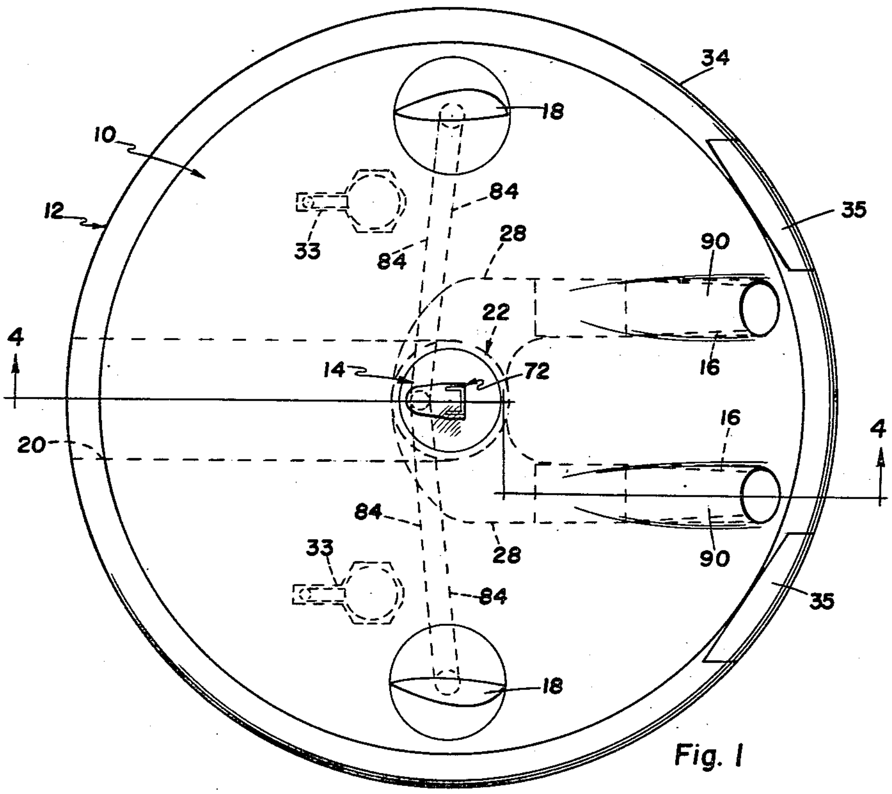
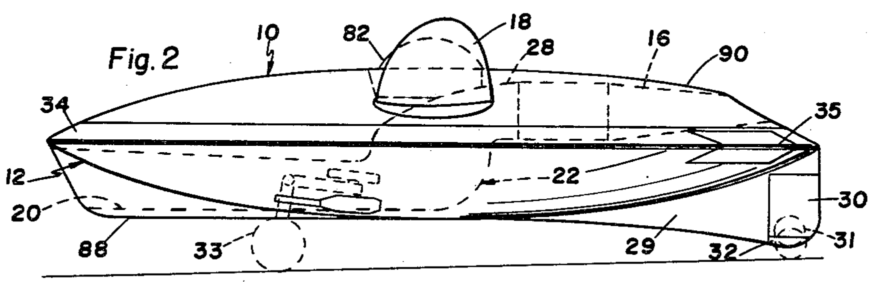



Fig. 1



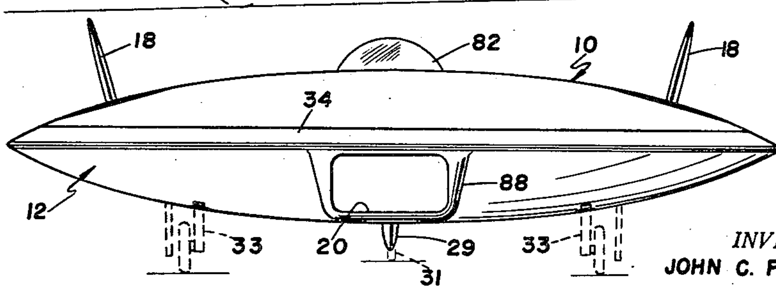




Fig. 3

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CIRCULAR AIRCRAFT AND CONTROL SYSTEM THEREFOR

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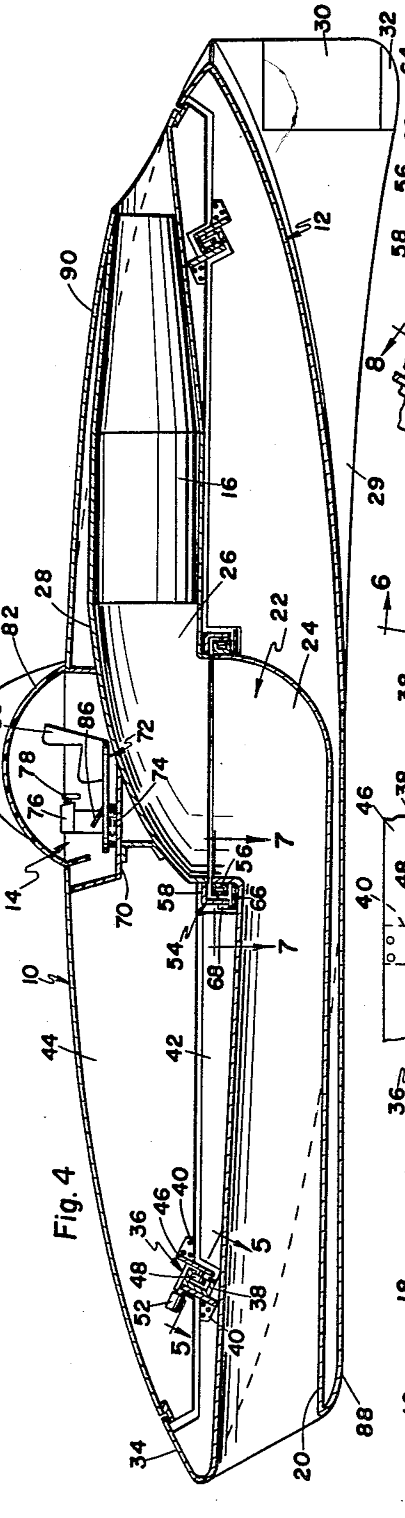

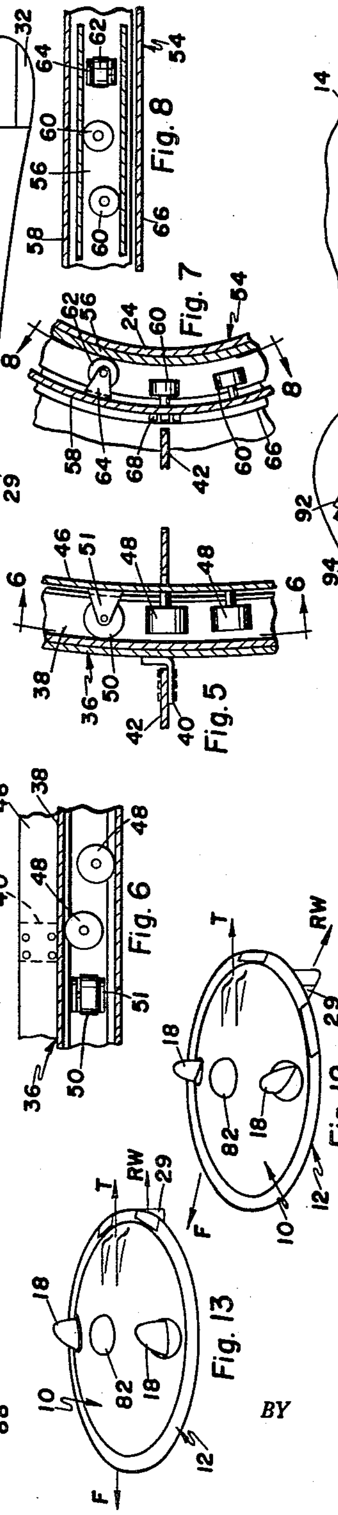

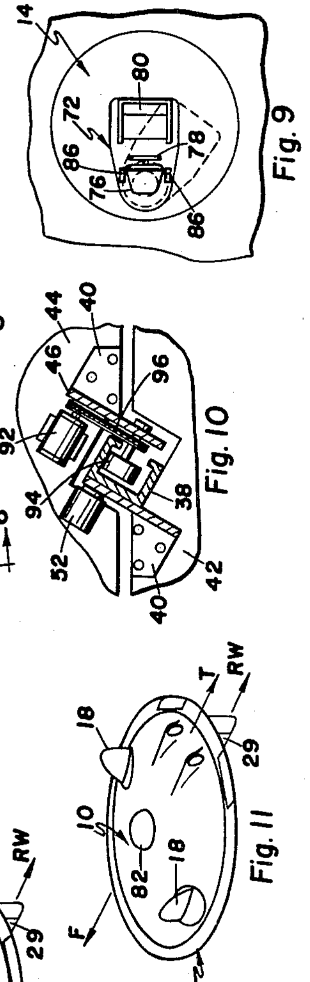

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# CIRCULAR AIRCRAFT AND CONTROL SYSTEM THEREFOR

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15 Claims. (Cl. 244—15)

The present invention relates generally to aircraft and more particularly to a circular aircraft and control system therefor.

The primary object of this invention is to provide a circular aircraft having a rotatably adjustable upper portion containing the propulsion means, and a mechanism for rotating the upper portion to alter the direction of thrust to obtain directional control of the aircraft.

Another object of this invention is to provide such an aircraft in which the lower portion has a stabilizing fin which tends to remain in parallel relation with the direction of relative wind while the aircraft is in flight. Thus during a turn, the lower portion of the aircraft is always aligned with the relative wind, so that normal pitching and rolling control of the aircraft may be maintained at all times, the lower portion also containing the control surfaces necessary for such maneuvers.

Another object of this invention is to provide an aircraft which is capable of sharp, flat turns without the necessity for banking as is normally required.

Another object of this invention is to provide an aircraft in which the pilot is seated generally at the center of rotation in such a position that the *g*-forces encountered during turns or similar maneuvers are imposed laterally to the pilot's body so that their effect is further minimized.

Another object of this invention is to provide an aircraft which, in addition to the special maneuvers made possible by the rotation of the upper portion, retains the full control of a conventional aircraft using conventional control surfaces.

Finally, it is an object to provide an aircraft of the aforementioned character which is simple and convenient to operate and which may be economically constructed according to accepted aircraft standards.

With these and other objects definitely in view, this invention consists in the novel construction, combination and arrangement of elements and portions, as will be hereinafter fully described in the specification, particularly pointed out in the claims, and illustrated in the drawings which form a material part of this disclosure and wherein similar characters of reference indicate similar or identical elements and portions throughout the specification and throughout the views of the drawings, and in which:

Fig. 1 is a top plan view of the aircraft.

Fig. 2 is a side elevation view of the aircraft.

Fig. 3 is a front elevation view of the aircraft.

Fig. 4 is an enlarged sectional view taken on the line 4—4 of Fig. 1.

Fig. 5 is an enlarged fragmentary sectional view taken on the line 5—5 of Fig. 4.

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 5.

Fig. 7 is an enlarged fragmentary sectional view taken on the line 7—7 of Fig. 4.

Fig. 8 is a sectional view taken on the line 8—8 of Fig. 7.



Fig. 9 is an enlarged fragmentary plan view of the pilot's cockpit showing the pivotally mounted seat and control pedestal.

Fig. 10 is an enlarged sectional view, similar to the portion of Fig. 4 at which the section 5—5 is taken, showing an alternative method of rotating the upper portion by means of a servo motor.

Figs. 11, 12 and 13 are diagrammatic views of the aircraft in three positions during a turn to illustrate the disposition of the upper and lower portions.

Referring now to the drawings, the aircraft comprises an upper shell **10** and a lower shell **12**. The exact method of constructing the aircraft is not important to this disclosure, except that the various structural components must be designed according to accepted aircraft standards. The upper shell **10** contains the pilot's cockpit **14** and the motors **16**, two turbo-jet motors being shown as an example. Also on the upper shell **10**, adjacent the outer rim thereof and positioned approximately on the lateral diameter of the disc, are a pair of rotatable fins **18** which are used to rotate the upper shell.

The lower shell **12** is provided with an air intake duct **20** to carry air to the motors **16**. At the center of the aircraft on the axis of rotation is a plenum chamber **22** comprising a lower chamber **24**, which is an extension of the duct **20**, and an upper chamber **26** communicating therewith. The upper chamber **26** is located in the upper shell **10** and leads to a bifurcated duct **28** communicating with the motors **16**. Thus air is supplied to the motors **16** regardless of the relative disposition of the upper and lower shells.

Mounted on the longitudinal axis of the lower shell **12** and adjacent the rear thereof is a fixed fin **29** having a pivotally attached rudder **30**. Installed in the rudder **30** is a tailwheel **31** which is enclosed by suitable doors **32**. The aircraft is supported by the main landing gear legs **33** which retract into the lower shell **12**. The disposition and arrangement of the landing gear legs **33** and the tailwheel **31** are illustrative, the actual structure being best determined in the detail design of the aircraft. The upper and lower shells together constitute an airfoil of suitable aerodynamic design to provide the necessary lift and stability for the aircraft. The lower shell **12** extends slightly above the horizontal axis of the airfoil so that the upper shell **10** is smaller in diameter than the lower shell. The extended rim **34** of the lower shell **12** is fitted with a pair of elevons **35** located at the trailing edge of the airfoil slightly outboard of the motors **16**. The elevons **35** constitute the combined ailerons and elevators normally used on tailless type aircraft.

The upper shell **10** is attached to the lower shell **12** by a large diameter roller bearing **36** shown in Figs. 4, 5 and 6. This roller bearing **36** comprises a generally C-shaped channel rail **38** secured by suitable brackets **40** to the structural ribs **42** of the lower shell **12**, said channel rail being mounted at an upwardly converging angle. Secured to the structural ribs **44** of the upper shell **10** by further brackets **40** is a bearing ring **46** on which are mounted a plurality of vertical load rollers **48** which are vertically displaced in pairs so that the rollers alternately bear on the upper and lower surfaces of the channel rail **38** as shown in Fig. 6. Intermediate the pairs of rollers **48** are lateral load rollers **50** mounted in brackets **51**, these rollers **50** bearing outwardly against the channel rail **38** and being at right angles to the rollers **48**. It will be evident that the rollers **48** and **50** together support the upper shell **10** against vertical and lateral loads. Engaging the channel rail **38** and secured to a convenient structural member in the upper shell **10** is a pilot operated friction brake **52** which is used to lock the upper shell against rotation during normal flight. This brake **52** may be actuated pneumatically, hydraulically or electrically, many existing types of brakes being suitable for the purpose.

The upper and lower portions of the plenum chamber **22** are connected by a roller bearing **54** to ensure alignment and prevent loss of incoming air due to leakage. The roller bearing **54** comprises a generally U-shaped channel rail **56** secured to the upper rim of the lower chamber **24**. Extending outwardly and downwardly from the upper chamber **26** is a bearing ring **58**, having thereon a plurality of vertical load rollers **60** alternately vertically staggered as shown in Fig. 8. Intermediate the rollers **60** are lateral load rollers **62** mounted in brackets **64** and bearing inwardly on the channel rail **56** as shown in Fig. 7. The combination of rollers thus absorbs all vertical and lateral loads in the roller bearing **54** in a manner similar to that described for the roller bearing **36**.

Fitted around the lower chamber **24** below the channel rail **56** is a slip ring **66** which carries the necessary electrical contact rings to connect the pilot's controls to the various mechanisms in the lower shell **12**. The wiper contacts **68** engaging the slip ring **66** are mounted on the bearing ring **58**. It will be evident that electrically operated controls are necessary for the various mechanisms, such as landing gear retraction and elevon operation, due to the relative rotation of the upper and lower portions of the aircraft. The structure of the electrical slip ring **66** and the wiper contacts **68** are according to accepted standards, the details being fully understood by those familiar with the art.

The pilot's cockpit **14** has a floor structure **70** on which is a control pedestal **72**, pivotally mounted on a base **74**. Extending upwardly from the control pedestal **72** is a column **76** on which are the control wheel **78** and the associated aircraft controls. Also mounted on the control pedestal **72** is the pilot's seat **80** of suitable design. The cockpit **14** is, of course, fitted with a transparent canopy **82** for maximum visibility.

The fins **18** are connected by means of cables **84** to generally conventional rudder pedals **86** mounted on the control pedestal **72**.

The duct **20** is faired into the forward lower surface of the lower shell **12** by a fairing **88**, while the motors **16** are similarly faired into the rear upper surface of the upper shell **10** by cowlings **90**.

In normal flight, the upper shell **10** is locked against rotation by the friction brake **52**, control of the aircraft being accomplished by the elevons **35** and fins **18** in the normal manner. In order to make a sharp, flat turn, the friction brake **52** is disengaged so that the upper shell **10** may rotate freely. The turning action is illustrated in Figs. 11–13 in which the various arrows are used to clarify the maneuver. Arrow F indicates the direction of flight, arrow T indicates the direction of thrust and arrow RW indicates the direction of relative wind.

Fig. 11 shows the straight and level flight position in which the directions of flight, thrust and relative wind are all in alignment longitudinally of the aircraft. To start the turn, the fins **18** are offset by means of the pedals **86** to the position shown in Fig. 12. This offset causes the upper shell **10** to be rotated by the slipstream until the fins **18** are once more aligned with the relative wind. At this position the direction of thrust is to one side of the line of flight, with the result that the aircraft will be propelled to the side opposite to the direction of thrust. At the same time, the lower shell **12** is held stationary relative to the line of flight by the tendency of the fixed fin **29** to "weather-vane" into the relative wind as shown in Fig. 12. However, the direction of relative wind is changing due to the aircraft being propelled to one side by the thrust of the motors, thus the fixed fin **29** will gradually turn into the new direction of relative wind, so that the upper and lower portions of the aircraft are once more in alignment. This, the completed turn position, is shown in Fig. 13. The fins **18** are, of course, returned to neutral by the pilot as the aircraft assumes the required new heading. It will be seen that the "weather-vaning" of the lower shell **12** holds the air intake ducts **20** directly into the relative wind, so providing maximum ram effect to maintain the motors **16** at full operating efficiency.

In conventional aircraft which bank when turning, the *g*-forces on the pilot are considerable at high speeds. With the pilot in a sitting position and the aircraft in a steep bank these *g*-forces are effective longitudinally of the pilot's body, so causing black-out as is well known. With the present aircraft making a flat turn, the *g*-forces are effective laterally through the pilot's body with the pilot seated normally. It is well known that the *g*-forces are at least effective in this direction so minimizing the tendency of the pilot to black-out.

The pilot being seated at the axis of rotation of the aircraft, the effects of the *g*-forces are still further minimized. It will be evident that much sharper turns are possible than with conventional aircraft without undue discomfort to the pilot, this being a distinct advantage in combat or evasive maneuvers.

In the case of the present type of aircraft flying at extreme speeds, the effects of the centrifugal and *g*-forces encountered in a high speed turn are minimized to a bearable degree as explained above. However, the acceleration of the aircraft in the new heading after making a turn may commence before the turn is actually completed. While the aircraft is still turning, the pilot may not be actually facing in the true direction of acceleration, with the result that excess side loads are experienced. In aircraft using very high powered turbo-jet or rocket motors these side loads may be sufficient to cause loss of control. For this purpose the entire control pedestal is allowed to swing on its base **74** as shown dotted in Fig. 9. During a turn the seat **80** will tend to swing outwardly under centrifugal force so that the pilot faces the new direction of travel slightly before the aircraft reaches that heading and is thus in a position to absorb the acceleration forces. As the aircraft accelerates the seat will be held in general alignment with the direction of acceleration by the acceleration force. If necessary, some form of damping may be applied to the control pedestal **72** to prevent free swinging and oscillating during normal maneuvers.

