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(54) **CIRCULAR VERTICAL TAKE OFF & LANDING AIRCRAFT**

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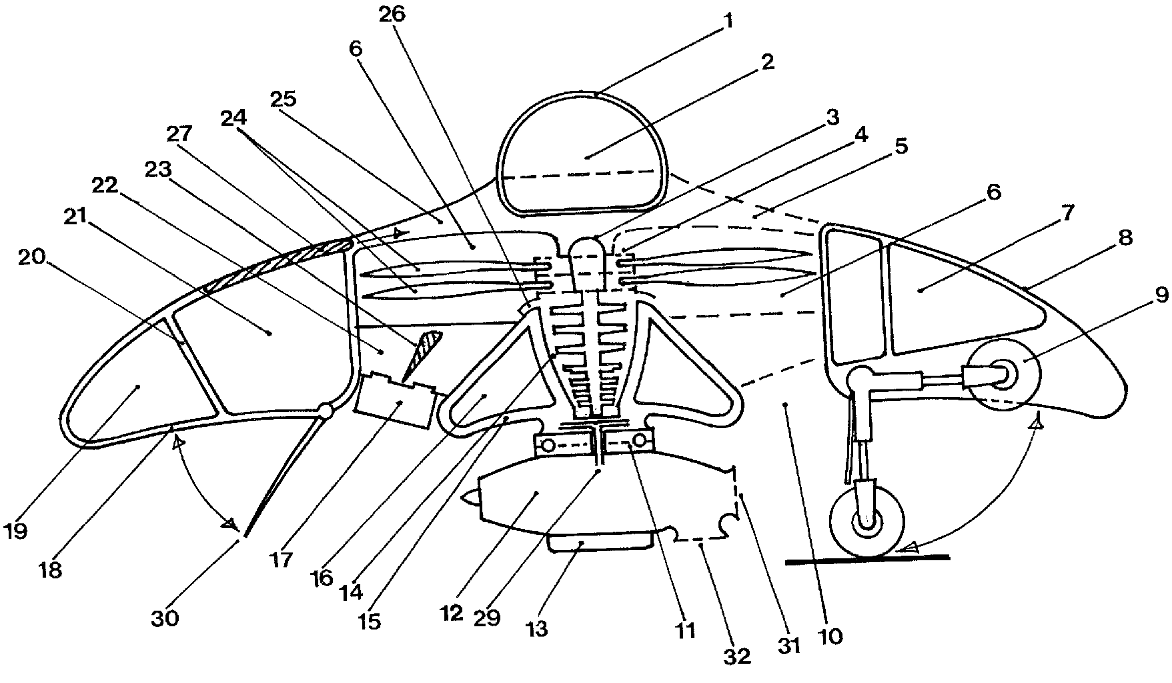
(57) **ABSTRACT**

A circular VTOL aircraft with a central vertically mounted turboprop engine **14**, driving contra-rotating co-axial propellers **24**, above a central jet engine (or engines) **12**, horizontally mounted on a turntable pod **11** which is steerable through 360 degrees. The turboprop provides vertical thrust from contra-rotating propellers compressing air from an upper circular intake **5** downward through a circular shaped rotor-chamber **6** to a circular vent **10** at the base of the craft. The resulting column of compressed air supports the craft during take-off and landing operations and provides a cushion of air in normal flight. The horizontally mounted jet turbine provides main thrust for horizontal flight and vectored thrust for VTOL. The passenger cabin **21** is circular and is situated in the main body of the disc-shaped craft. Fuel tanks are situated around the circumference of the craft to maximise fuel capacity. The flight-deck **2** is situated at the top centre of the craft, above the engine unit **15,** which is detachable.