For taxying and maneuvering on the ground the rudder **30** together with the tailwheel **31** are used. The tailwheel **31** is, of course steerable with the rudder, the pilot's controls for such a mechanism being well known to those skilled in the art.

During flight at extreme altitudes in rarefied atmosphere, the fins **18** are less effective. To maintain the required maneuverability at such altitudes the rotation of the upper shell **10** may be augmented by a servomotor or the like. Such an arrangement is shown in Fig. 10 in which a motor **92** is mounted on a convenient structural rib **44** adjacent the bearing ring **46**. Mounted on the bearing ring **46** is a driven roller **94** operatively connected to the motor **92** by a drive chain **96** or the like. The motor **92** is of the reversible type and is preferably operatively connected to the pedals **86** to rotate the upper shell **10** in conjunction with the action of the fins **18**. For certain applications it may be desirable to eliminate the fins **18**, in which case the upper shell **10** may be entirely rotated by the motor **92** to alter the direction of thrust.

It will be evident that aside from performing all maneuvers possible with conventional aircraft, the presently disclosed aircraft is capable of additional maneuvers previously impossible. Besides making sharp turns in a horizontal plane, a similar sequence of operations may be carried out to obtain changes of direction in a vertical plane or in any direction therebetween. This is accomplished by first rolling the aircraft on its axis longitudinal to the line of flight, by means of the elevons, into the plane of the desired direction change. The aircraft is then turned into the new direction by rotating the upper shell 10 as previously described. By this means the aircraft may be made to dive or climb abruptly or to take an angular course in any desired direction without discomfort to the pilot.

It should be understood that the specific structure shown in the drawings is illustrative only, many forms of construction being suitable for such an aircraft.

Although the present disclosure specifically describes an aircraft, the principle of rotating that portion of the body of a powered vehicle containing the propulsion means is equally applicable to other vehicles such as surface or underwater vessels. Furthermore, the propulsion motors may be installed in either the upper or lower portion of the body without departure from the scope of the invention, the actual arrangement being dependent on the particular vehicle and its purpose.

The operation of this invention will be clearly comprehended from a consideration of the foregoing description of the mechanical details thereof, taken in connection with the drawings and the above recited objects. It will be obvious that all said objects are amply achieved by this invention.

Further description would appear to be unnecessary.

It is understood that minor variation from the form of the invention disclosed herein may be made without departure from the spirit and scope of the invention disclosed herein, and that the specification and drawings are to be considered as merely illustrative rather than limiting.

I claim:

1. In an aircraft of generally circular form, a lower portion, an upper portion rotatably adjustably mounted on said lower portion, propulsion means in said upper portion, means for rotating said upper portion to alter the direction of propulsive thrust, and means tending to hold said lower portion against shifting in relation to the direction of motion of the aircraft while said upper portion is rotated.

2. In an aircraft of generally circular form, a lower portion, an upper portion rotatably adjustably mounted on said lower portion, propulsion means in said upper portion, means for rotating said upper portion to alter the direction of propulsive thrust, means tending to hold said lower portion against shifting in relation to the direction of motion of the aircraft while said upper portion is rotated, and means for locking said upper portion against rotative movement relative to the lower portion.

3. In an aircraft of generally circular form, a lower portion, an upper portion rotatably adjustably mounted on said lower portion, rearwardly thrusting propulsion motors in said upper portion, means for rotating said upper portion to alter the direction of propulsive thrust, a stabilizing fin on said lower portion to bias the same against shifting in relation to the direction of motion of the aircraft while said upper portion is rotated, and means for locking said portions against relative rotation.

4. In an aircraft of generally circular form, a lower portion, an upper portion rotatably adjustably mounted on said lower portion, said lower and upper portions together constituting an aerodynamic lifting surface, rearwardly thrusting propulsion motors in said upper portion, means for rotating said upper portion to alter the direction of propulsive thrust, a stabilizing fin on said lower portion to bias the same against shifting in relation to the direction of motion of the aircraft while said upper portion is rotated, and means for locking said portions against relative rotation.

5. In an aircraft of generally circular form, a lower portion, an upper portion rotatably adjustably mounted on said lower portion, said lower and upper portions together constituting an aerodynamic lifting surface, rearwardly thrusting propulsion motors in said upper portion, pivotal fin means on said upper portion for rotating the same to alter the direction of propulsive thrust, a stabilizing fin on said lower portion to bias the same against shifting in relation to the direction of motion of the aircraft while said upper portion is rotated, and means for locking said portions against relative rotation.



6. In an aircraft of generally circular form, a lower portion, an upper portion rotatably adjustably mounted on said lower portion, said lower and upper portions together constituting an aerodynamic lifting surface, rearwardly thrusting propulsion motors in said upper portion, pivotal fin means on said upper portion for rotating the same to alter the direction of propulsive thrust, a stabilizing fin on said lower portion to bias the same against shifting in relation to the direction of motion of the aircraft while said upper portion is rotated, means for locking said portions against relative rotation and hinged control surfaces in said lower portion for rolling and pitching control of the aircraft about its longitudinal and lateral axes, respectively.

7. In an aircraft of generally circular form, a lower portion, an upper portion adjustably rotatably mounted on said lower portion, rearwardly thrusting propulsion motors in said upper portion, pilot actuated controls in said upper portion, pivotal fin means on said upper portion, actuating means operatively connecting said controls to said fins for rotating the same whereby said upper portion is rotated to alter the direction of propulsive thrust, a stabilizing fin on said lower portion to bias the same against rotation relative to the direction of motion of the aircraft while said upper portion is rotated, and means for locking said portions against relative rotation.

8. In an aircraft of generally circular form, a lower portion and an upper portion, an annular bearing rotatably interconnecting said upper and lower portions, rearwardly thrusting propulsion motors in said upper portion, pilot actuated controls in said upper portion, pivotal fin means on said upper portion, actuating means operatively connecting said controls to said fins for rotating the same whereby said upper portion is rotated to alter the direction of propulsive thrust, a stabilizing fin on said lower portion to bias the same against rotation relative to the direction of motion of the aircraft while said upper portion is rotated, and means for locking said portions against relative rotation.

9. An aircraft according to claim 8 and including a driven roller in said bearing, and a motor operatively connected to said driven roller to rotate said upper portion relative to said lower portion.

10. An aircraft according to claim 3 and including a steerable landing wheel in said fin, and a main aircraft supporting landing gear in said lower portion.

11. An aircraft according to claim 8 wherein said locking means comprises a frictional brake engaging said bearing.

12. In an aircraft of generally circular form, a lower portion, an upper portion rotatably adjustably mounted on said lower portion, rearwardly thrusting jet propulsion motors in said upper portion, an air intake duct in said lower portion, a plenum chamber at the axis of rotation of said upper portion, said plenum chamber comprising a lower chamber communicating with said air intake duct and an upper chamber communicating with said motors, and an annular bearing interconnecting said lower and upper chambers in substantially sealed relation, means for rotating said upper portion to alter the direction of propulsive thrust, and means tending to hold said lower portion against shifting in relation to the direction of motion of the aircraft while said upper portion is rotated.

13. An aircraft according to claim 1 and including a pilot's cockpit in said upper portion at the axis of rotation thereof, a control pedestal pivotally mounted in said cockpit, and a seat on said control pedestal.

14. In a vehicle, a body having a lower portion, and an upper portion rotatably mounted on said lower portion, means for rotating one of said portions relative to the other of said portions, propulsion means in one of said portions, and means for biasing the other of said portions against rotation relative to the direction of motion of the

vehicle while the portion containing said propulsion means is rotating.

15. An aircraft of generally circular form, comprising two portions mounted for rotative adjustment relative to each other, propulsion means in one of said portions, and means for maintaining the other of said portions substantially in alignment with the direction of flight while the portion containing said propulsion means is rotatively adjusted.




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July 30, 1957 C. P. LENT 2,801,058

SAUCER-SHAPED AIRCRAFT

Filed Dec. 6, 1950 3 Sheets-Sheet 1

FIG. 1.

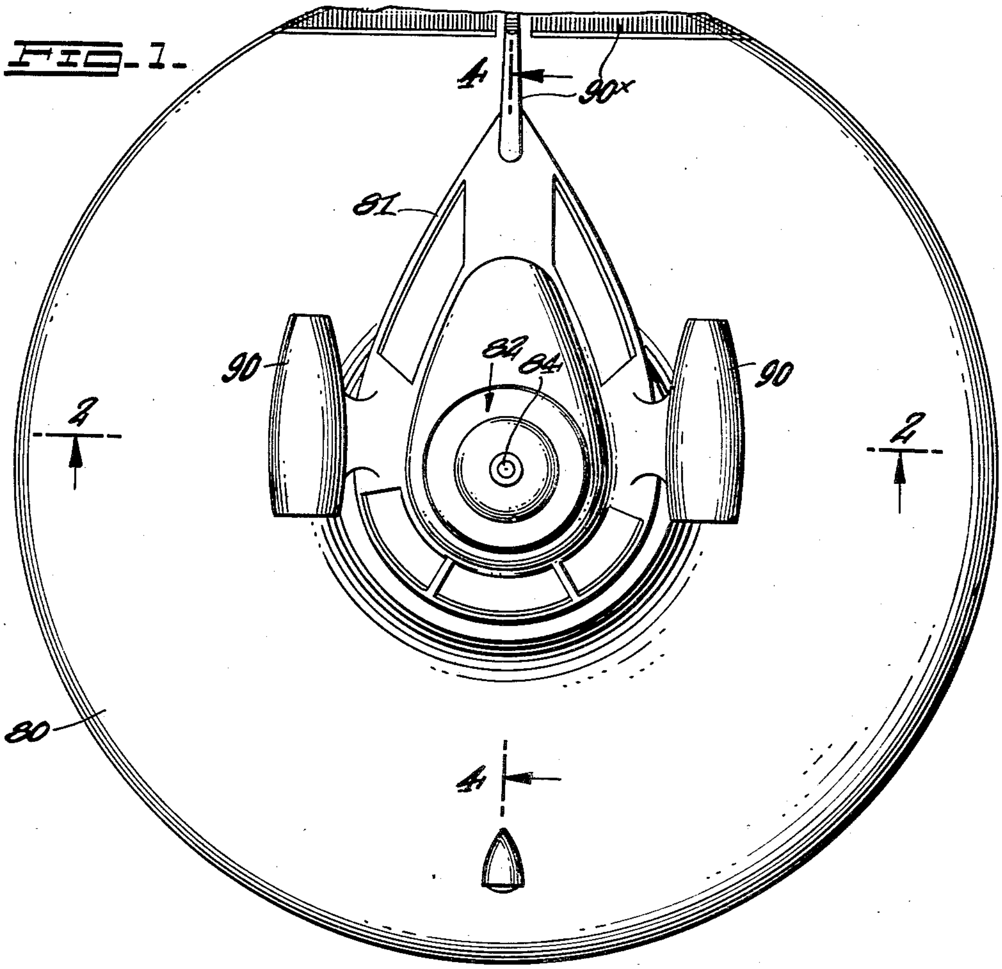


FIG. 2.

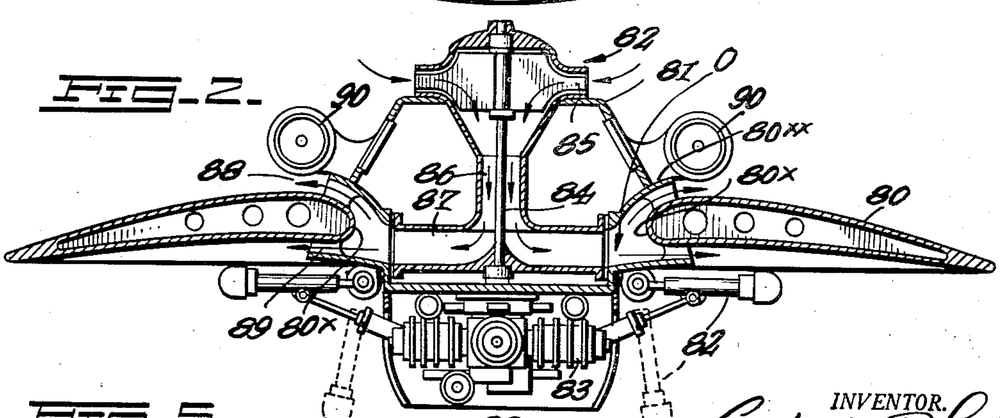


FIG. 5.

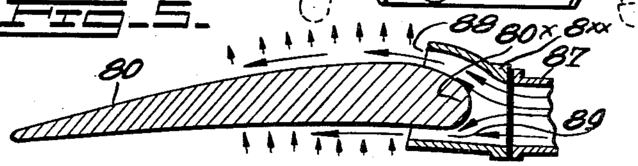


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FIG. 3.

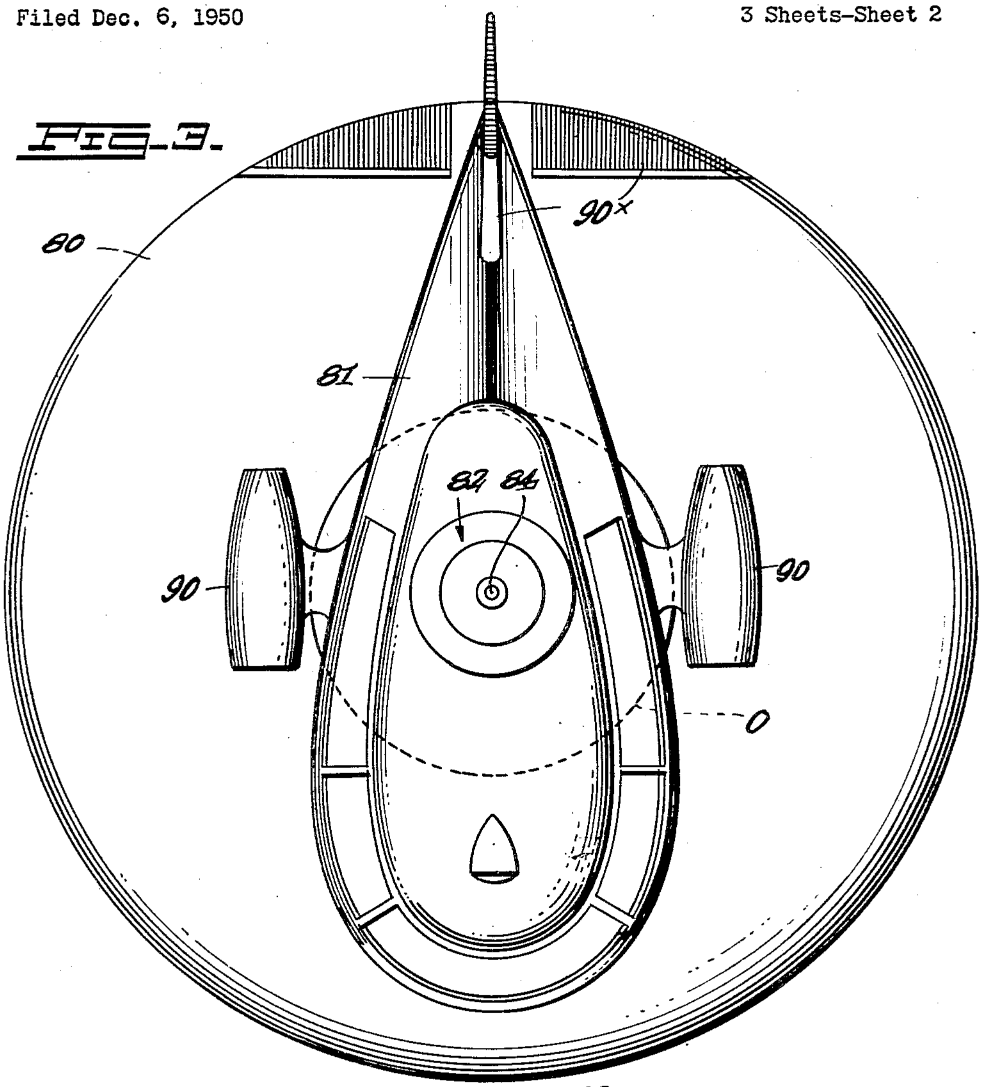


FIG. 4.

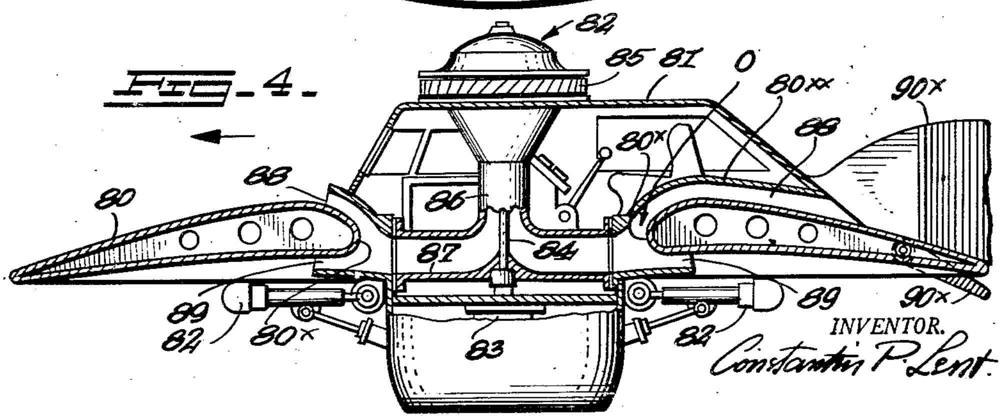


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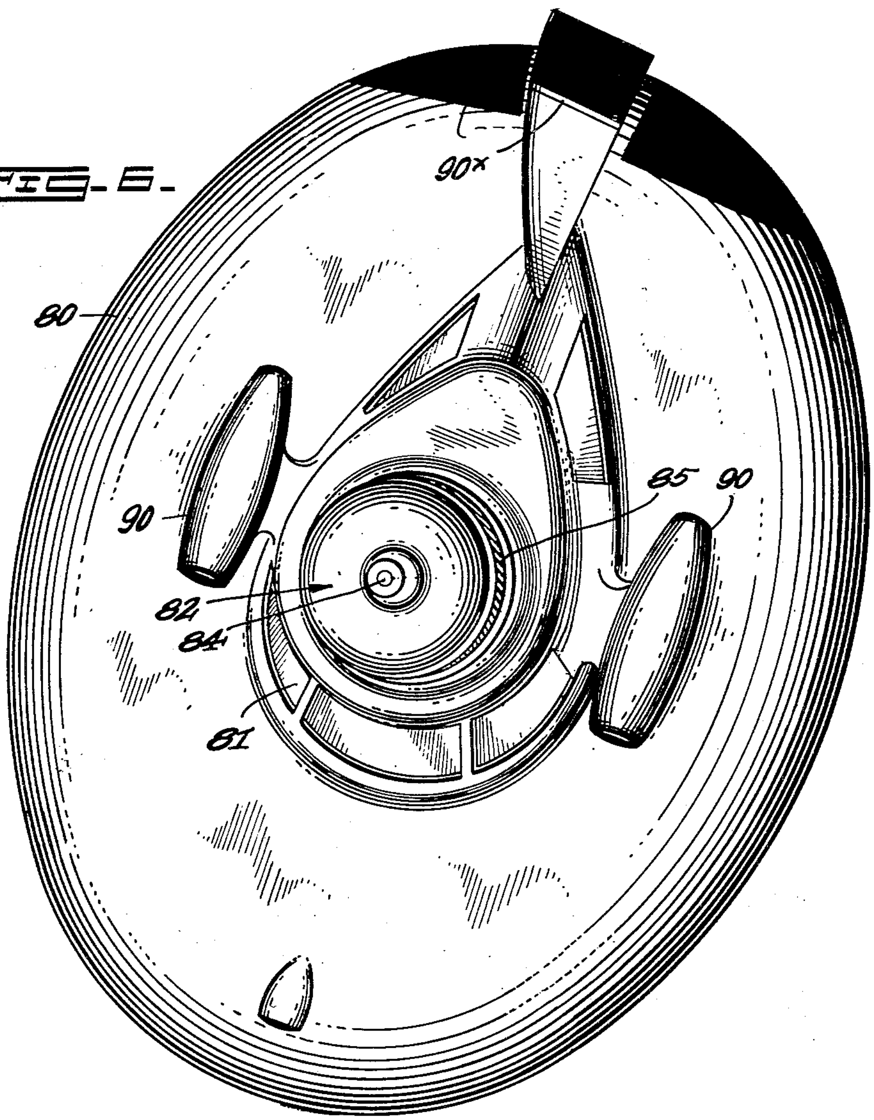
FIG. 6.