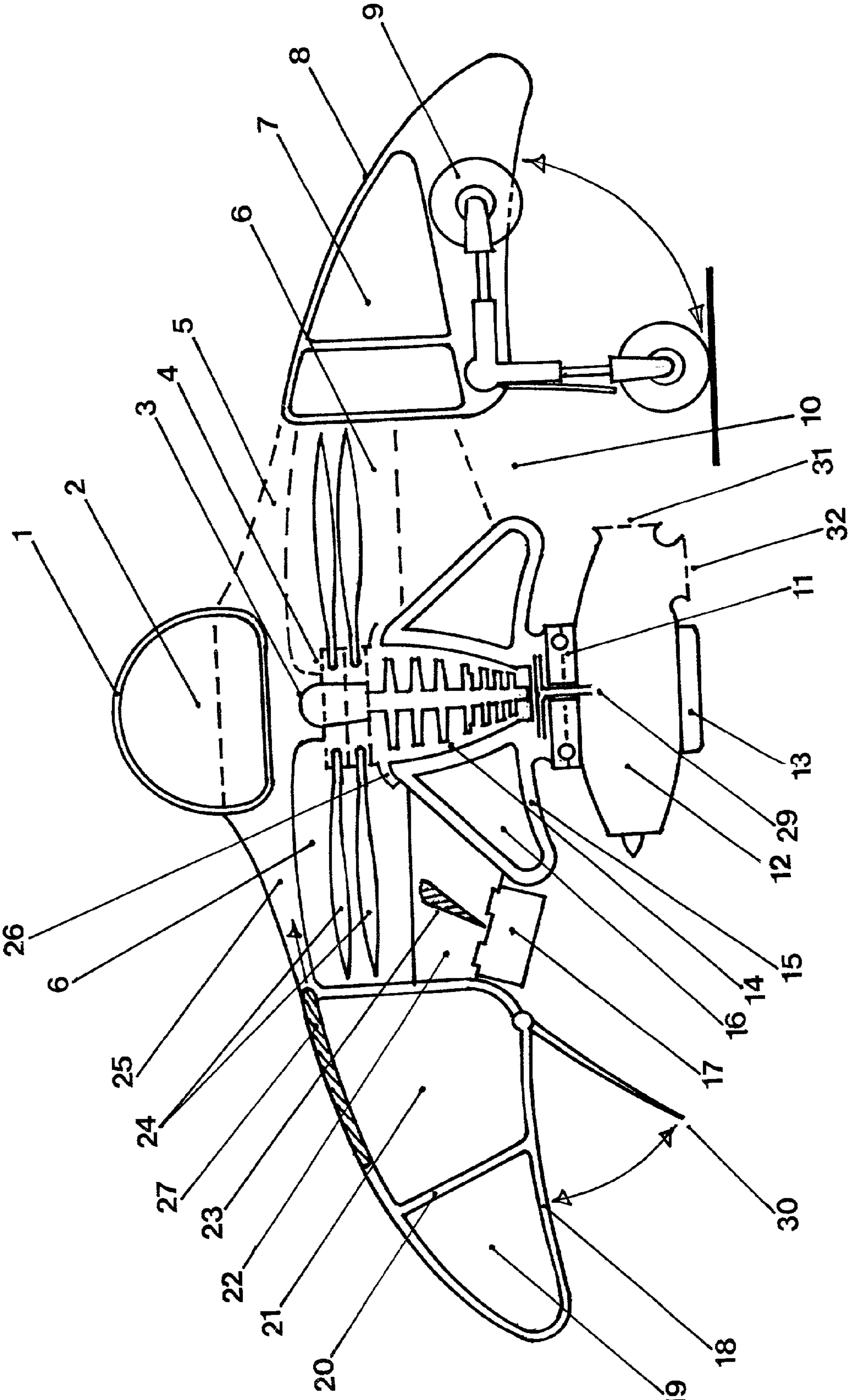

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