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United States Patent Office 2,801,058
Patented July 30, 1957



2,801,058

# SAUCER-SHAPED AIRCRAFT

Constantin P. Lent, New York, N. Y.

Application December 6, 1950, Serial No. 200,531
6 Claims. (Cl. 244—12)

This invention relates to saucer-shaped aircraft and more particularly to vehicles having a round or circular body contour known as "flying saucers."

The flying saucer described in this invention is not a thing in the realm of phantasy but a very practical aircraft obeying approved aerodynamic principles. Its mode of operation permits it to remain indefinitely in the air and as long as its prime-mover is supplied with fuel. It can hover over the ground at any height from 5 to 50,000 feet and more. It can move transversely under the control of a navigator and crew. It can carry passengers.

The saucer-shaped aircraft described in this invention can find utilization in commercial transportation such as air travel, transcontinental and transoceanic passenger service, commuter transport, mail transport and delivery and bus service for cities and towns. It is extremely useful for private plane operation.

The flying saucer described in this invention can attain tremendous speeds and its manuverability is enormous. It can rise vertically instantaneously and travel at supersonic speeds. But it can also fly at extremely low speeds and if necessary it can land and take off vertically at a passenger elevator speed or even less.

The flying saucer is safe and easy to operate. In case of motor failure, it will safely land by means of its circular wing the latter serving as a landing parachute.

Heretofore, heavier than air craft such as airplanes and helicopters relied upon the aerodynamic action of straight or slanted wings to produce the desirable lift. In the helicopter the aerodynamic action of the rotor blades being rotated through the air produce the lift.

In an airplane, the fuselage of the craft including its wings is propelled through the medium of the atmospheric air by means of the forward pull of propellers which are driven by reciprocating engines. In jet planes, forward pull is produced by the reaction of the gases in jet motors. In rocket driven planes, forward motion is produced by the reaction of the gases in its rocket motors. The well known aerodynamic action of the airfoil of the wing of the plane as it streams through the air creates a vacuum space above the wing and an air pressure space below it. The sum total of both, vacuum and air pressure, producing the vertical lift component which permits the wing and the fuselage of the plane to leave the ground. This is the principle that makes an airplane fly.

In a helicopter, the oversized rotor blades have an airfoil cross-section similar to the wing of the plane. As the blades of the rotor are rotated through the air by means of its motor, a vacuum space is created above the blades and an air pressure below; the sum total of both producing a vertical lift. This is the principle that makes a helicopter hover above ground. In the flying saucer craft described in this invention, the fuselage of the round-shaped body of the vehicle or circular wing is provided at the center portion thereof with air inlets or openings to permit a flow of air. The airflow in question passes from above the fuselage of the craft, under it. The flow of air is created by means of propellers or rotors



driven by a prime-mover. The action of the air passing through the air inlet in the vehicle is twofold. First, the sucking action of the propeller or rotor lifts the craft aloft and second, the flow of air thus created is directed against the airfoil cross-section of the circular wing.

Generally speaking this invention provides a circular structure which is equipped with one or a plurality of openings passing through said structure and being fitted with a motive means for creating an air stream and directing it from above said structure below it. The stream thus created creating a vacuum over the top surface of the circular structure and air pressure under said structure. The resultant sum of vacuum and pressure creating a vertical lift and permitting the circular wing to hover or move anywhere under the direction of a navigator.

One object of this invention is to provide a circular wing for aircraft provided with motive means to create a vertical lift.

Another object of this invention is to provide a circular wing aircraft and motive means to create a vertical lift.

Still another object of this invention is to provide a circular wing aircraft provided with one single centrally located opening said circular wing aircraft resembling a doughnut-shaped fuselage.

Still another object of this invention is to provide motive means within the centrally located opening or openings in said round-shaped wing fuselage.

Still another object of this invention is to provide propeller means within the centrally located opening or openings in said round-shaped wing fuselage.

Still another object of this invention is to provide a round-shaped wing fuselage provided with rotor means within centrally located opening or openings in said round-shaped wing fuselage.

Another object of this invention is to provide an arrangement of wing structure and motive force to create a stream of air which being drawn from above said aircraft and its wing will be directed below it. This action producing a vertical lift.

Another object of this invention is to provide a doughnut-shaped craft having a circular wing of airfoil cross-section and means to pass a stream of air against said wing. The aerodynamic action of the air against said wing permitting the saucer and doughnut-shaped craft not only to rise vertically but also to hover over the same position indefinitely or move sideways or to any other direction under the control of a navigator and crew.

Still another object of this invention is to create a flow of air and direct it against the inside edge of a circular airfoil differentiating from a straight airfoil. The action of the air blown against the inside edge of the circular wing creating a vacuum space over the wing and an air pressure space under it thus making it possible for said wing to take off vertically.

A further object of this invention is to provide a fuselage of a round-shaped wing contour which will contain an air inlet or hole in its center, the round-shaped wing being stationary in relation to a set of rotating propellers or air rotors, the propellers or rotors being located adjacent to said air inlet, and the action of the propellers or rotors creating a stream of air through said inlet in the round-shaped wing.

Still another object of this invention is to provide double-acting propeller means within the openings in said round-shaped wing fuselage.

Still another object of this invention is to provide a circular wing structure and reciprocating engine means or electric motor means to operate propellers or rotors contained within an opening leading into said wing structure.

A still further object of this invention is to provide a round-shaped wing structure and air pump means located within openings leading through said round-shaped structure.

Still another object of this invention is to provide a round-shaped wing structure, holes passing through said structure, propeller or rotor means located within said holes, said holes being equipped with baffle plates to direct a stream of air entering said holes from above through the holes in said wing structure.

Still another object of this invention is to provide a round-shaped wing structure resembling a doughnut, a single hole passing in the center portion of said structure, propeller or air rotor means inside said hole. Said hole being provided with baffle plates to direct a stream of air entering said hole against the wall portion comprising said hole in said wing structure.

Still another object of this invention is to provide a round-shaped wing structure comprising an airfoil with a single opening in its center, said wing structure resembling a doughnut-shaped wing, having a propeller or air rotor means located within said opening, said round-shaped wing provided also with a baffle plate within said circular opening for directing the air entering said opening from above against the internal edge of said airfoil.

A still further object of this invention is to provide a circular wing structure, said structure in cross-section being similar to the cross-section of standard airplane wings, or airfoils.

A still further object of this invention is to provide a circular wing comprising a saucer-shaped structure, one or more openings in said structure, motive means in said structure to operate air rotors or propellers within said opening or openings.

A still further object of this invention is to provide a standard airfoil fuselage comprising a doughnut-shaped circular wing with a hole in its center, propellers or rotors within said opening and motivating means to operate said propellers or rotors.

A still further object of this invention is to provide a circular wing plane provided with openings which contain propellers or air rotors, and motive means to operate said propellers, said wing provided with directional control means such as rudder and ailerons.

A still further object of this invention is to provide a circular doughnut-shaped wing structure and means for landing and launching said structure.

A still further object of this invention is to provide a circular doughnut-shaped wing fuselage, landing and take-off means on said fuselage, said means comprising rubber tires or legs to absorb the shock of landing or launching said fuselage.

A still further object of this invention is to provide a circular wing plane equipped with an opening or openings, propeller or air rotor means in said openings, said propeller means being operated by motor means in said wing, and jet or propeller motive means upon said wing, said motor means within said openings facilitating vertical lift while said motive means on said wing facilitates transverse motion.

Further objects will be seen and become apparent as the specification of this invention will proceed.

Referring to figures:

Fig. 1 is a plan view of the flying saucer craft shown in Fig. 6.

Fig. 2 is a cross-section through the circular wing craft taken on the line **2—2** of Fig. 1.

Fig. 3 is a plan view of a circular flying saucer craft with the navigator cabin running transversely the entire width of the craft.

Fig. 4 is a cross-section on the line **4—4** of Fig. 1 showing the navigator cabin.

Fig. 5 is a cross-section through the inside edge of the circular airfoil-shaped wing showing the manner in which air is directed against it to create an aerodynamic vacuum on the top of the airfoil and an air pressure below it.

Fig. 6 is a perspective view of a preferred embodiment of the circular flying saucer craft.



Referring more particularly to Fig. 1, it is a plan view of a flying saucer aircraft of a more advanced design. Numeral **80** in the drawing designates the circular wing and **81** the navigator's cabin. A rotor or propeller means **82** is preferably located upon the top of the cabin **81** and is being operated by means of a reciprocating motor means **83**, although any other power source can be used. The engine means **83** turns a vertical shaft **84** which is secured to the rotor ring of the rotor means **82**. The rotor ring is designated by the numeral **85**.

Referring to Fig. 2, the air from the rotor means **85** is directed through the vertical channel **86** to the horizontal circular air distributor **87** and from then on it is distributed through the space **88** around the wing edge **80*x*** and above it and through the space **89** below it to provide a vertical lift. Jet motor means (can be also propeller means) **90** are used to provide forward motion. Rudder means **91** is used for directional control. In this particular case the flying saucer vehicle lands upon the landing legs **82** which are moved out of the way when the vehicle is in flight.

Fig. 3 shows a craft similar in construction to the one shown in Figs. 1 and 2 but with a navigator's cabin **81** running transversely the entire length of the circular wing **80**.

Fig. 4 is a cross-section through the navigator's cabin **81** taken on the line **4—4** of Fig. 1 showing further details.

The air from the distributor **87** is directed against the inside edge **80*x*** of the circular doughnut-shaped wing **80**. A portion of the air thus directed against the edge **80*x*** is passed through the space **88** which is formed by the upper portion of the wing **80** and the distributor **87**, while another portion of the air is passed under the wing **80** and the space formed by the distributor **87** and the circular wing. The air passing above the wing **80**, in accordance with aerodynamic principles pertaining to standard cross-section airfoils, creates a vacuum while the air passing under the wing creates a pressure. The combined sum of vacuum above the wing and air pressure below it providing a vertical lift. The force or the amount of lift depending upon the size of the prime mover, the diameter of the air rotor or propellers and the rate of revolutions.

*Operation*

Referring more particularly to Figs. 1, 2, 3, 4 and 5 inclusive, it can be seen that the circular wing **80** has an air inlet or opening O which is centrally located in respect to the wing proper. The wing **80** also has a standard airfoil cross-section. In addition, the wing edge **80*x*** faces the inside rim of the air inlet O and is flanked by the air baffle member **80*xx***. The vertical shaft **84** which is rotated by the reciprocating motor **83** is secured at its upper end to the ring **85** of the air rotor **82**. As the air rotor ring **85** rotates at high speed, it sucks in the air from above the cabin **81** and through the upright circular channel **86** delivers it to the air distributors **87**.

By means of the air baffle member **80*xx*** the air is directed against the edge **80*x*** of the wing **80**. A part of it passes through the space **88** created by the upper portion of the surface of the wing **80** and the air baffle member **80*xx*** creating an aerodynamic vacuum; another part of the air is directed through the space **89** built by the lower surface of the wing **80** and the baffle member **80*xx***, under the wing to create an aerodynamic pressure.

The sum total of both, aerodynamic vacuum and pressure providing the craft with a vertical lift.

By means of its rudder and ailerons **90*x*** the craft can maneuver sidewise and fly transversely. To further facilitate sidewise movement, a pair of jet motors **90** are provided. The reaction of the jets permitting the craft high transverse motion and high degree of maneuverability. Propellers can be used too to derive the same effect. To land the craft, the landing legs **83** are extended at will by the navigator. They are retracted when the craft is in motion.

Having now described my invention what I claim is:

1. A flying wing fuselage of circular contour comprising a disk-shaped body with a concentric opening, the shape of said wing being aerofoil-like in cross-section; an aviator's cabin located over said opening, a vertical air passage traversing said cabin, a prime-mover means under said wing, a vertical shaft extending from said prime-mover and passing through said cabin, an air suction means located over said cabin, said suction means secured to said vertical shaft and being operated by it; said prime-mover being secured to said wing, the operation of said air suction means by said prime-mover means creating a stream of air to pass through said vertical air passage in said cabin, baffle plate means included to direct the air from said passage against the aerofoil cross-section of said wing to create a vertical lift; landing gear to launch said wing and jet motor means to propel said wing in the air.

2. A flying machine including an aerofoil-shaped disk-like body with a concentric opening therein; said body having a wider section near the opening in the center and a thinner tapering away section near the outer edge of the disk; an aviator's cabin located over said opening, air suction means in said machine and a prime-mover to operate said suction means, a vertical shaft running from said prime-mover to said suction means and means securing said prime-mover to said machine; the operation of said air suction means by said prime-mover creating a stream of air to pass through a vertical passage in said cabin and to strike against the wider section of said body.

3. The same structure as set forth in claim 2: said air suction means including an air rotor, said rotor secured to said upright shaft and being rotated by said shaft.



4. A disk-like saucer-shaped flying wing including a circular body, an opening passing through said body, said body having an aerodynamically aerofoil-like cross-section resembling the standard cross-section through the wing of an aeroplane with a wider section near said opening and a thinner section near the outer rim of said disk; a navigator's cabin over said opening, an air passage leading through said cabin, an air suction means in said passage, a vertical shaft and a prime-mover, said air suction means being secured to said shaft, said prime-mover rotating said shaft to operate said suction means, said suction means creating a stream of air to pass through said passage in said cabin, baffle plate means in said air passage to direct the air against the wider section in said body to create a vertical lift, and jet motor means to drive the flying wing forward.

5. The same structure as set forth in claim 4: and shock absorber means secured to the lower portion of said body to facilitate safe landing and launching as set forth.

6. The same structure as set forth in claim 4: and control devices in said cabin to permit the aviator at will to direct said saucer-shaped flying wing in its flight through the air, said devices being operatively connected to a rudder and aileron for directional and vertical control.


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AIRCRAFT WITH ENCLOSED ROTOR

Filed July 15, 1953 4 Sheets-Sheet 1

Fig. 1

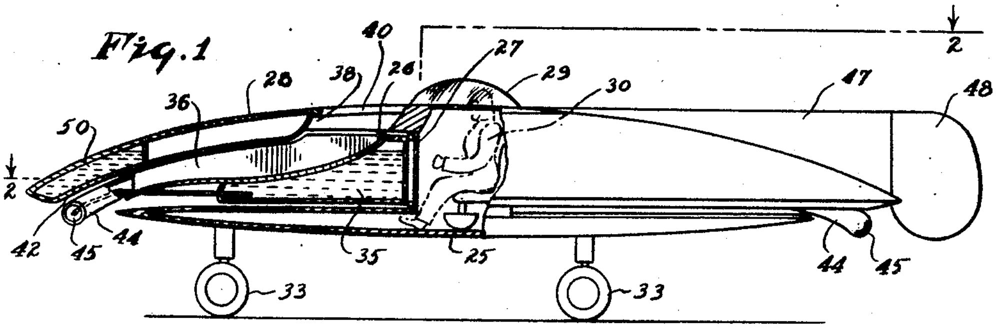
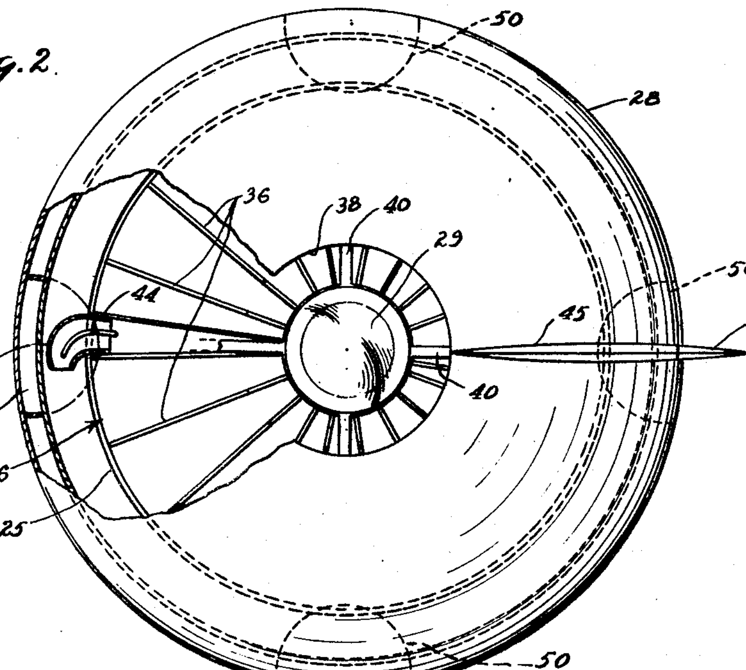
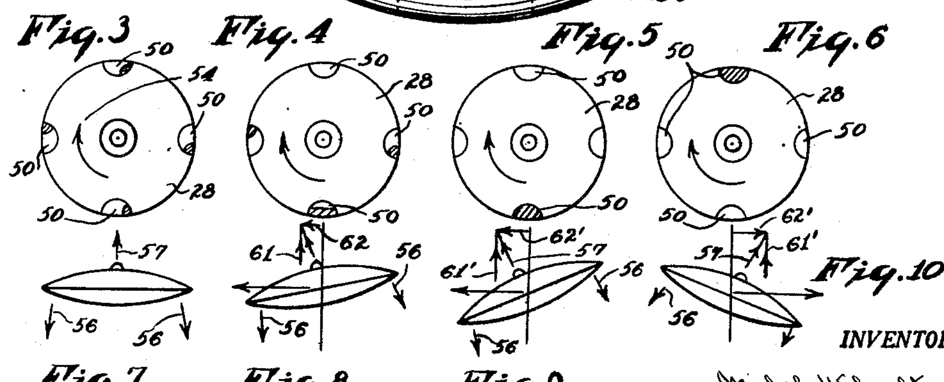



Fig. 2

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AIRCRAFT WITH ENCLOSED ROTOR

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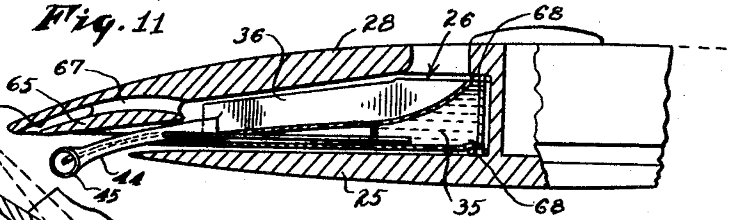
Fig. 11