Fig 1

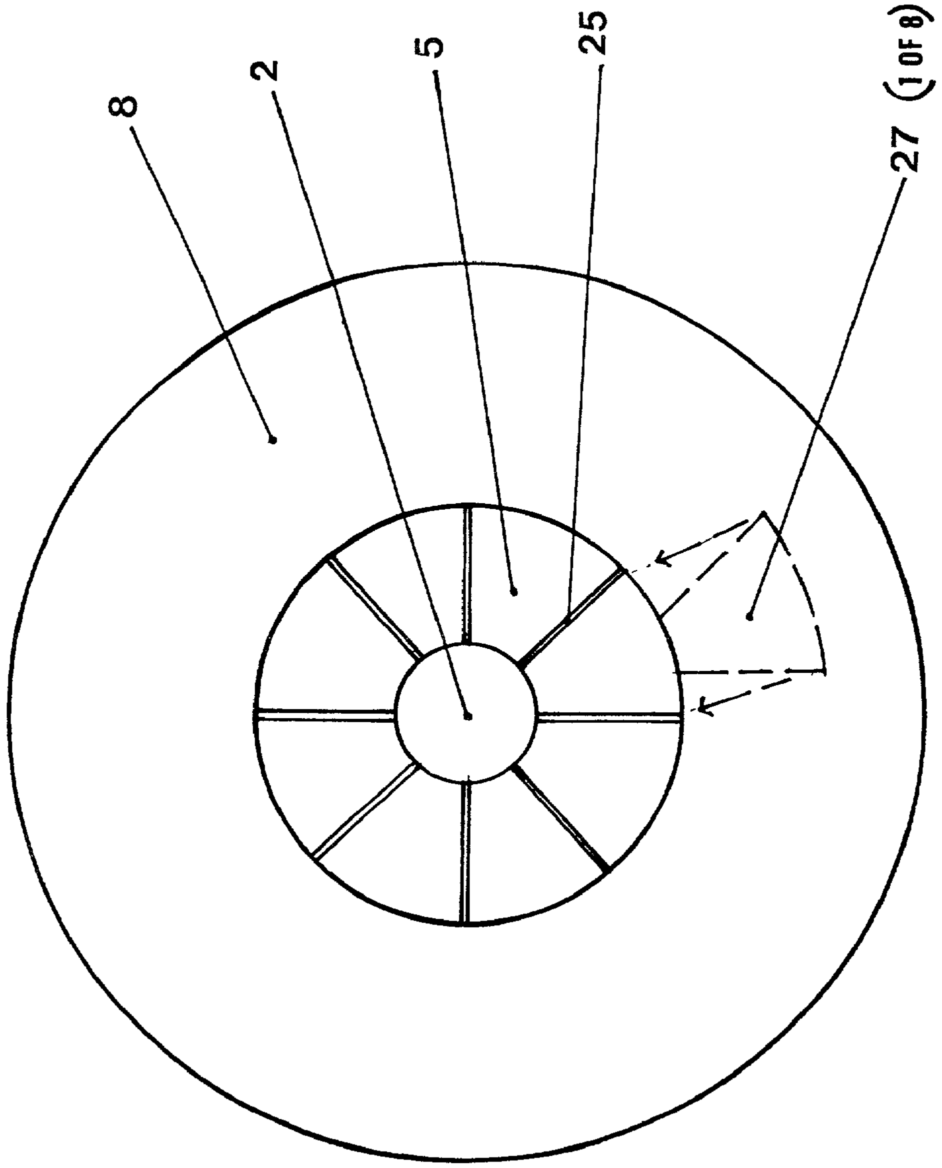



Fig 2