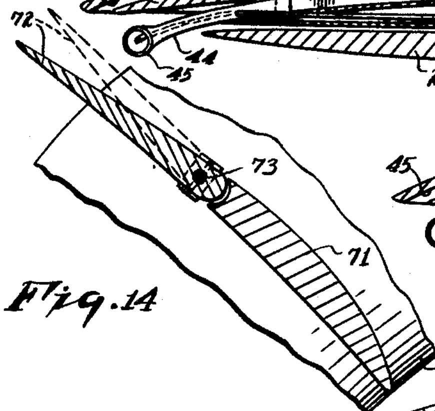




Fig. 14

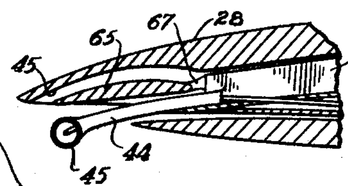



Fig. 12

Fig. 13

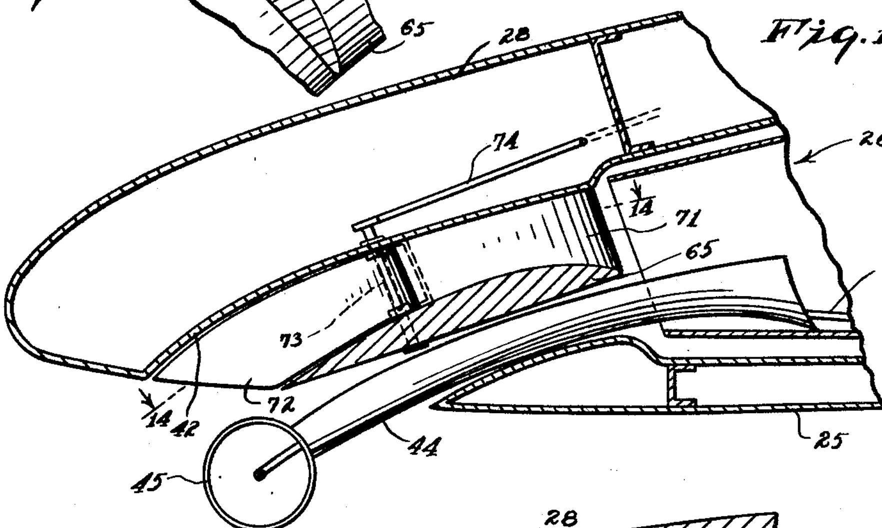
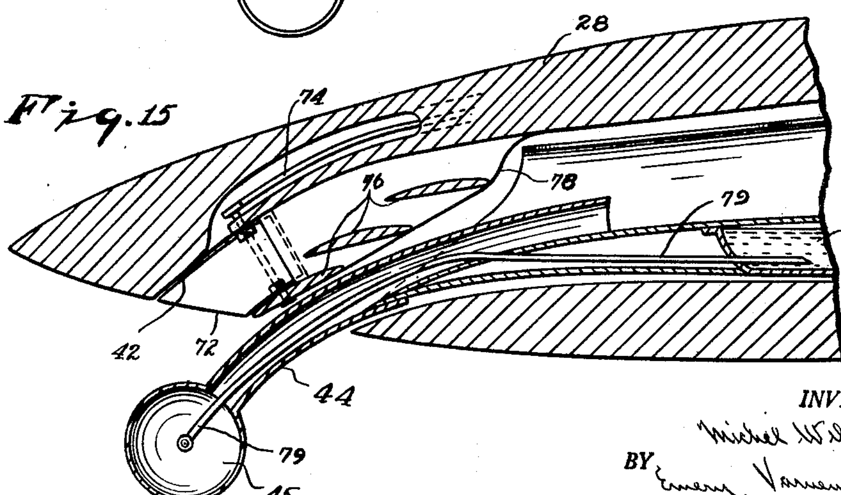



Fig. 15

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AIRCRAFT WITH ENCLOSED ROTOR

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Fig. 16

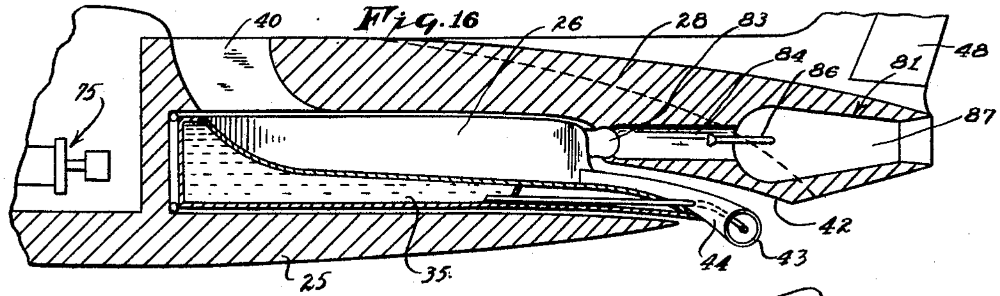



Fig. 17

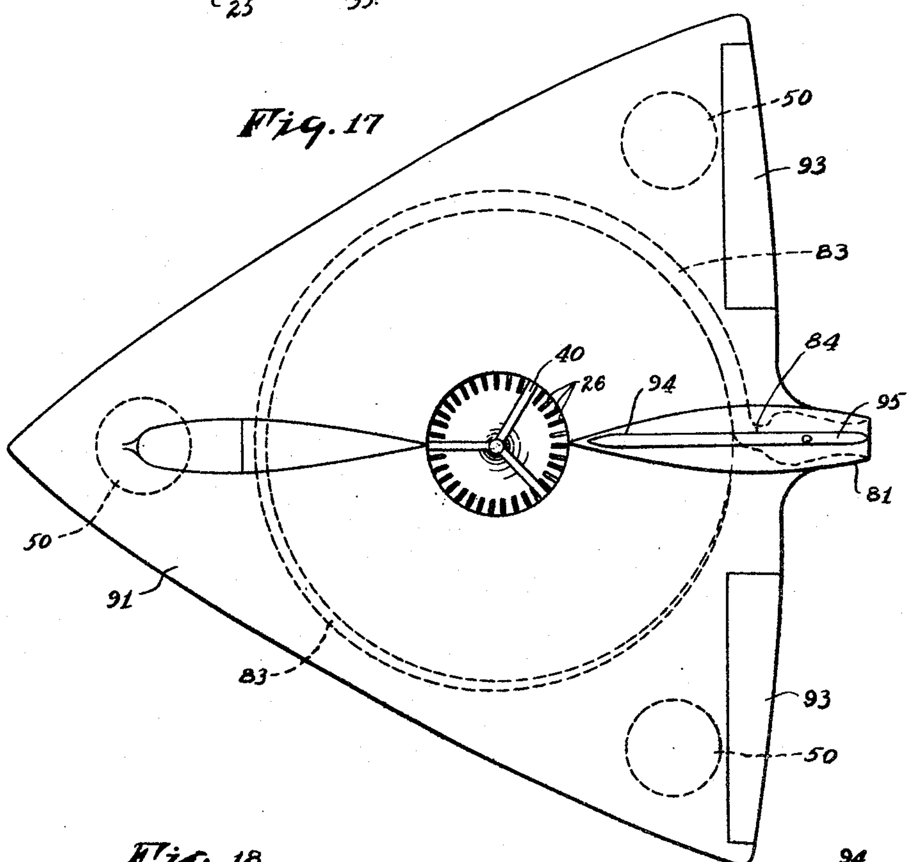
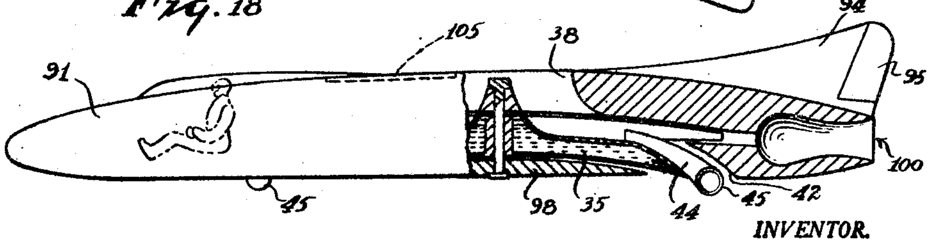



Fig. 18

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AIRCRAFT WITH ENCLOSED ROTOR

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Fig. 19

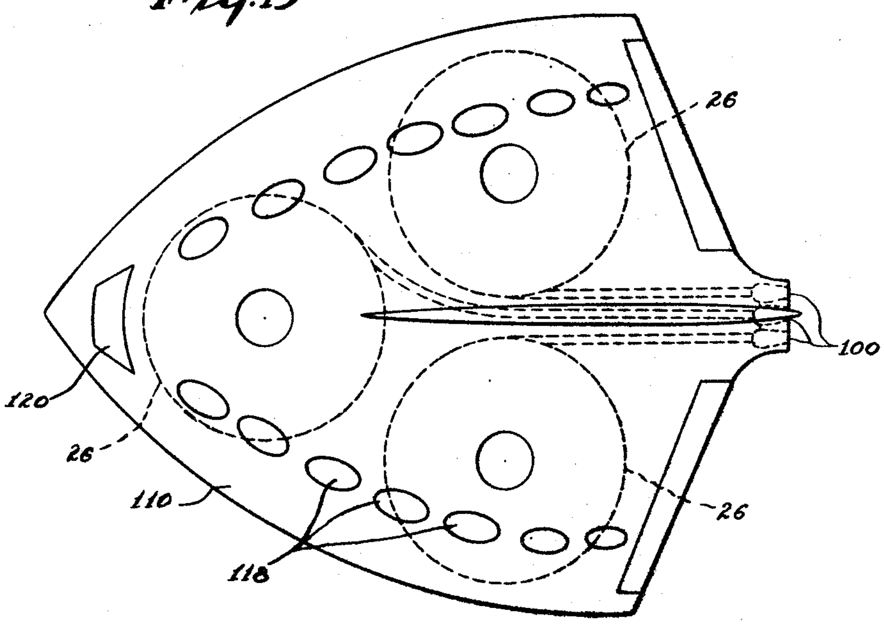



Fig. 20

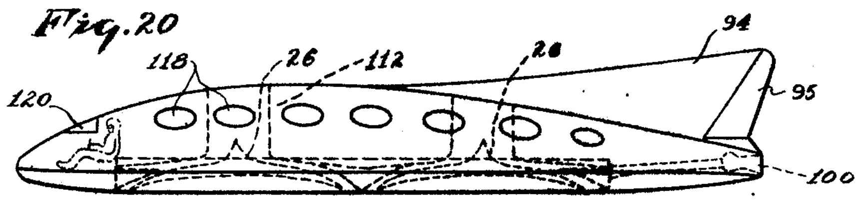
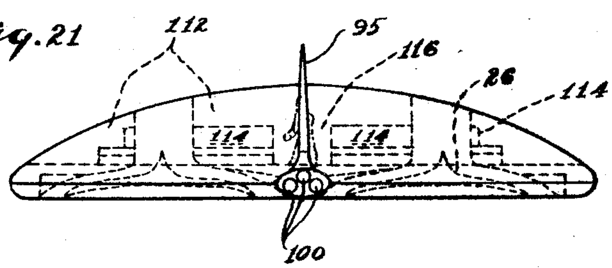



Fig. 21

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# AIRCRAFT WITH ENCLOSED ROTOR

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This invention relates to heavier-than-air aircraft and pertains to a novel type of aircraft which I refer to as a "Gyropter," and which possesses the flying characteristics of both the airplane and the helicopter.

The airplane and the helicopter each have specific advantages and disadvantages which are inherent in and peculiar to their types. For example, the airplane can be driven at very high speeds, but as higher and higher speeds have been achieved, wing surface areas have been reduced and wing loadings have been increased with the result that with planes designed for supersonic speeds, critical stalling speeds are very high, and large landing fields with extremely long runways are required for safety in take offs and landings. It is impossible, of course, for the airplane to rise or descend vertically or to hover.

The latter are the great virtues and advantages of the helicopter. But the great disadvantage of the helicopter is its inherent limitation in speed. When a single rotor helicopter is ascending or descending vertically, the center of lift is at or near the axis of rotation of the winged rotor. As the helicopter begins to advance in a horizontal direction, however, the center of lift shifts away from the axis of rotation and as forward speed increases, the center of lift moves further and further away from the axis of rotation, until at some critical speed the helicopter will capsize. Multiple rotors have been used in an effort to overcome this difficulty, but multiple rotors introduce other difficulties.

Aircraft according to the present invention comprise essentially a rotor mounted on and entirely enclosed within upper and lower interconnected stator elements which carry one or more annular airfoils extending around the periphery of the rotor. The rotor is mounted for rotation on a vertical axis and is preferably in the nature of a large centrifugal blower. The upper stator is provided with an intake opening preferably near or surrounding the axis of rotation of the rotor, and the rotor is provided with blades or other means, such as discs, which accelerate the air and discharge it outwardly from the periphery in a substantially horizontal direction, or at an angle producing a downwash which generates a component of vertical lift. The annular airfoils which surround the periphery of the rotor are located in the path of the air discharged from the rotor, being so arranged that the resultant of the aerodynamic forces acting thereon exerts vertical lift. Since the airfoils are entirely within and enclosed by the upper and lower stators, they are thereby protected from the influence of air currents resulting from horizontal motion of the aircraft. Consequently, there is no shift of the center of lift as horizontal speed increases.

The rotor may be driven in any suitable manner, but is preferably driven by one or more jet reactors in order to eliminate torque which would be present if the rotor were driven by a source of power located on the stators. Any tendency of the stators to rotate due to air friction or drag or to mechanical friction in the bearings between rotor and stators may be corrected aerodynamically by airfoils, preferably adjustable, located in the path of the air discharged from the rotor. Alternatively, it may be corrected gyroscopically, or, after the aircraft attains sufficient horizontal speed, by fins and/or rudders on the stators.

The aircraft may be propelled horizontally in a variety of ways. For example, the gyroscopic action of the rotor may be utilized to produce a tilt of the aircraft through which moderate horizontal speeds can be obtained. This can also be obtained by conventional aerodynamic controls connected with the stators, or by changing the angle of sectors of the lift ring or rings, or also by strangling sectors of the streams of air passing to the rotor or the lift rings. The aircraft will then move horizontally in the direction of the tilt. Alternatively or supplementally the aircraft may be propelled by propellors, jet reactors or any other suitable means mounted on the stators.

In applying the principles of the invention to aircraft of large size, it will be found to be advantageous to utilize multiple rotors rather than to attempt to utilize a single rotor of very large diameter. In such cases by suitable choice of location and direction of rotation of the rotors, any tendency of the stators to rotate may be largely eliminated.

The outside configuration of the stators may be varied depending on the size of the aircraft and the type of service for which it is designed. In the case of small single rotor aircraft, the stator assembly may be in the shape of a disk, thin at its peripheral edges and thickened toward the center. Alternatively, and more particularly in the case of high speed ships, the stator assembly is preferably in the form of a wing. In such cases, once the aircraft is off the ground and propelled horizontally at sufficient speed, the aerodynamic lift of the wing may be used to supplement the lift of the annular airfoil, or in some cases may supersede it entirely. In the latter case, doors are used to obstruct the air inlet of the rotor in order to prevent any exchange of pressure between the upper and lower parts of the stator. In the latter event the lift of the annular airfoil would be used only in ascending from or descending to an airfield.

It will be observed, therefore, that the aircraft of the present invention combines many of the advantages of the airplane and the helicopter while eliminating some of the disadvantages of each. Thus, it can ascend and descend vertically and it can hover, but it can also move horizontally at very high speeds. It is more stable in flight than either the airplane or the helicopter because of the gyroscopic effect of the rotor.

Other objects and advantages of the invention will appear hereinafter.

A preferred embodiment of the invention selected for purposes of illustration are shown in the accompanying drawings, in which,

Fig. 1 is a diagrammatic, side elevation, partly broken away and in section, showing a simple aircraft embodying this invention;

Fig. 2 is a top plan view partly broken away and in section, of the aircraft shown in Fig. 1;

Figs. 3, 4, 5 and 6 are diagrammatic, reduced scale, top plan views, showing the way in which the ballast is distributed for controlling the trim of the aircraft;

Figs. 7, 8, 9 and 10 are diagrammatic side elevations showing the trim of the aircraft with the ballast distributed as in Figs. 3, 4, 5 and 6, respectively;

Fig. 11 is a view similar to Fig. 1 but showing a first modified form of the invention;

Fig. 12 is a fragmentary detail view showing a second modification of the invention;

Fig. 13 is an enlarged, fragmentary, vertical, sectional view showing the air flow to the reactor jet and the air flow to the anti-rotational fins;

Fig. 14 is a top plan view of one of the anti-rotational fins shown in Fig. 13;

Fig. 15 is an enlarged, vertical, sectional view showing a third modified form of the invention;

Fig. 16 is a vertical, sectional view showing jet propulsion means for obtaining horizontal flight;

Fig. 17 is a top plan view of a fourth modified form of the invention in which the upper stator is in the form of a delta wing;

Fig. 18 is a side elevation, partly broken away and in section of the aircraft shown in Fig. 17;

Fig. 19 is a top plan view of a fifth modified form of the invention in which a plurality of rotors are used in a single stator which is shaped as a cambered wing;

Fig. 20 is a side elevation of the modified form of aircraft shown in Fig. 19; and

Fig. 21 is a rear elevation of the aircraft shown in Figs. 19 and 20.

In its simplest form the aircraft of this invention includes a lower stator **25**, a rotor **26** rotatably mounted on a central hub **27**, and an upper stator **28**. The stators **25** and **28** are rigidly connected by the hub **27**. The hub **27** is hollow and may be of substantial internal diameter to provide accommodations for passengers and freight. In the construction shown, there is a transparent turret **29** at the top of the hub **27** providing visibility for a pilot **30**.

The bottom stator **25** has wheels **33** and such other landing gear structure as may be desirable. The rotor **26** has a hollow hub portion which serves as a fuel tank **35**. This tank is preferably sectional or provided with anti-surge partitions. Above the fuel tank **35**, the rotor **26** has blades **36** extending radially. In the construction shown in Figs. 1 and 2, the blades **36** extend along radii of the rotor, but the radially extending blades may slope in the direction of, or against the direction of rotation in accordance with conventional practice of centrifugal blowers. There is a wide annular opennig **38** in the upper stator **28** above the inner ends of the blades **36**; and air is drawn downwardly through this air inlet opening **38** by the rotor **26** which operates as a centrifugal blower.

There are spars **40** extending across the air inlet opening **38** for rigidly connecting together the portions of the stator **28** which are on opposite sides of the air inlet opening **38**. These spars **40** are preferably streamlined so as to offer a minimum of resistance to the flow of air to the rotor **26**.

The upper stator **28** extends across the top of the rotor **26** with a running clearance. In the structure illustrated, the peripheral portion of the upper stator **28** extends beyond the ends of the rotor blades **36**. The lower surface of the upper stator **28**, beyond the blades **36**, provides an annular surface which serves as a liftring for the aircraft. This annular surface or liftring, designated by the reference character **42**, slopes downwardly so that it deflects the air from the rotor **26**, and this deflecting of the air provides an upward thrust for lifting the aircraft. When the surface above the blades has a downward slope, the pressure of the air stream against this surface develops a component of lift.

The space between the peripheral portions of the lower stator **25** and upper stator **28** is open around the entire aircraft to provide running clearance for arms **44** which project from diametrically opposite locations, on the rotor **26**, beyond the lower stator **25** and into the ambient atmosphere below the aircraft. There is a jet reactor **45** connected to the outer end of each of the arms **44**, and these reactors **45** drive the rotor **26**.

Fuel for the reactors **45** is supplied by centrifugal force from the fuel tank **35** in the rotor. These reactors **45** are used in the preferred embodiment of the invention because they provide simple and reliable means for driving the rotor without gearing or other mechanism having moving parts. In the broader aspects of the invention, however, the reactors **45** are merely representative of power means for turning the rotor **26** to draw air through the inlet opening **38** and to discharge the air against the liftring **42**, or any of the other liftring constructions which will be described in connection with certain modified forms of the invention.