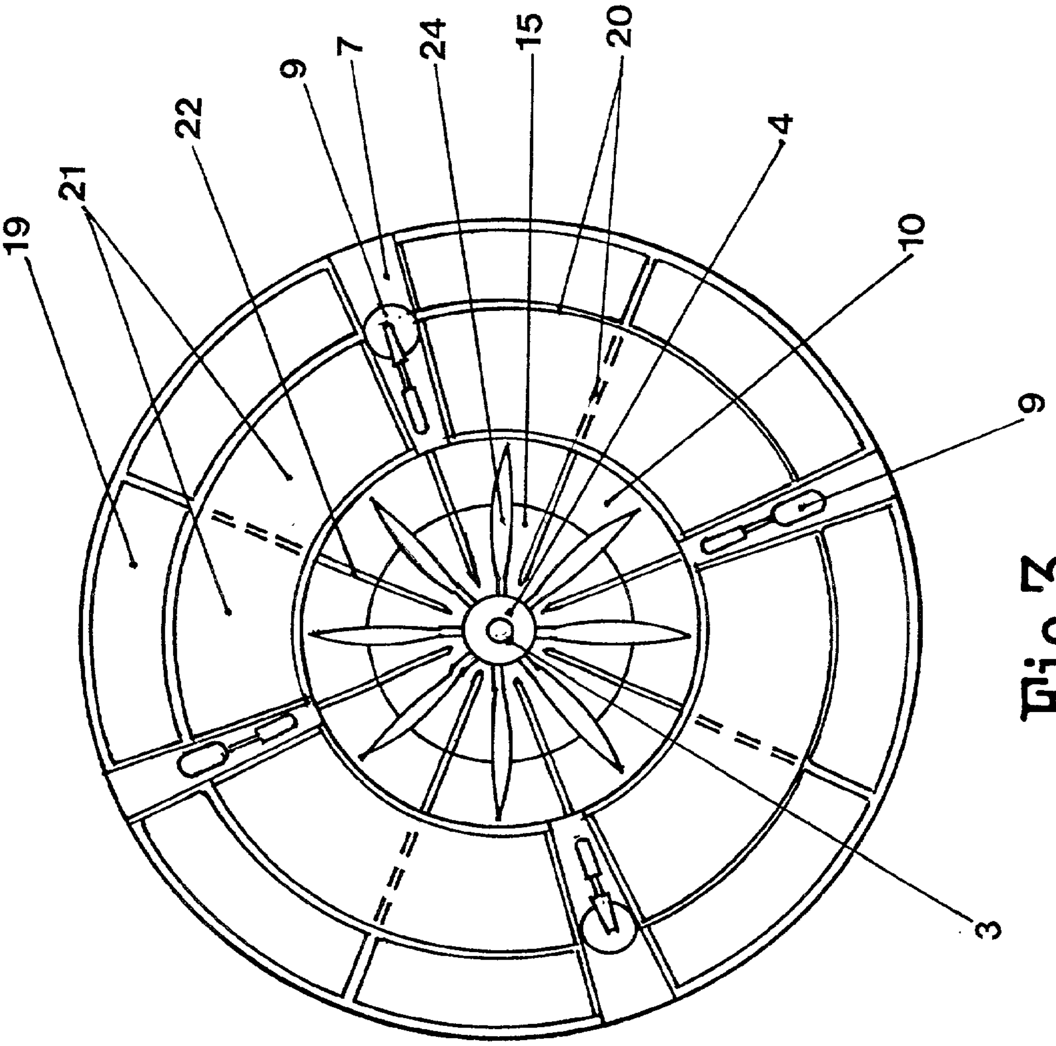
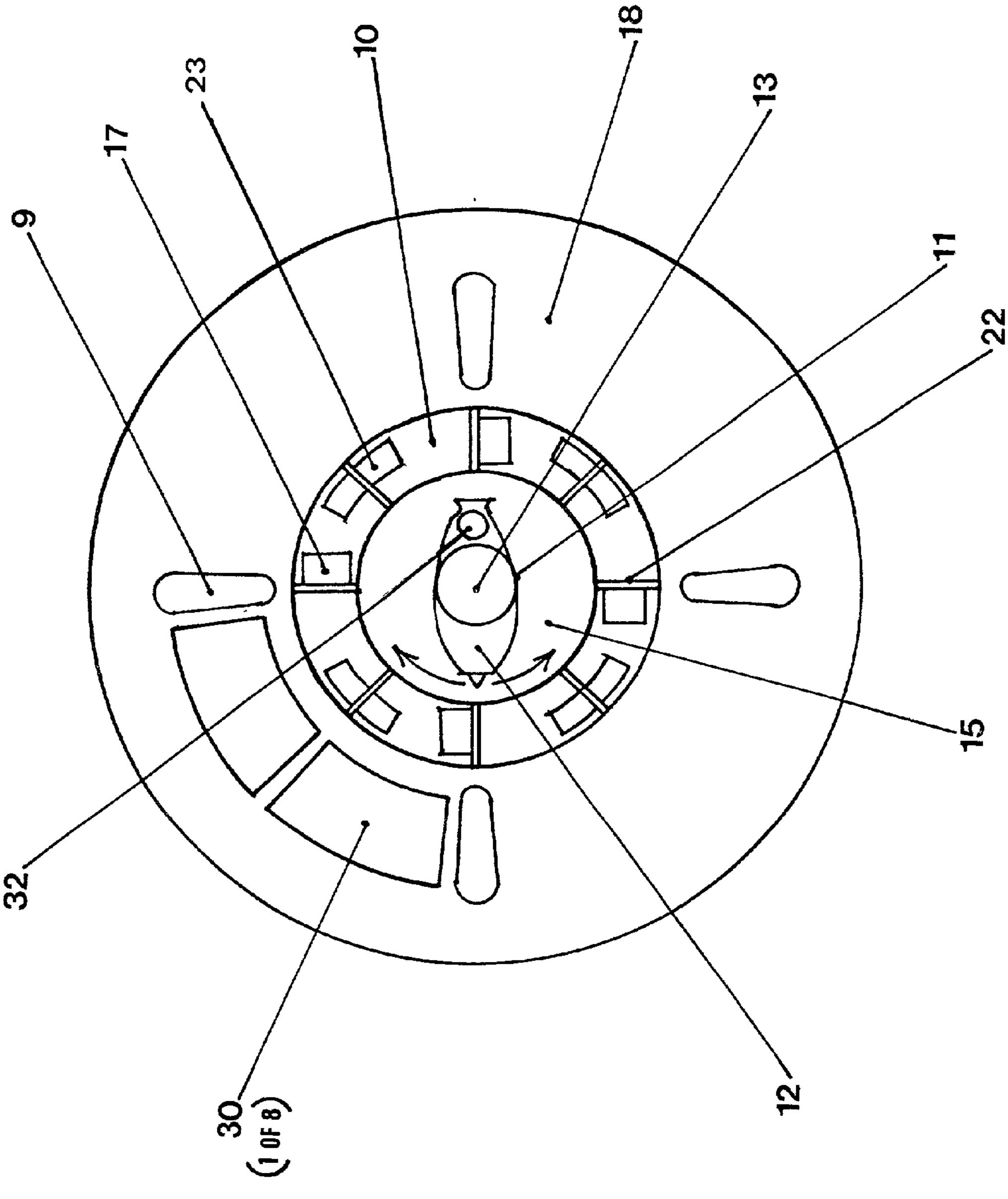



Fig 3

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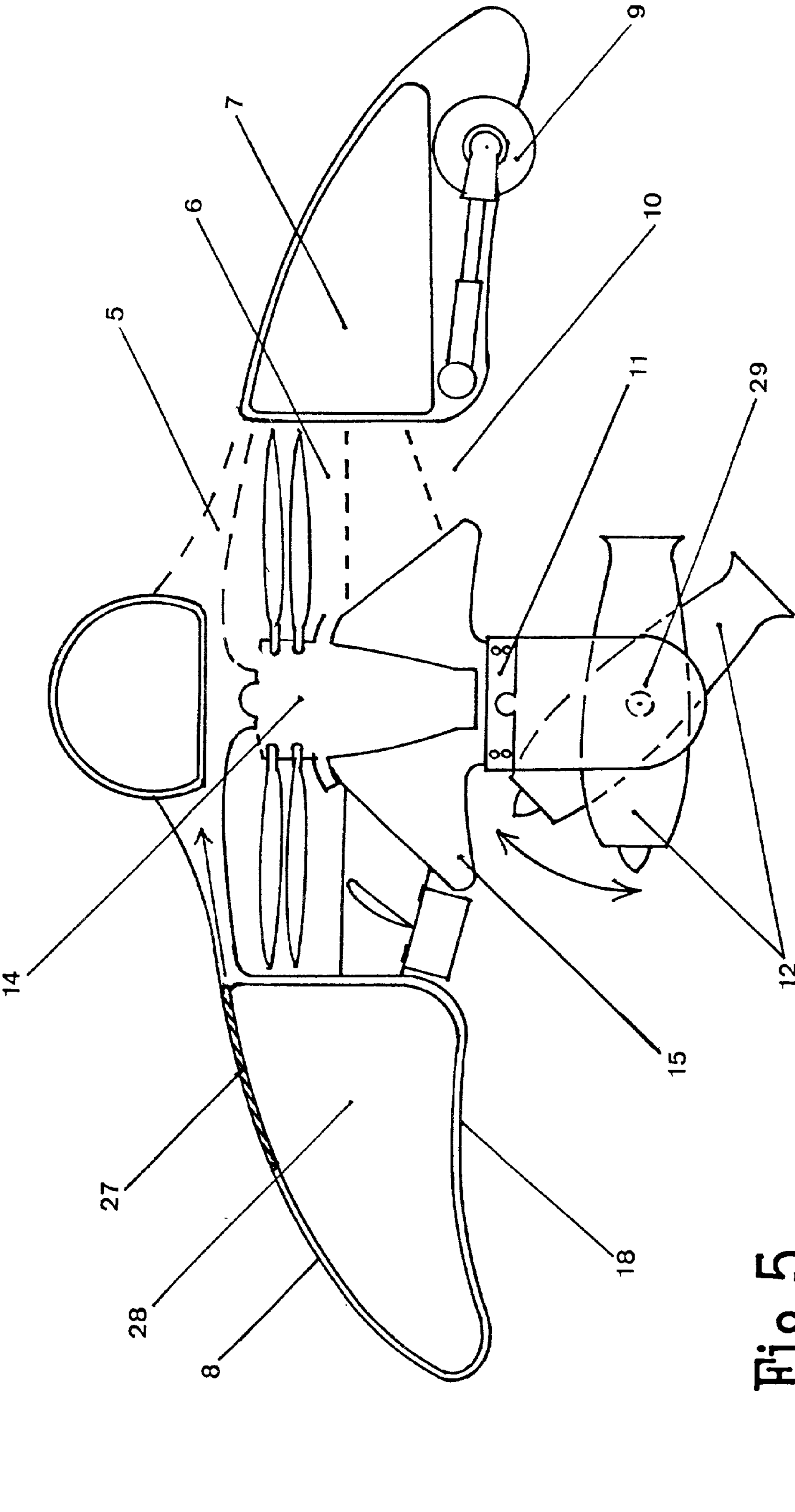