The upper stator **28** has a fin **47** and rudder **48** at its rearward end. There are a plurality of ballast tanks **50** located at angularly spaced regions around the peripheral portion of the upper stator **28**. The construction illustrated has four ballast tanks **50**. These are sufficient for controlling the trim of the aircraft, in a manner which will be described, but more than four tanks can be used if desired. There are conduits connecting the ballast tanks **50** and pumps or other suitable means for moving liquid ballast from one tank to another.

From the construction thus far described it will be apparent that the aircraft shown in Figs. 1 and 2 is capable of vertical ascent and hovering in the same manner as a helicopter because its lift does not depend upon horizontal speed. The aircraft can also move horizontally in a manner similar to a helicopter, if the nose of the aircraft is tilted downwardly so that the annular current of air, discharged by the rotor around the entire periphery of aircraft, has a net rearward component. In horizontal flight, however, the aircraft of this invention does not experience any change in the center of lift, as in the case of a helicopter, because the rotor **26** is entirely enclosed within the housing provided by the stators. The operation of the enclosed rotor is just the same with the aircraft moving horizontally as when the aircraft is hovering or moving vertically.

Fig. 3 shows the rotor turning in a clockwise direction, as indicated by the arrow **54**, and ballast equally divided among all of the tanks **50**. With the aircraft symmetrically loaded, as indicated in Fig. 3, the axis of the aircraft is substantially vertical and the thrust reaction from the liftrings is symmetrical about a vertical axis as indicated by the arrows **56** in Fig. 7. The axial thrust of the aircraft is directly vertical as indicated by the axial vector **57**.

Since the rotor **26** acts as a large gyroscope, any pressure tending to tilt the gyroscope downwardly at the right side of the aircraft will cause the gyroscope to tilt its axis rearwardly. This phenomenon by which force at one side of a gyroscope causes the axis to tilt 90° out of phase with the applied force is a well known property of gyroscopes. The present invention takes advantage of this phenomenon by shifting the ballast from the right hand tank **50** to the left hand tank **50**, as shown in Fig. 4, when it is desirable to tilt the nose of the aircraft downward for forward flight as shown in Fig. 8.

With the aircraft tilted as shown in Fig. 8, the annular air stream **56** has a rearward component, and the axial vector **57** slopes at an angle to the vertical so that it has vertical and horizontal components, indicated by the vectors **61** and **62**, respectively, and the aircraft moves in a forward direction.

For greater forward speed, the aircraft can be tilted still further, as shown in Figs. 5 and 9. This is done by shifting all of the ballast into the right hand tank **50**. The axial thrust component **57** has a greater slope to the vertical and thus produces a horizontal vector **62′** which is greater than the vector **62**, and a lift vector **61′** which is somewhat less than the lift vector **61** in Fig. 8. An increase in the speed of the rotor will compensate the reduction of the lift vector **61′** in order to keep the same altitude of flying.

Figs. 6 and 10 are similar to Figs. 5 and 9 except that the entire ballast is shifted to the right hand tank **50** and the direction of movement of the aircraft is rearward instead of forward. The vectors are indicated by the same reference characters as in Fig. 9 and the only difference is that the horizontal vector **62'** is toward the rear instead of toward the front. It will be understood that if the rotor **26** were turning in the opposite direction to that indicated in Fig. 6, that is, were turning in a counter-clockwise direction, loading of the right hand ballast tank **50** would tilt the aircraft forwardly instead of rearwardly.

The examples shown in Figs. 3 to 10 are believed to be sufficient to illustrate the way in which trim and direction of travel of the aircraft can be statically controlled. When high speed forward movement is desirable, other power means in addition to the thrust from the rotor are used as will be explained in connection with Fig. 16.

Fig. 11 shows a first modified form of the invention in which a liftring **65** is located some distance below the liftring surface **42** of the upper stator **28**. This liftring **65** is an airfoil section which is similar, in radial cross section, to a cambered airplane wing, but the liftring **65** is annular and it acts as an airplane wing of the infinite aspect ratio. The liftring **65** is connected to the upper stator **28** by vanes **67**.

This construction with a liftring **65** in addition to the liftring surface **42** utilizes the airstream from the rotor **26** more efficiently; and the liftring **65** is shaped to take advantage of the Bernoulli effect in obtaining increased lift from the liftring **65**.

Fig. 12 shows a second modified construction in which the liftring **65** is attached to the rotor **26**, by vanes **67**, instead of being attached to the upper stator **28**. With this construction, the liftring **65** tends to lift the rotor **26** and this lift is transmitted to the aircraft through an upward thrust bearing at the center hub of the rotor, such as the upper thrust bearing **68** shown in Fig. 11. The rotor **26** of Fig. 11 is shown with thrust bearings **68** at both ends of its hub to provide against end play. All of the rotor bearings shown in the drawing are diagrammatic and it will be understood that all of them have provision for preventing excessive end play. In Fig. 12, the upper stator **28** still provides lift because of the reaction of the air stream against the liftring surface **42**.

Fig. 13 shows a construction which is similar to Fig. 11, but with a somewhat different construction for the vanes which connect the liftring **65** to the upper stator **28**. In Fig. 13, vanes **71** extend at a tangential slope to the direction of discharge of the air stream from the rotor **26**. This slope of the vanes **71** is calculated to produce a torque for the upper stator **28** equal and opposite to the torque which results from air friction and friction of the rotor on the hub bearing. When the aircraft has no horizontal movement for making its fin and rudder effective, and no other means are provided to counteract the effect, there is a tendency for the stators to gradually assume a rotation in the same direction as the rotor. This results not only from mechanical friction of the rotor on the stator hub, but also from a component of movement of the air stream tangentially discharged by the rotor.

Since the tendency of the stators to pick up rotation from the rotor varies with the speed of rotation, the slope of the vanes **71** will exactly compensate at only one rotor speed. For this reason, the vanes **71** are preferably made with tail portions **72** pivoted to the forward portion of the vanes at **73**. These tail portions **72** are similar to rudders in an air stream, and they shift one way or another to control the tangential thrust of the air stream against the vanes **71** so as to compensate fully any tendency of the stators to pick up the rotation from the rotor. The tail portions **72** are operated by tillers **74** through control cables or other motion transmitting connections operated by the pilot.

Another way in which rotation of the stators can be prevented is by providing a gyroscope **75** (Fig. 16) carried by the stator assembly with the axis of rotation of the gyroscope **75** extending in a direction transverse of the direction of the rotor axis.



Fig. 15 shows a third modification of the construction in which there are a plurality of liftrings **76** spaced from the liftring surface **42** of the upper stator **28**, and from each other. These liftrings **76** are connected to the upper stator **28** by vanes **78**.

Fig. 15 also shows the way in which a portion of the air from the rotor **26** is supplied through the hollow interior of the arm **44** to the jet reactor **45**. The fuel from the tank in the rotor flows to the reactor through a fuel pipe **79**.

Fig. 16 shows the upper stator **28** equipped with a jet reactor **81** at the rearward end of the aircraft. A portion of the air from the rotor **26** is blown into a collector **83** and this air flows through a passage **84** to the combustion chamber of the reactor **81**. This air is mixed with fuel from a fuel pipe **86** which delivers a jet of liquid fuel against the air current for atomization. The air fuel mixture burns in a combustion chamber **87** and is discharged rearwardly to provide a propulsion jet for driving the aircraft through the air in a horizontal direction. When the aircraft is travelling at high speed in a horizontal direction, and the air delivered by the rotor is not to be used for lift, the entire output of air from the rotor can be delivered to the jet reactor by having a retractable collector **83** that can be dropped down into position to block the flow of air to the lift rings and divert all of the air to the reactor.

With a propulsion jet reactor **81** to drive the aircraft, it is not necessary to tilt the aircraft for developing a horizontal component from the rotor discharge. However, the propulsion jet reactor **81** can be used in addition to any horizontal component developed by tilting of the aircraft.

When very high horizontal speed is desired, one or more powerful propulsion jet reactors **81** are used and the tilting of the aircraft is not relied upon for horizontal flight because the drag is somewhat increased by any tilting of the aircraft with a resulting increase in the front profile of the upper stator.

Fig. 17 shows a fourth modification of the invention in which the rotor is placed in a wing **91**. This wing **91** has ailerons **93**, a fin **94** and a rudder **95**. The wing is an upper stator of the aircraft, and there is a lower stator **98** which functions in the same way as the other modifications of the invention. There is a propulsion jet reactor **100** at the trailing edge of the wing **91** and this jet reactor **100** is supplied with air from the rotor in the same manner as already described in connection with Fig. 16.

The wing **91** has a number of advantages over the simpler upper stator **28** when high horizontal speed is desired and when the aircraft is designed for greater carrying capacity. The wing **91** has a shape of delta wings which are designed for high speed jet planes, and the rotor **26** enclosed within the wing offers no additional drag when the aircraft is traveling at high horizontal speed.

With the modification of the invention shown in Fig. 17, the rotor **26** can be used for vertical ascent, and when the aircraft has assumed sufficient horizontal speed to derive ample lift from the wing **91**, the rotor **26** can be shut off, if other means are available to supply air to the jet reactor **100**. The aircraft is then operated entirely as a jet plane. A slide or door **105** can be used to cover the air inlet opening **38** during high speed horizontal flight, and provision can be made for moving the reactors **45** up into the wing in the same manner as retractable landing gear. The annular discharge space between the upper and lower stators can be closed, if desired, in a manner similar to the way in which slot controllers are used with conventional aircraft.

Fig. 19 shows a fifth modification of the invention in which a plurality of rotors **26** are enclosed within a large wing **110**. This fifth modification differs from that shown in Fig. 17 principally in the size of the wing and in the use of more than one rotor **26**.

In the case of multi-rotor aircraft, such as shown in Fig. 19, the gyroscope effects of the rotors compensate themselves and the normal conditions of static and aerodynamics controls takes place.

Three jet reactors **100** are provided for propelling the aircraft shown in Fig. 19. Each of these reactors is supplied with air from a different one of the rotors **26**. The wings **91** and **110**, shown in Figs. 17 and 19 have the advantage of providing space beyond and above the rotors for the accommodation of passengers and freight. The wing **19** has an extensive cabin **112** above the rotors, seats **114** and a center aisle **116**. The cabin has windows **118**, throughout its length and the pilot is located in the nose of the wing **110** with a window **120** providing good visibility to the front and sides.

The preferred embodiments, and some modifications of the invention have been illustrated and described, but other modifications can be made without departing from the invention as defined in the claims.

I claim:

1. A heavier-than-air aircraft comprising, in combination, a stator assembly comprising spaced upper and lower interconnected stator elements, a rotor mounted on said stator assembly for rotation on a vertical axis, said rotor being located between said stator elements and in a chamber formed thereby, means on said rotor for discharging air outwardly from the periphery of the rotor in a substantially horizontal direction, and an annular air foil surrounding the periphery of said rotor and having a surface lying in the path of said air and curving downwardly and forming the upper surface of an opening through the bottom of the aircraft.

2. An aircraft including an upper stator having an opening for the downward flow of air, a lower stator rigidly connected to the upper stator, a rotor housed between the stators and having radially extending blades in position to draw air downwardly through the opening in the upper stator and to discharge the air outwardly, and a lift ring surface below the upper stator and forming the upper surface of an opening through the bottom of the aircraft.

3. An aircraft comprising a rotor housed between upper and lower stators, the upper stator having an opening therethrough above the center of the rotor, and the rotor having blades that draw air through the opening and discharge it radially, and an annular lift ring surface under a portion of the upper stator beyond the peripheral limit of the rotor and forming the upper surface of an opening through the bottom of the aircraft.

4. The aircraft described in claim 3 with a jet reactor connected to the rotor by a support which extends from the rotor outwardly and downwardly to a location below the lift ring.

5. An aircraft comprising a stator assembly, a rotor housed within the stator assembly, the rotor comprising a centrifugal blower having blades that draw air downwardly through an opening in the stator assembly, and that discharge the air by centrifugal force outwardly, an annular air foil attached to the stator assembly, and in the air stream and curving downwardly and forming the upper surface of an opening through the bottom of the aircraft and power driving mechanism connected to the rotor for turning it.

6. An aircraft comprising a stator assembly, a power-driven rotor housed within the stator assembly, the rotor having a hub portion that turns on a bearing in the stator assembly about an axis extending substantially vertically, and the rotor having radially extending blades that draw air downwardly through an opening in the stator assembly around the hub portion of the rotor, and that discharge the air radially outward, power driving mechanism for turning the rotor, and a lift ring comprising an annular air foil connected to the stator assembly in the air stream discharged by the rotor, and curving downwardly and forming the upper surface of an opening through the bottom of the aircraft.

7. An aircraft including a stator assembly, a rotor comprising a centrifugal blower having a hub portion that rotates on a bearing, carried by the stator assembly, about a substantially vertical axis, radially extending blades of the rotor completely housed within the stator assembly in position to draw air downwardly through an opening in the stator assembly, said stator assembly having an annular outlet passage extending from adjacent the circumference of the rotor and downwardly and outwardly from the rotor with the upper wall of the annular passage serving as a lift ring surface against which the blast of air from the rotor is directed to impart lifting force to the aircraft the surface of the lift ring curving downwardly and forming the upper surface of an opening through the bottom of the aircraft, and power driving mechanism for the rotor.

8. The aircraft described in claim 7, characterized by a second lift ring including an annular air foil located between the upper and lower walls of the outlet through which the air from the rotor is discharged, the second lift ring being connected to the stator assembly above it by vanes that hold the second lift ring in a predetermined spaced relation to the top wall of the opening.

9. An aircraft comprising a stator assembly with a chamber therein, a rotor enclosed within the chamber, the rotor comprising a centrifugal blower with a hub portion that turns about a substantially vertical axis and on bearings carried by the stator assembly, the rotor also having radially extending blades which rotate between upper and lower walls of the chamber provided by the stator assembly, power driving mechanism for the rotor, the stator assembly having an inlet opening above the hub portion of the rotor in position to supply air to the blades, and having also an annular outlet opening extending outwardly and downwardly from a region beginning at the outer limits of the blades, and at least one annular lift ring attached to the blades and located in the air outlet of the stator assembly and in the air stream from the rotor, the surface of the lift ring curving downwardly and forming the upper surface of an opening through the bottom of the aircraft.

10. An aircraft comprising a stator assembly having a chamber therein with a central opening at the top and an annular lower opening with a lift ring surface therein, the surface of the lift ring curving downwardly and forming the upper surface of an opening through the bottom of the aircraft a rotor housed within the chamber and comprising a centrifugal blower with a hub portion that turns on a bearing on the stator assembly about a substantially vertical axis and that has radially extending blades which propel a stream of air from the central opening through the lower annular opening, fuel tanks within the hub portion of the rotor, and power driving means for the rotor including a jet reactor connected to the rotor by a frame extending from the blades outwardly and downwardly through the annular lower opening so as to locate the reactor in the ambient atmosphere below the aircraft, and a fuel line through which fuel is supplied from the tanks to the jet reactor by centrifugal force.

11. An aircraft comprising a stator assembly having a chamber therein with a central upper opening and an annular lower opening, a rotor enclosed within the chamber and comprising a centrifugal blower with radially extending blades to draw air from the upper opening and discharge it downwardly and outwardly through the annular lower opening, power driving mechanism for the rotor including a jet reactor connected to the rotor by a support extending inwardly and upwardly from the jet reactor and to the rotor, and a lift ring comprising an annular air foil in the path of the air stream discharged

by the rotor, the surface of the lift ring curving downwardly and forming the upper surface of an opening through the bottom of the aircraft.

12. An aircraft as described in claim 11 characterized by a lift ring which is an annular air foil spaced from the walls of the annular opening, and further characterized by vanes extending upwardly in the path of the air stream through the lower annular opening, said vanes extending at acute angles to radii from the axis of rotation of the rotor in directions to deflect the air stream from the rotor at an angle which produces a reaction counter to the direction of rotation of the rotor for preventing the stator assembly from turning in the same direction as the rotor.

13. An aircraft comprising a stator assembly having a rotor chamber therein with a central upper opening and a downwardly and outwardly extending lower annular opening through the bottom of the aircraft, a rotor in the chamber having radially extending blades, power driving mechanism for rotating the rotor to propel an air stream downwardly through the central upper opening and outwardly through the lower annular opening, a lift ring comprising an annular air foil in the lower annular opening, vanes connected to the stator assembly and located in the path of the air stream discharged from the rotor, said vanes extending at acute angles to radii from the axis of rotation of the rotor in directions for counteracting the tendency of the stator to turn with the rotor, at least part of the vanes being adjustable angularly with respect to said radii to compensate for changes in the friction which tends to turn the stator assembly with the rotor.

14. The aircraft described in claim 13 and in which the lift ring constitutes an annular air foil located in the lower annular opening from the chamber and spaced from the upper wall of the opening, and the vanes include fixed portions that connect the lift ring to the stator assembly and movable portions that can be shifted into different angular positions transverse of said radii for producing different degrees of reaction in a direction to compensate the tendency of the stator assembly to turn with the rotor.

15. An aircraft including a rotor having radially extending blades, power driving mechanism for the rotor, a stator having a bearing on which the rotor turns about a substantially vertical axis, annular lift rings including a bottom surface of the stator in the air stream from the rotor and shaped to deflect the air stream in a direction to develop lift and forming the upper surface of an opening through the bottom of the aircraft, a plurality of other annular lift rings spaced from the bottom surface of the stator and from each other but all located in the path of the air stream from the rotor and all shaped to deflect the air stream through the opening in the bottom of the aircraft and in directions to produce lift.

16. An aircraft comprising an upper stator, a lower stator, a rotor located between the stators with radially extending blades that draw air downwardly through an opening in the upper stator and that discharge the air outwardly and downwardly through an annular outlet in the bottom of the aircraft and between the upper and lower stators, and lift rings including an annular bottom surface of the upper stator comprising a top wall of the annular outlet opening shaped to deflect air downwardly to develop lift, a second lift ring comprising an air foil spaced downwardly from the top wall of the annular outlet and attached to the rotor for rotation as a unit therewith, the inner edge of the other lift ring being located near the outer tips of the rotor blades.

17. An aircraft having an upper stator with an opening therein for the downward flow of air, a lower stator rigidly connected to the upper stator, a rotor comprising a centrifugal blower located between the stators and enclosed thereby, the rotor having a hub portion that rotates on a bearing carried by the stators and about a substantially vertically extending axis, fuel tanks within the hub of the rotor, power driving mechanism for the rotor including a jet reactor which is supplied with fuel from the fuel tanks in the rotor by centrifugal force, an air duct through which the reactor is supplied with air from the rotor, and a lift ring comprising an annular air foil with its inner edge located near the outer tips of the rotor blades, and forming the upper surface of an opening through the bottom of the aircraft to deflect the air stream from the rotor in a direction to produce lift.



18. An aircraft including a stator assembly with a chamber therein, a rotor housed within the chamber and having radially extending blades for drawing a current of air downwardly through an opening in the stator assembly and for discharging the air outwardly and downwardly through an annular outlet passage in the bottom of the stator assembly, power driving mechanism for the rotor, a lift ring in the air stream from the rotor, the surface of the lift ring curving downwardly and forming the upper surface of an opening through the bottom of the aircraft and other power means for producing a reaction in a direction substantially normal to the axis of the rotor for imparting horizontal movement to the aircraft.

19. The aircraft described in claim 18 and in which the other power means include a rearwardly directed reactor jet supplied with air by the rotor.

20. An aircraft including a stator assembly having a chamber therein, a rotor enclosed in the chamber and comprising a centrifugal blower that draws air downwardly through an opening in the top of the stator assembly and then discharges the air through a passage in the stator assembly and in an annular stream downwardly through an outlet opening in the bottom of said stator assembly, an annular lift ring in the passage and located in position to deflect the air stream and shaped to deflect the air stream in a direction to produce lift for vertical ascent, the stator assembly constituting a wing which serves as an air foil section for producing lift when the aircraft is flying horizontally at substantial speed, the wing being thick enough to include the rotor chamber, and control surfaces connected to the wing for manoeuvring the aircraft in horizontal flight.

21. An aircraft including a stator assembly having chambers therein, a rotor enclosed in each of said chambers, each rotor comprising a centrifugal blower that draws air downwardly through an opening in the top of the stator assembly and then discharges the air radially, and a lift ring around each of the blowers curving downwardly and forming the upper surface of a passage opening through the bottom of the stator assembly to deflect the air stream in a direction to produce lift.

22. The aircraft described in claim 21 and in which the stator assembly constitutes a wing which serves as an air foil section for producing lift when the aircraft is flying horizontally at substantial speed and in which the wing is thick enough to include the chambers that house the rotors, and in which the wing has control surfaces for manoeuvring in horizontal flight.


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Dec. 9, 1958 J. W. DAVIS 2,863,621

VERTICAL AND HORIZONTAL FLIGHT AIRCRAFT

Filed April 12, 1957 6 Sheets-Sheet 1

FIG. 1.

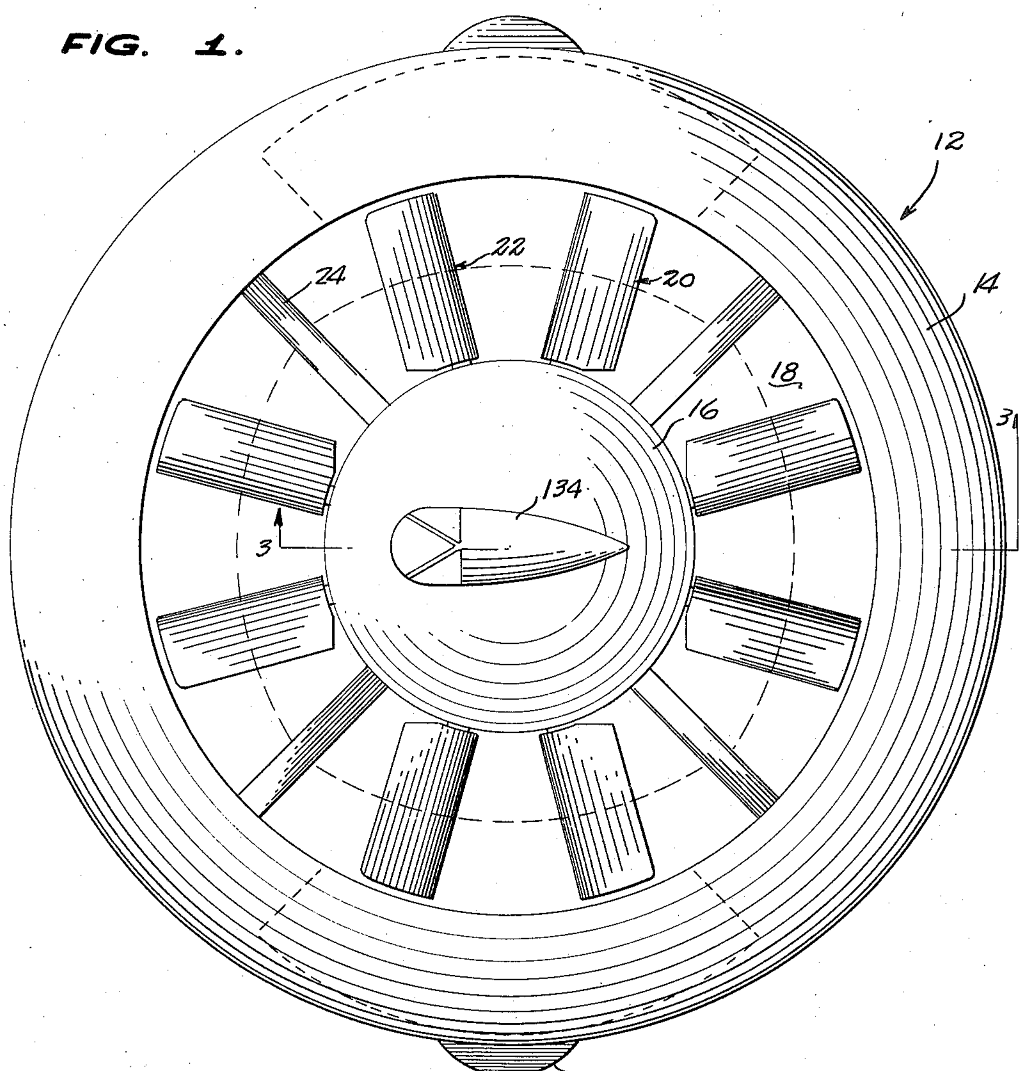
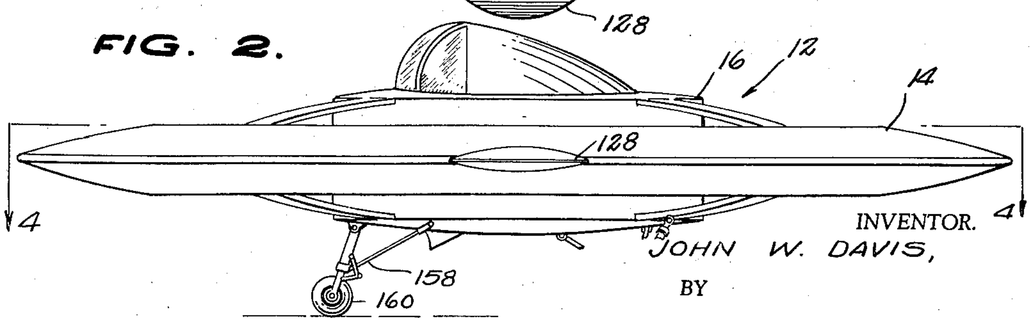



FIG. 2.

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VERTICAL AND HORIZONTAL FLIGHT AIRCRAFT

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FIG. 3.

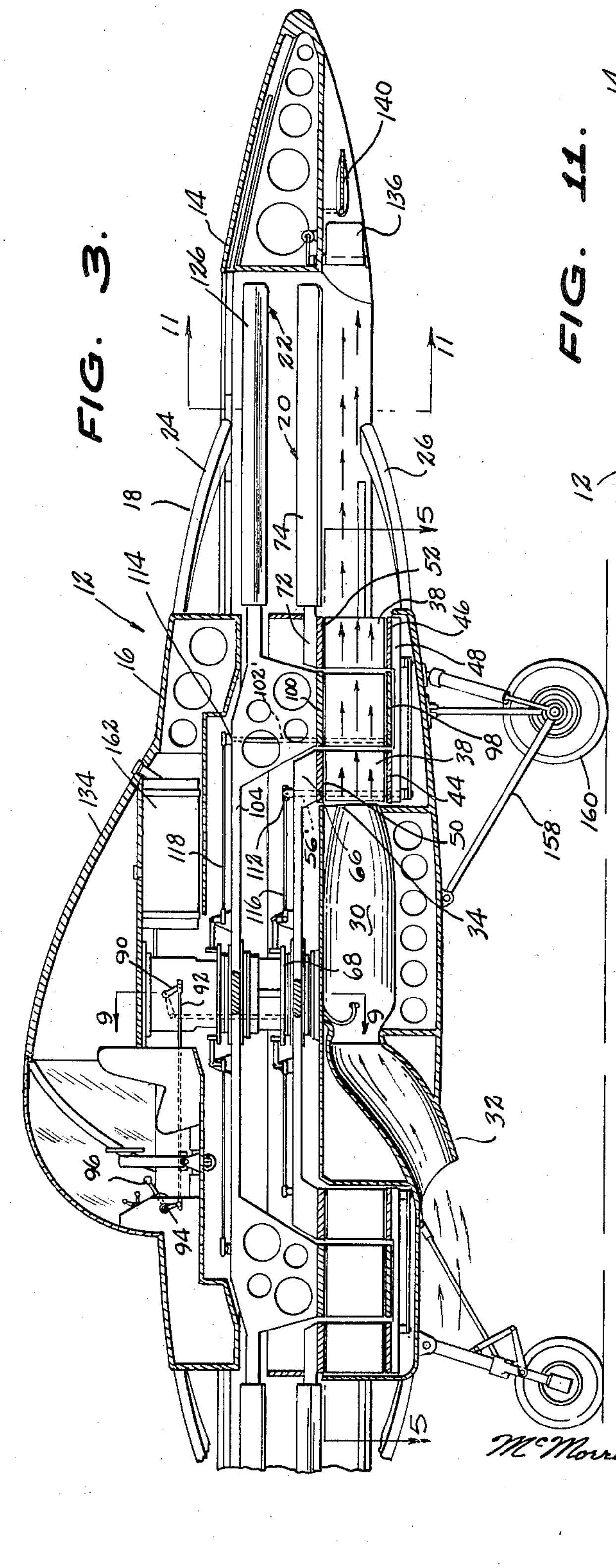
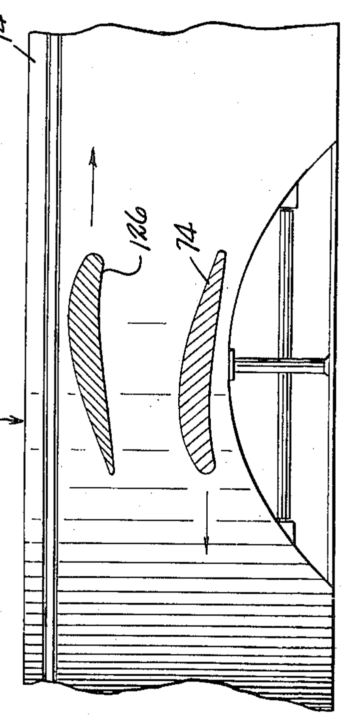



FIG. 11.



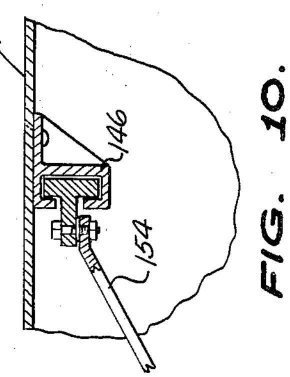




FIG. 10.

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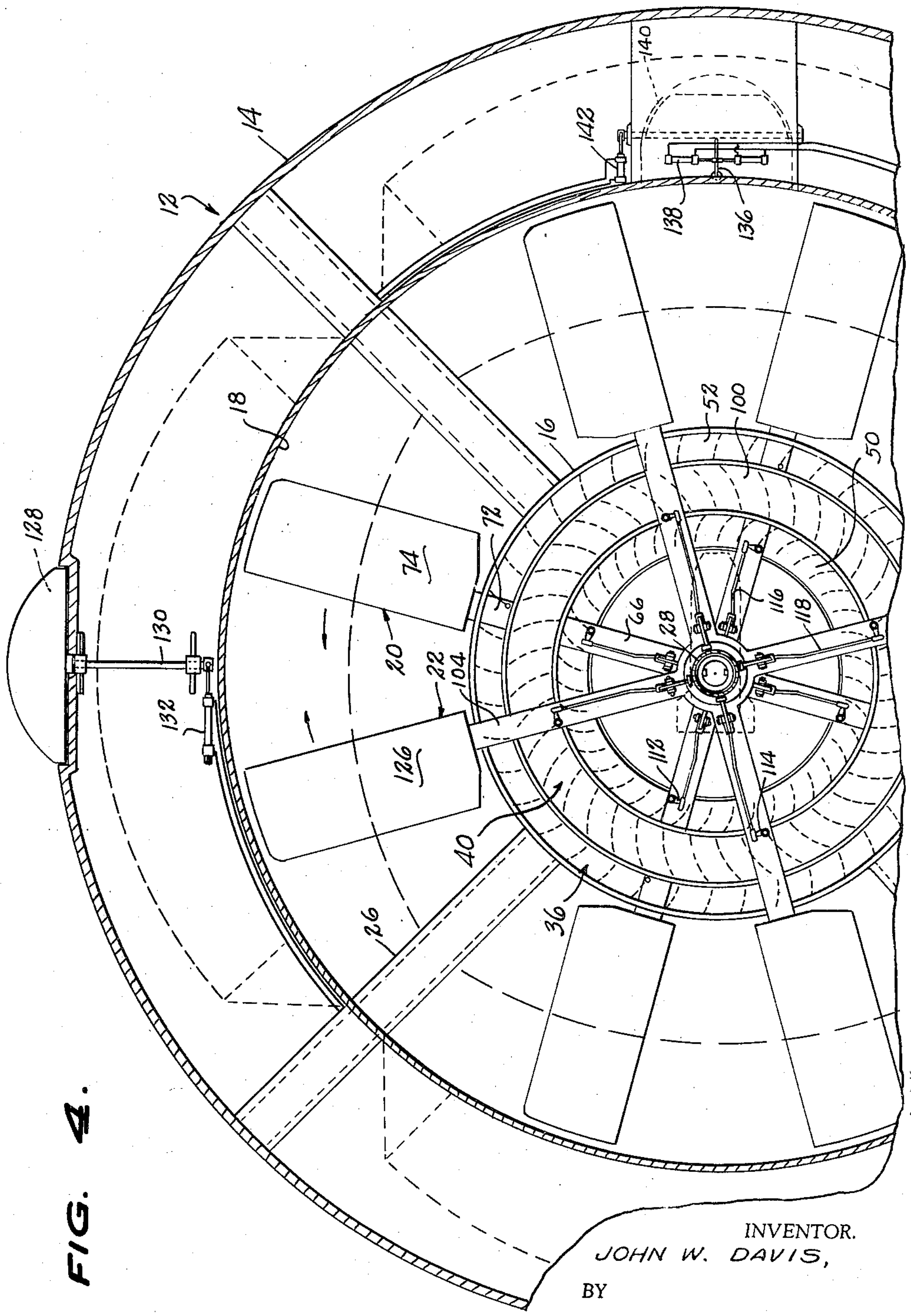


FIG. 4.

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VERTICAL AND HORIZONTAL FLIGHT AIRCRAFT

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FIG. 5.

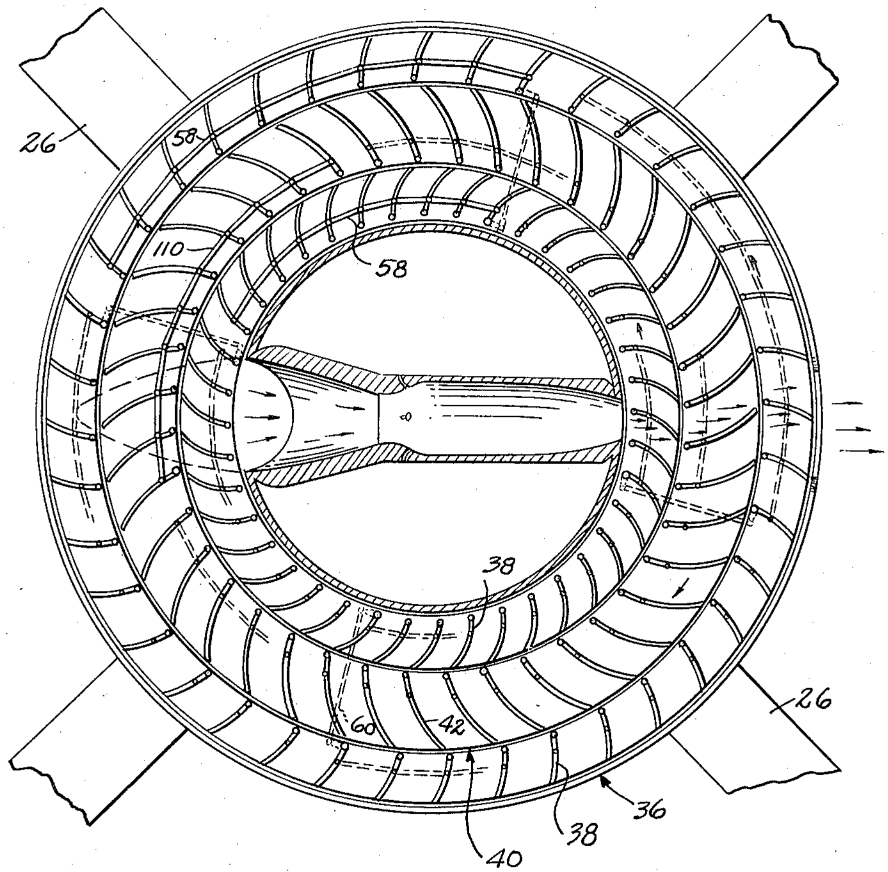
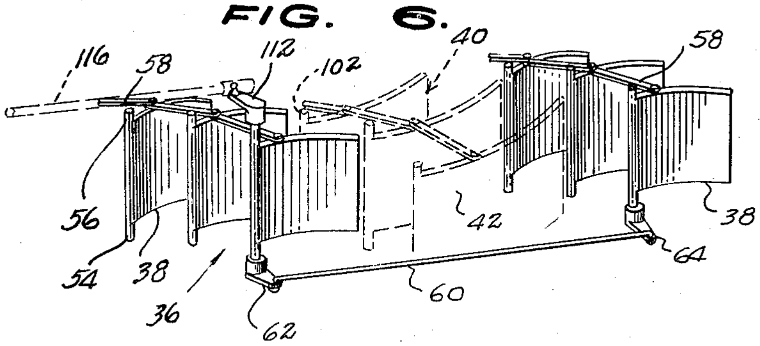



FIG. 6.

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Dec. 9, 1958 J. W. DAVIS 2,863,621

VERTICAL AND HORIZONTAL FLIGHT AIRCRAFT

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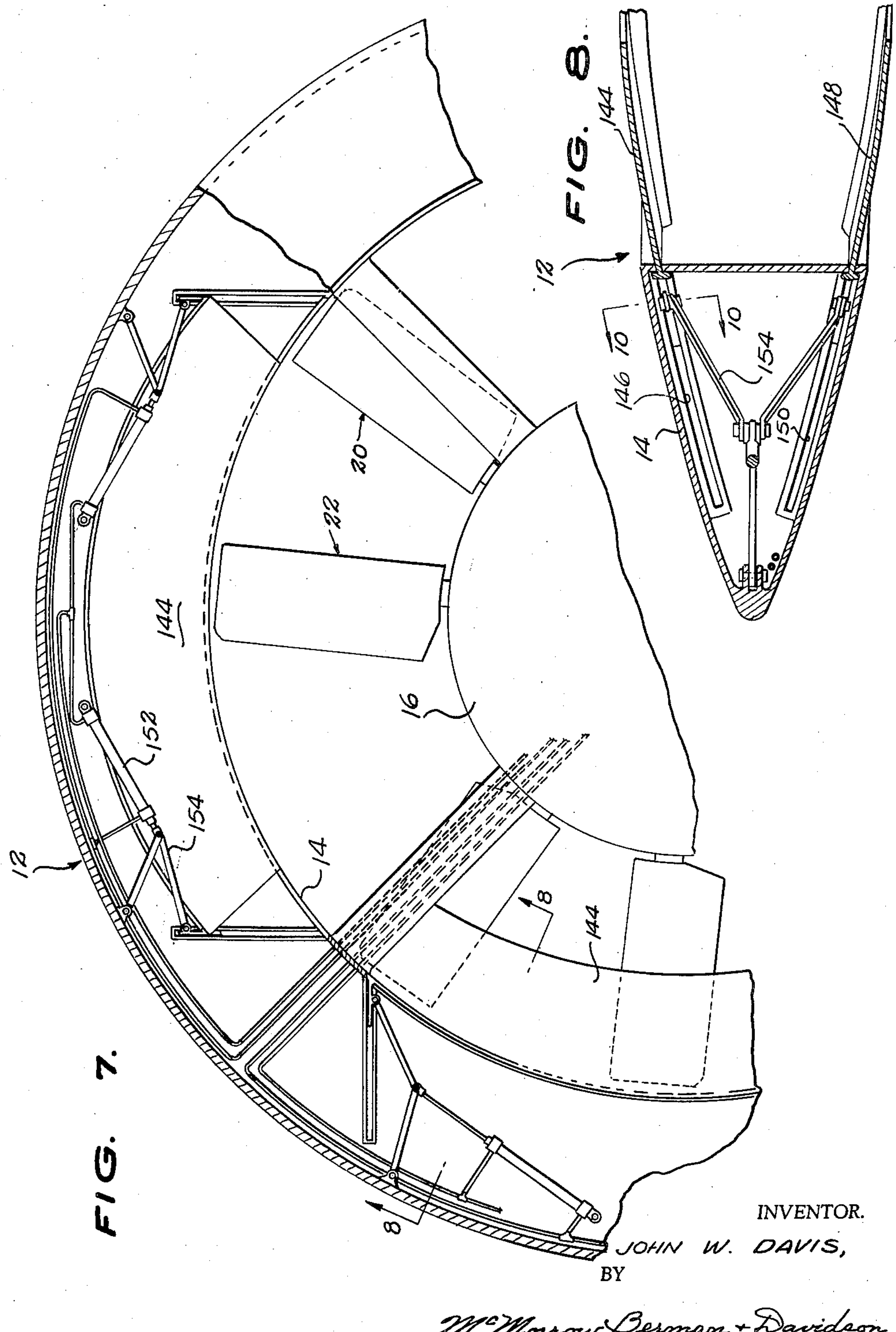


FIG. 7. FIG. 8.

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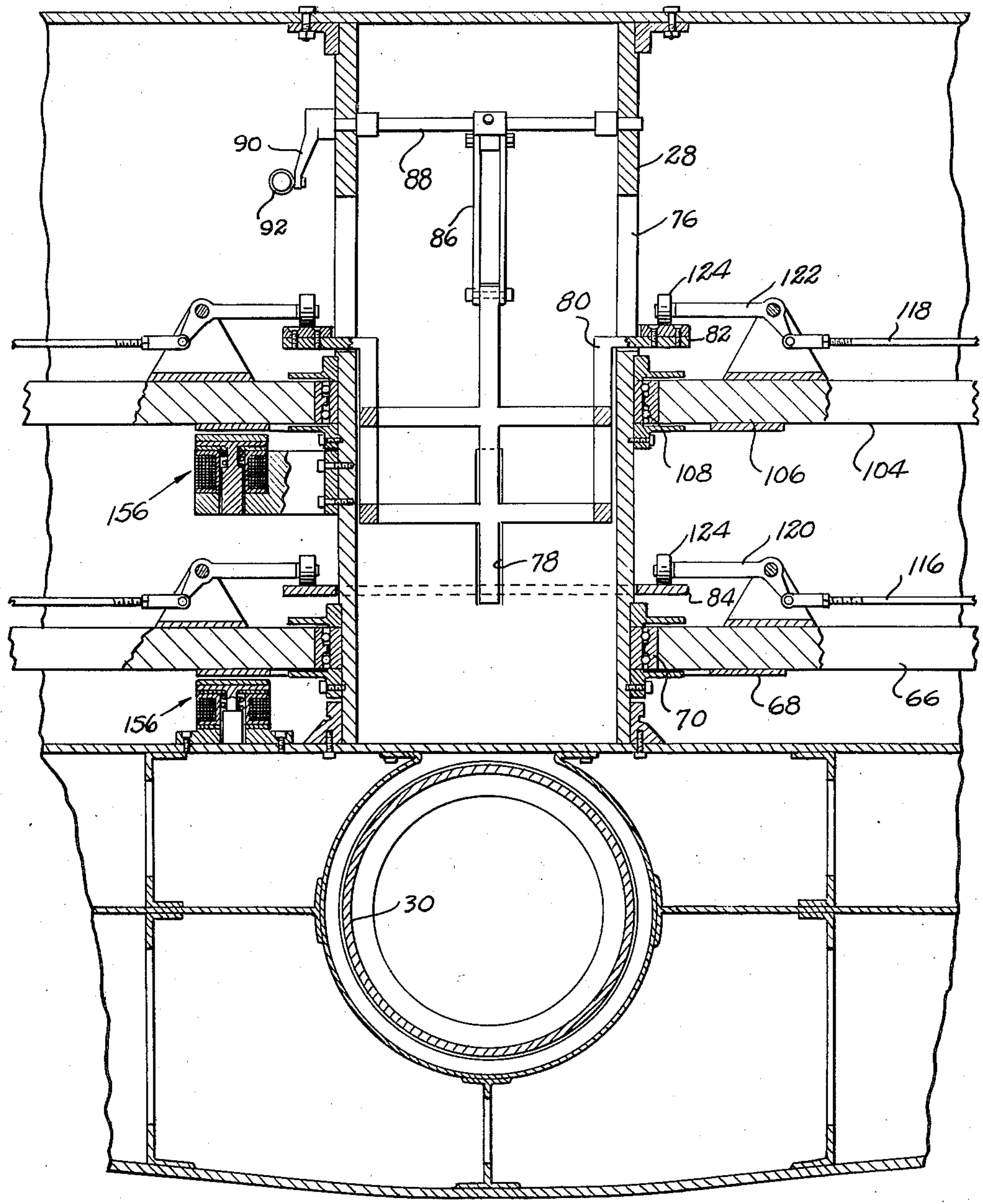


FIG. 9.

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United States Patent Office 2,863,621 Patented Dec. 9, 1958



2,863,621

# VERTICAL AND HORIZONTAL FLIGHT AIRCRAFT

John W. Davis, El Paso, Tex.

Application April 12, 1957, Serial No. 652,552

5 Claims. (Cl. 244—23)

This invention relates to a vertical and horizontal flight aircraft.

An object of the present invention is to provide an aircraft which can quickly take off vertically and level off and attain a high rate of speed.

Another object of the present invention is to provide an aircraft which can hover and land in small areas.

A further object of the present invention is to provide an aircraft which is economical to fabricate and assemble, and one which is highly efficient in action.

These and other objects and advantages of the present invention will be fully apparent from the following description when taken in connection with the annexed drawings, in which:

Figure 1 is a top plan view of the aircraft of the present invention,

Figure 2 is a side elevational view,

Figure 3 is a fragmentary sectional view, on an enlarged scale, taken on the line 3—3 of Figure 1,

Figure 4 is a fragmentary sectional view, on an enlarged scale, taken on the line 4—4 of Figure 2,

Figure 5 is a sectional view taken on the line 5—5 of Figure 3,

Figure 6 is an isometric fragmentary view of the first turbine blade assembly shown in full lines with the second turbine blade assembly shown in dotted lines,

Figure 7 is a fragmentary sectional view showing the means for partially closing the annular opening in the aircraft,

Figure 8 is a sectional view, on an enlarged scale, taken on the line 8—8 of Figure 7,

Figure 9 is a sectional view, on an enlarged scale, taken on the line 9—9 of Figure 3,

Figure 10 is a sectional view, on an enlarged scale, taken on the line 10—10 of Figure 8, and

Figure 11 is a sectional view, on an enlarged scale, taken on the line 11—11 of Figure 3.

Referring in greater detail to the drawings, in which like numerals indicate like parts throughout the several views, the aircraft according to the present invention is designated generally by the reference numeral **12** and comprises a horizontally disposed outer fuselage **14** and an inner fuselage **16** separated from each other by an annular opening **18** extending vertically through the aircraft **12**. The aircraft **12** is disc shaped with its upper and lower surfaces shaped relative to each other, so as to present an airfoil in cross section.

A first propeller blade assembly **20** is positioned within the opening **18** so as to extend across and about the opening **18** and is connected to the inner fuselage **16** for rotational movement about a vertical axis in one direction. A second propeller blade assembly **22** is positioned within the opening **18** in superimposed spaced relation with respect to the assembly **20**, and is also arranged to extend across and about the opening **18** and is connected to the inner fuselage **16** for rotational movement about the same vertical axis as the assembly **20**. As indicated by the arrows in Figure 4, the second propeller blade assem-



bly **22** rotates in the opposite direction to the direction of rotation of the first propeller blade assembly **20**.

Upper and lower beams **24** and **26** respectively, connect the outer fuselage **14** and the inner fuselage **16** together and extend across the opening **18** at four equidistant points, as seen in Figure 1. Each of the propeller assemblies **20** and **22** are mounted upon a common hub **28** which is disposed vertically and centrally of the inner fuselage **16** and about which the propeller assemblies **20** and **22** rotate as a common vertical axis.

A reaction motor **30** of conventional construction having an intake scoop **32** projecting beneath the bottom surface of the inner fuselage **16** and having an exhaust nozzle **34**, is positioned horizontally in the lower portion of the inner fuselage **16** inwardly of the opening **18** with the nozzle facing rearward.

Means is provided for effecting the rotation of the propeller assemblies **20** and **22** in opposite directions. Specifically, this means includes a first turbine blade assembly **36** embodying a pair of rows of spaced blades **38**, the rows being arranged concentrically and spaced from each other. A second turbine blade assembly **40** consisting in spaced blades **42** arranged in a circular row, is positioned in the space between the pair of rows of the first turbine blade assembly **36**. One of the rows of the first turbine blade assembly **36** is positioned so that the blades **38** thereof are exteriorly of and adjacent the nozzle **34** of the reaction motor **30** in the path of travel of the exhaust gases emerging from the motor **30**. Means is provided connecting the first turbine blade assembly **36** to the first propeller assembly **20**, and the second turbine blade assembly **40** to the second propeller assembly **22**. Specifically, this means connecting the turbine blade assembly **36** to the propeller assembly **20** consists in a flat ring **44** positioned below and adjacent the blades **38** of the first row of the turbine blade assembly **36**, and another flat ring **46** positioned below the blades **38** of the other row of the assembly **36**. The rings **44** and **46** are connected together at intervals by bars **48**, as shown in Figure 3.

Another flat ring **50** is arranged in superimposed spaced relation with respect to the flat ring **44** and a further flat ring **52** is similarly arranged with respect to the flat ring **46**. Each of the blades **38** of the first turbine blade assembly **36** is provided at one end with lower and upper pivot pins **54** and **56** respectively, for mounting the blades **38** in the associated rings **44** and **50**, and **46** and **52**. The pivot pin mountings of the blades **38** permit the blades **38** to move from an operative position to an inoperative position in the path of travel of the exhaust gases emerging from the nozzle **34**. Links **58** connect each of the blades **38** together for simultaneous movement and bars **60** attached to the free ends of crank arms **62** and **64** connect certain ones of the lower pivot pins **54** to complemental ones of the pivot pins **54** associated with the blades **38** of the other row of the assembly **36**.

Referring to Figures 3 and 9, the flat ring **50** is seen to be carried upon the outer end of a support member **66** which is one arm of a spider having a hub **68** circumposed about the hub **28** with a bearing member **70** interposed therebetween. An arm **72** is carried by the flat ring **52** and supports a blade **74** of the first propeller assembly **20**. The hub **28** is provided with slots **76** and **78** (Figure 9), through which extend bars **80** supporting a pair of circular trackways **82** and **84**. The trackways **82** and **84** are shiftable upwardly and downwardly with respect to the hub **28** by means of linkage **86** connecting the bars **80** to a horizontally disposed shaft **88**, a crank arm **90** connecting the shaft **88** to a control arm **92**, and other crank arms **94** connecting a control rod **92** to an operating handle **96**, as shown in Figure 3.

Other flat rings **98** and **100** are positioned below and above the blades **42** of the second turbine blade assembly 40. Other pivot pins 102 secure the blades 42 to the ring 100 and dependingly support the ring 98. Another support member 104 formed as a horizontally disposed arm of a spider having a hub 106 connects the flat ring 100 to the hub 106 for rotation about the hub 28 as a vertical axis. A bearing 108 is interposed between the hub 106 and the hub 28. Links 110 connect each of the blades 42 of the second turbine blade assembly 40 together for movement in unison about their pivot pins 102 as an axis for movement from the operative position to an inoperative position. Certain ones of the pivot pins 56′ and 102′ are extended, as seen in Figure 3, for attachment thereto of crank arms 112 and 114 respectively. Control rods 116 and 118 connect the crank arms 112 and 114, respectively, to levers 120 and 122 respectively, which carry rollers 124 on their free ends. The rollers 124 ride upon the upper surfaces of the trackways 82 and 84 and effect a shifting of the control rods 116 and 118 upon upward movement of the bars 80 in response to actuation of the handle 96.

A blade 126 is carried upon the free end of each of the support members 104 in superimposed spaced relation with respect to the blade 74 of the first propeller blade assembly 20. Control means for the aircraft 12 consists in an aileron 128 positioned on each side of the outer fuselage 14 and connected to the outer fuselage 14 for movement about a horizontal axis, such axis constituting a control shaft 130 actuable by means of a hydraulic cylinder assembly 132 and controlled from the cockpit 134 of the aircraft 12. A vertically extending rudder 136 is positioned in tandem spaced relation with respect to the exhaust 34 of the reaction motor 30, and is connected to the outer fuselage 14 for swinging movement about a vertical axis. Other hydraulic cylinder assemblies 138 actuated from the cockpit 134 control the movement of the rudder 136. An elevator 140 is positioned in tandem relation with respect to the rudder 136 and is similarly controlled by hydraulic cylinder assembly 142 for swinging movement about a horizontal axis. The rudder 136 and elevator 140 are cooperatively positioned with respect to the nozzle 34.

Means is provided for partially closing the upper end of the opening 18, so as to reduce resistance to travel through the air and turbulence of the air passing over the upper portion of the outer fuselage 14 and the inner fuselage 16 during level flight. Such means consists in a plurality of covers 144 having an end mounted in a trackway 146 carried on the inner wall of the outer fuselage 14. Similar covers 148 are carried on other trackways 150 and are shiftable, so as to partially close the lower end of the opening 18. Hydraulic cylinder assemblies 152 and appropriately arranged arms and levers 154 are used to shift the covers 144 from the retracted position to the extended position, as shown in Figure 7. Means is provided for slowing down one of the propeller assemblies relative to the speed of the other propeller assembly and comprises a solenoid operated brake assembly 156 associated with the under side of each of the hubs 68 and 106 and operable by conventional means (not shown), in the cockpit 134.

Suitable landing gear 158 having wheels 160 is provided on the under side of the aircraft 12 and is connected thereto for extensile and retractile movement in the conventional manner.

In operation, with the aircraft 12 carrying a load of appropriate fuel in its tank 162, the blades 38 and 42 of the first and second turbine blade assemblies 36 and 40 respectively, are turned to the position in which the gas is ejected from the exhaust nozzle 34 of the motor 30 and impinge upon the concave sides of such blades, and the motor 30 is started. The exhaust gases impinging upon the blades of the turbine assemblies causes the first and second propeller blade assemblies 20 and 22 to rotate in opposite directions and to impart to the aircraft 12 vertical motion. Slowing of one of the propeller assemblies 20 or 22 by means of the brake assembly 156 will cause the aircraft to turn about a vertical axis with the appropriate one of the ailerons 128 serving as a yaw control. Adjustment of the angle of the blades 38 and 42 will result in controlling the vertical flight of the aircraft 12 and enable the same to travel in horizontal flight with virtually no air driven downwardly through the opening 18. With the aircraft 12 in horizontal flight, the rudder 136 and the elevator 140 may be used together with the ailerons 128 to execute turns and to maintain the attitude of the aircraft 12 as desired.



What is claimed is:

1. In an aircraft, the combination with a horizontally disposed fuselage provided with an annular opening extending vertically therethrough, a first propeller assembly positioned within said opening so as to extend across and about said opening and connected to said fuselage for rotational movement about a vertical axis in one direction, a second propeller assembly positioned within said opening and spaced from said first propeller assembly and arranged so as to extend across and about said opening and connected to said fuselage for rotational movement about said vertical axis in an opposite direction, of a reaction motor having a nozzle for the ejection of exhaust gases therefrom positioned horizontally within said fuselage inwardly of said opening with the nozzle facing rearward, a turbine blade assembly positioned so that it is exteriorly of and adjacent said nozzle and connected to said fuselage for rotational movement about said vertical axis responsive to impingement of gases when ejected from said nozzle, and means operatively connecting said first and second propeller assemblies to said turbine blade assembly for rotation with the latter.

2. In an aircraft, the combination with a horizontally disposed fuselage provided with an annular opening extending vertically therethrough, a first propeller assembly positioned within said opening so as to extend across and about said opening and connected to said fuselage for rotational movement about a vertical axis in one direction, a second propeller assembly positioned within said opening and spaced from said first propeller assembly and arranged so as to extend across and about said opening and connected to said fuselage for rotational movement about said vertical axis in an opposite direction, of a reaction motor having a nozzle for the ejection of exhaust gases therefrom positioned horizontally within said fuselage inwardly of said opening with the nozzle facing rearward, a first turbine blade assembly positioned so that it is exteriorly of and adjacent said nozzle and connected to said fuselage for rotational movement about said vertical axis in said one direction responsive to the impingement of gases when ejected from said nozzle, a second turbine blade assembly positioned in concentric spaced relation with respect to said first turbine blade assembly and connected to said fuselage for rotational movement about said vertical axis in said another direction in response to impingement of gases when ejected from said nozzle, means operatively connecting said first propeller assembly to said first turbine blade assembly for rotation with said first turbine blade asembly, and means operatively connecting said second propeller assembly to said second turbine blade assembly for rotation with the latter.

3. In an aircraft, the combination with a horizontally disposed fuselage provided with an annular opening extending vertically therethrough, a first propeller assembly positioned within said opening so as to extend across and about said opening and connected to said fuselage for rotational movement about a vertical axis in one direction, a second propeller assembly positioned within said opening and spaced from said first propeller assembly and arranged so as to extend across and about said opening and connected to said fuselage for rota-

tional movement about said vertical axis in an opposite direction, of a reaction motor having a nozzle for the ejection of exhaust gases therefrom positioned horizontally within said fuselage inwardly of said opening with the nozzle facing rearward, a turbine blade assembly positioned so that it is exteriorly of and adjacent said nozzle and connected to said fuselage for rotational movement about said vertical axis responsive to the impingement of gases when ejected from said nozzle, means operatively connecting said first and second propeller assemblies to said turbine blade assemblies for rotation with the latter, and an aileron positioned on each side of said fuselage and connected to said fuselage for movement about a horizontal axis.

4. In an aircraft, the combination with a horizontally disposed fuselage provided with an annular opening extending vertically therethrough, a first propeller assembly postioned within said opening so as to extend across and about said opening and connected to said fuselage for rotational movement about a vertical axis in one direction, a second propeller assembly positioned within said opening and spaced from said first propeller assembly and arranged so as to extend across and about said opening and connected to said fuselage for rotational movement about said vertical axis in an opposite direction, of a reaction motor having a nozzle for the ejection of exhaust gases therefrom positioned horizontally within said fuselage inwardly of said opening with the nozzle facing rearward, a first turbine blade assembly embodying a pair of annularly arranged rows of blades positioned so that one row of said pair is exteriorly of and adjacent said nozzle and the other row of said pair is circumposed about and spaced from said one row, said one and other rows of blades being connected to said fuselage for rotational movement as a unit about said vertical axis in one direction responsive to the impingement of gases when ejected from said nozzle, a second turbine blade assembly positioned in the space between said rows of blades of said first turbine blade assembly and connected to said fuselage for rotational movement about said vertical axis in said other direction in response to the impingement of gases when ejected from said nozzle, means operatively connecting said first propeller assembly to said one and other rows of blades for rotation with said one and other rows of blades, and means operatively connecting said second propeller assembly to said second turbine blade assembly for rotation with the latter.

5. In an aircraft, the combination with a horizontally disposed fuselage provided with an annular opening extending vertically therethrough, a first propeller assembly positioned within said opening so as to extend across and about said opening and connected to said fuselage for rotational movement about a vertical axis in one direction, a second propeller assembly positioned within said opening and spaced from said first propeller assembly and arranged so as to extend across and about said opening and connected to said fuselage for rotational movement about said vertical axis in an opposite direction, of a reaction motor having a nozzle for the ejection of exhaust gases therefrom positioned horizontally within said fuselage inwardly of said opening with the nozzle facing rearward, a first turbine blade assembly embodying a pair of annularly arranged rows of blades positioned so that one row of said pair is exteriorly of and adjacent said nozzle and the other row of said pair is circumposed about and spaced from said one row, said one and other rows of blades being connected to said fuselage for rotational movement as a unit about said vertical axis in one direction responsive to the impingement of gases when ejected from said nozzle, a second turbine blade assembly positioned between said one and other rows of blades of said first turbine blade assembly and connected to said fuselage for rotational movement about said vertical axis in said other direction in response to the impingement of gases when ejected from said nozzle, means operatively connecting said first propeller assembly to said one and other rows of blades for rotation with said one and other rows of blades, means operatively connecting said second propeller assembly to said second turbine blade assembly for rotation with the latter, hand actuable means connecting the blades of said first and second turbine blade assemblies together for movement from an operative position to an inoperative position, an aileron positioned on each side of said fuselage and being connected to said fuselage for movement about a horizontal axis, and rudder and elevator control means cooperatively positioned with respect to said nozzle and connected to said fuselage for movement relative to the latter.

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March 10, 1959 H. F. STREIB 2,876,965

CIRCULAR WING AIRCRAFT WITH UNIVERSALLY TILTABLE DUCTED POWER PLANT

Filed July 23, 1956 2 Sheets-Sheet 1

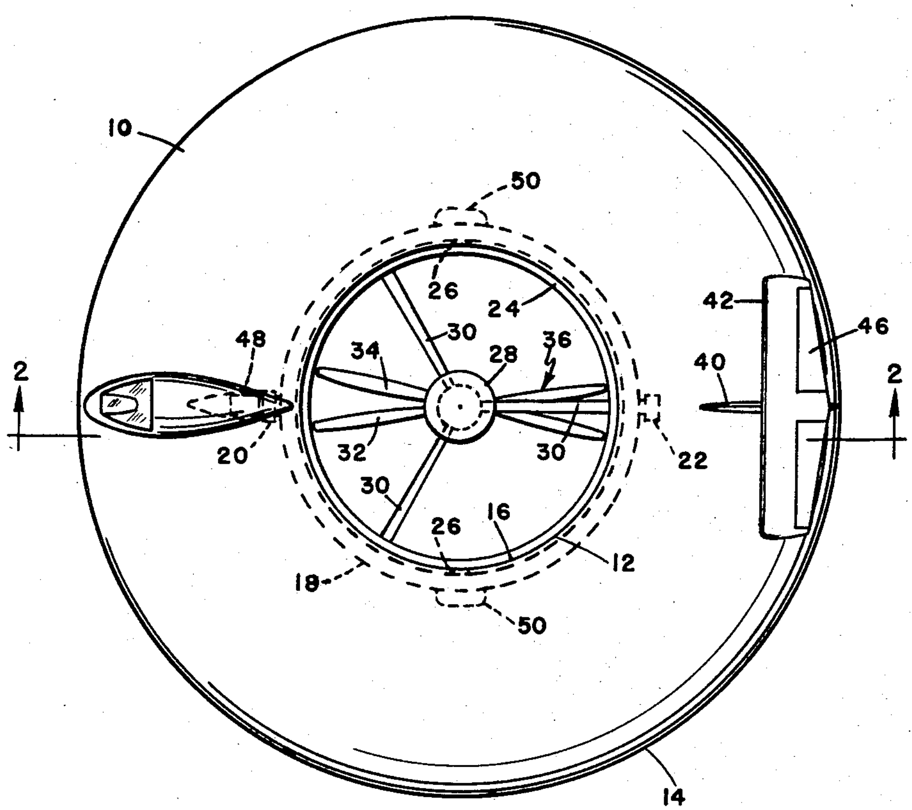


Fig. 1

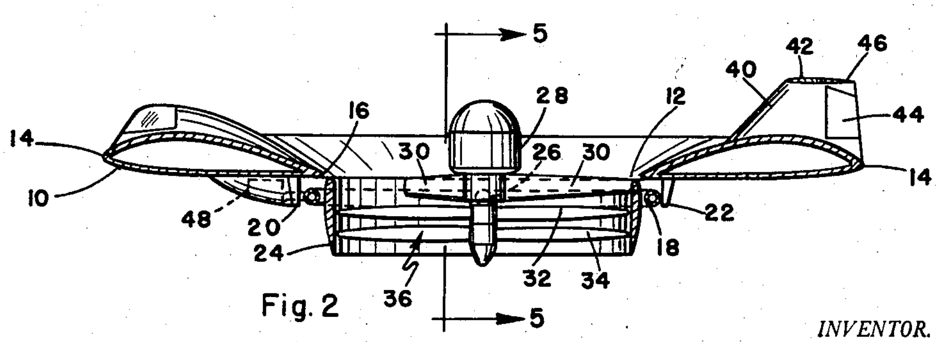


Fig. 2

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CIRCULAR WING AIRCRAFT WITH UNIVERSALLY TILTABLE DUCTED POWER PLANT

Filed July 23, 1956 2 Sheets-Sheet 2

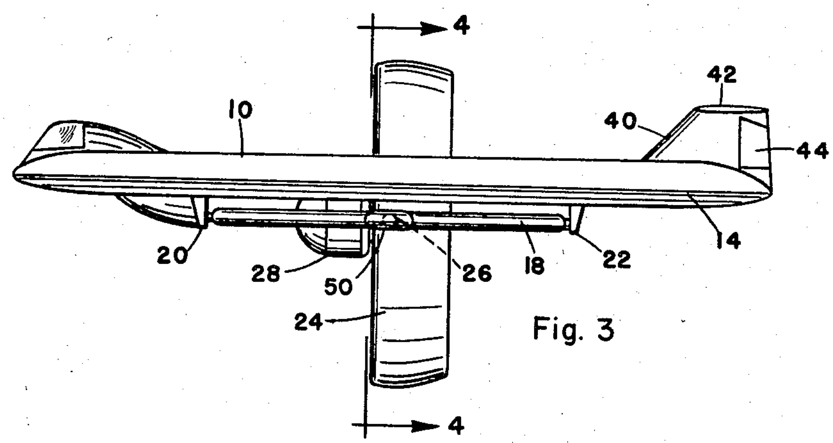


Fig. 3

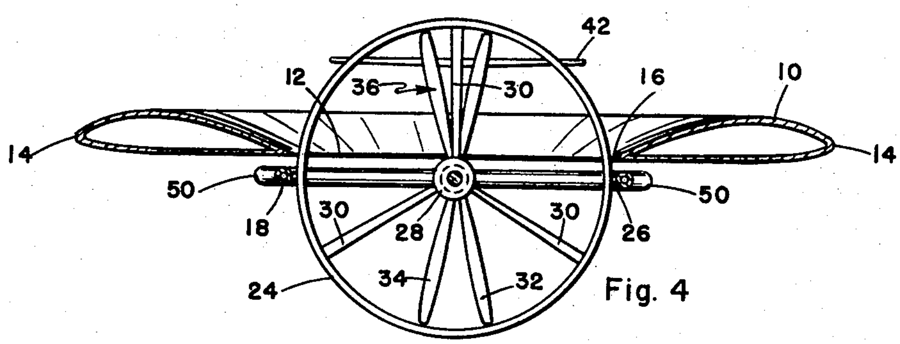


Fig. 4

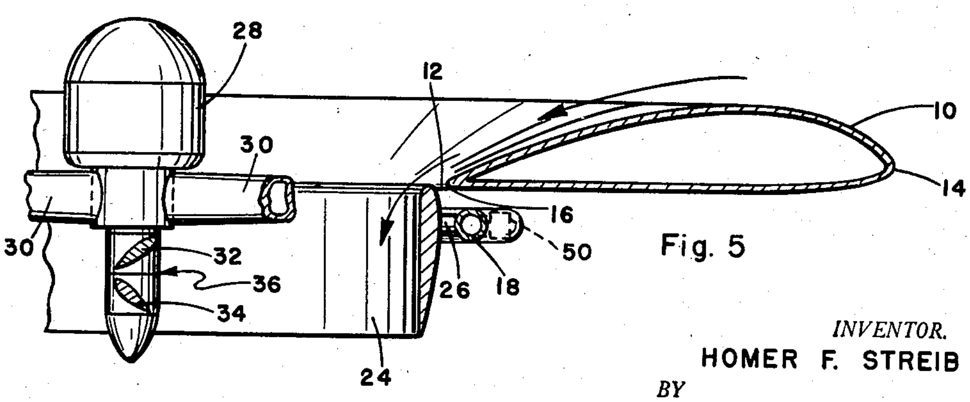


Fig. 5

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# United States Patent Office

2,876,965

Patented Mar. 10, 1959

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2,876,965

## CIRCULAR WING AIRCRAFT WITH UNIVERSALLY TILTABLE DUCTED POWER PLANT

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Application July 23, 1956, Serial No. 599,571

6 Claims. (Cl. 244—12)

The present invention relates generally to aircraft and more particularly to a circular wing aircraft capable of vertical and horizontal flight.

The primary object of this invention is to provide a circular wing aircraft having a shiftable impeller mounted in a central opening in the wing and arranged to move air radially inwardly over at least a major portion of the upper surface of the wing, in all positions of the impeller, and since the radial cross-section of the wing is an efficient airfoil a major portion of the lift is obtained from this radial airflow thus achieving simple, efficient design.

Another object of this invention is to provide a circular wing aircraft in which the impeller is encircled by a shroud ring to duct the air more effectively and increase the efficiency of the impeller in all positions thereof.

Another object of this invention is to provide a circular wing aircraft in which the impeller and its shroud ring are tiltable through at least 90 degrees about the lateral axis of the aircraft to provide forward thrust for horizontal flight.

Another object of this invention is to provide a circular wing aircraft in which the impeller is tiltable to a limited degree about the longitudinal axis of the aircraft to provide a lateral thrust component.

Finally, it is an object to provide a circular wing aircraft which, by suitable control of the impeller, can be safely flown in many different directions of flight, control being maintained in both high and low speed ranges.

With these and other objects which will appear hereinafter definitely in view, this invention consists in the novel construction, combination and arrangement of elements and portions, as will be hereinafter fully described in the specification, particularly pointed out in the claims, and illustrated in the drawings which form a material part of this disclosure, and in which:

Figure 1 is a top plan view of the aircraft;

Figure 2 is a vertical sectional view taken on the line 2—2 of Figure 1;

Figure 3 is a side elevation view of the aircraft showing the impeller tilted to the full forward flight position;

Figure 4 is a sectional view taken on the line 4—4 of Figure 3; and

Figure 5 is an enlarged fragmentary sectional view taken on the line 5—5 of Figure 2.

Referring now to the drawings in detail, the aircraft comprises a circular wing **10** having a central, substantially circular opening **12**. The cross-sectional shape of the wing may be constant as shown and must constitute an efficient airfoil in respect of an airflow induced toward said opening. The chord of the airfoil of the wing **10** extends in a radial direction. Beneath the opening **12** and concentric therewith is a gimbal ring **18** which is mounted for pivotal movement about the longitudinal axis of the wing between a front bearing **20** and a rear bearing **22**, said bearings extending downwardly below the wing adjacent to the opening **12**. Within the gimbal ring **18** is mounted an axially elongated circular shroud

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ring **24**, which is supported by diametrically opposed bearings **26** extending from said gimbal ring along the lateral axis of the aircraft. Centrally mounted in the shroud ring **24** is a motor **28** which is supported by a spider type structure having radial support arms **30** fixed to said shroud ring and the motor. The term "motor" is used herein in the broadest sense, as any suitable type power plant can be used. In the illustrated form counter-rotating propellers **32—34** with their tips enclosed by the shroud ring **24** constitutes the thrust-producing unit which will be referred to herein as the impeller **36**. With the impeller **36** in the horizontal or vertical thrust position as in Figures 1, 2 and 5, the motor **28** is located above the impeller and substantially outside the shroud ring **24**.

At the forward edge of the wing **10** is a cockpit structure **38** while at the rear is an upwardly extending fin **40**, on top of which is mounted a horizontal tailplane **42**. The fin **40** and tailplane **42** are provided with a movable rudder **44** and elevons **46**, respectively, to provide direction control in normal forward flight. The elevons **46**, of course, are similar to those used on conventional tailless aircraft and provide both pitching and rolling control. However, in low speed on vertical flight, control is obtained by tilting the impeller **36**. For tilting movement about the longitudinal axis an actuating motor **48** is installed in the front bearing **20**, while for movement about the lateral axis actuating motors **50** are mounted on the gimbal ring **18** and coupled to the bearings **26**. The actuating motors **48** and **50** may be of any suitable type such as electric or hydarulic units, the actual means for achieving tilting motions not being considered critical in the present disclosure and being diagrammatically illustrated.

In operation, for vertical flight, the impeller **36** creates a downwardly moving airstream through the shroud ring **24**, which causes air to be drawn radially inwardly over the upper surface of the wing **10** as shown by the direction arrows in Figure 5. Since the cross sectional shape of the wing in a radial direction represents an efficient airfoil, this airflow produces a high lift over the entire surface of the wing, as described in my co-pending application Serial No. 369,638, filed July 22, 1953. It has been found in tests, that by inducing the radially inward airflow over the wing, by means of a propeller not attached to the wing in any way, that the wing lifts independently, proving that the downward thrust of the propeller is not essential to lift. By merely varying the speed of rotation of the impeller **36**, the rate of ascent or descent of the aircraft can be closely controlled.

To obtain lateral motion or sideways flight at low speeds, the shroud ring **24** and impeller **36** may be tilted about the longitudinal axis together with the gimbal ring **18**, by means of the actuating motor **48**. This causes an offset of the airflow through the shroud ring **24** and also causes an uneven radial airflow over the wing **10** so that the wing has more lift on one side than on the other. The wing **10** thus tilts and the aircraft moves in the direction of the low lift side of the wing.

For hovering and forward or backward directional control at low speed, the impeller **36** may be tilted as necessary within the gimbal ring **18** by means of the actuating motors **50**, thus causing uneven airflow over the wing **10** so that the required airspeed or ground speed in the desired direction as explained above is attained.

For full forward flight at high speed, the impeller **36** may be tilted 90 degrees so that the rotational axis of the impeller is parallel to the longitudinal axis of the aircraft, as in Figures 3 and 4. With all the thrust directed to the rear, the aircraft is driven forward and is maintained in flight by the rearwardly moving air over the wing. The transition from vertical to horizontal flight is best accomplished by first slightly tilting the impeller **36** to give the aircraft a slow speed forward motion. When sufficient forward speed has been obtained to maintain the aircraft in flight, the impeller speed is reduced while the impeller is tilted to the full forward thrust, after which the impeller speed may be increased for high speed flight. The reduction of rotational speed while the impeller is being tilted prevents undue directional change of the aircraft during the transition stage, although under certain circumstances it may be found that the impeller may be tilted quickly enough to avoid effects of offset thrust. It is realized that the efficiency of the wing **10** in forward flight is less than that of a conventional wing, but the large total area of the wing provides ample lift. Furthermore, due to the fact that the airfoil of the rear portion of the wing is now reversed to the airflow, the forward portion will tend to be raised due to its more effective lifting properties. This is compensated for by the weight of the motor **28** which is moved forward as the impeller is tilted to the forward flight position, although suitable aerodynamic means could also be used.

It should be understood that the structure, mounting and design of the impeller **36** and shroud ring **24** are illustrative only and may be arranged to suit a particular aircraft. Similarly, the aerodynamic design of the aircraft may be varied to a considerable extent without departing from the basic function described herein.

The operation of this invention will be clearly comprehended from a consideration of the foregoing description of the mechanical details thereof, taken in connection with the drawing and the above recited objects. It will be obvious that all said objects are amply achieved by this invention.

Further description would appear to be unnecessary.

It is understood that minor variation from the form of the invention disclosed herein may be made without departure from the spirit and scope of the invention, and that the specification and drawing are to be considered as merely illustrative rather than limiting.

I claim:

1. An aircraft comprising a circular wing having a central circular opening therein; an impeller operatively mounted in said opening; said impeller being tiltably mounted for movement through an angle of approximately 90 degrees about an axis substantially coinciding with the lateral axis of the aircraft and supplying forward thrust in one position of the impeller and vertical thrust in another position thereof; and a shroud ring constituting a duct for said impeller and mounted to tilt therewith.

2. An aircraft comprising a circular wing having a central circular opening therein; an impeller operatively mounted in said opening; said impeller being tiltably mounted for movement through an angle of approximately 90 degrees about an axis substantially coinciding with the lateral axis of the aircraft and supplying forward thrust in one position of the impeller and vertical thrust in another position thereof; and said impeller also being tiltable about an axis parallel to the longitudinal axis of the aircraft; and a shroud ring for said impeller and mounted to tilt therewith.



3. An aircraft comprising a circular wing having a central opening therein; a gimbal ring mounted on said wing below and concentric with said opening; said gimbal ring being tiltably mounted for movement about an axis parallel to the longitudinal axis of the aircraft; an impeller operatively mounted in said gimbal ring and tiltable through an angle of at least 90 degrees about an axis parallel to the lateral axis of the aircraft and supplying forward thrust in one position of the impeller and vertical thrust in another position thereof; and a shroud ring for said impeller and mounted to tilt therewith.

4. An aircraft comprising a circular wing having a central opening therein; a gimbal ring mounted on said wing below and concentric with said opening; said gimbal ring being tiltably mounted for movement about an axis parallel to the longitudinal axis of the aircraft; a shroud ring concentrically mounted in said gimbal ring; an impeller operatively mounted within said shroud ring; said impeller and shroud ring being tiltable through an angle of at least 90 degrees about an axis parallel to the lateral axis of the aircraft and supplying forward thrust in one position of the impeller and vertical thrust in another position thereof.

5. An aircraft comprising a circular wing having a central opening therein; a shroud ring mounted on said wing at said opening for tilting movement through an angle of approximately 90 degrees about an axis substantially coincident with the lateral axis of the aircraft; and an impeller operatively mounted in said shroud ring and coaxially of said shroud ring; and means for tilting said shroud ring and impeller together and supplying forward thrust in one position of the impeller and vertical thrust in another position thereof.

6. An aircraft comprising a circular wing having a central opening therein; a shroud ring mounted on said wing at said opening for tilting movement through an angle of approximately 90 degrees about an axis substantially coincident with the lateral axis of the aircraft; and an impeller operatively mounted in said shroud ring and coaxially of said shroud ring; and means for tilting said shroud ring and impeller together and supplying forward thrust in one position of the impeller and vertical thrust in another position thereof; said shroud ring being also tiltable about the longitudinal axis of the aircraft for lateral thrust directional control.


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