Fig 5

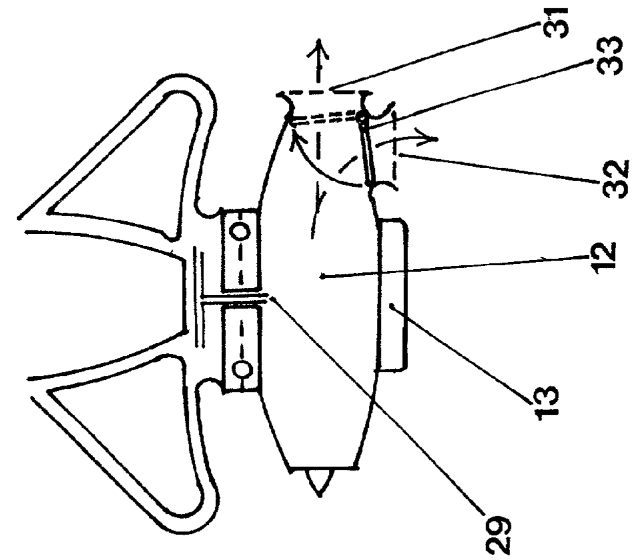

Fig 8

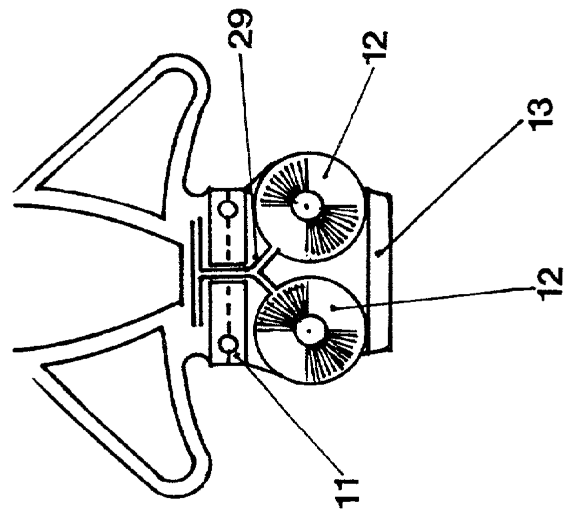

Fig 7

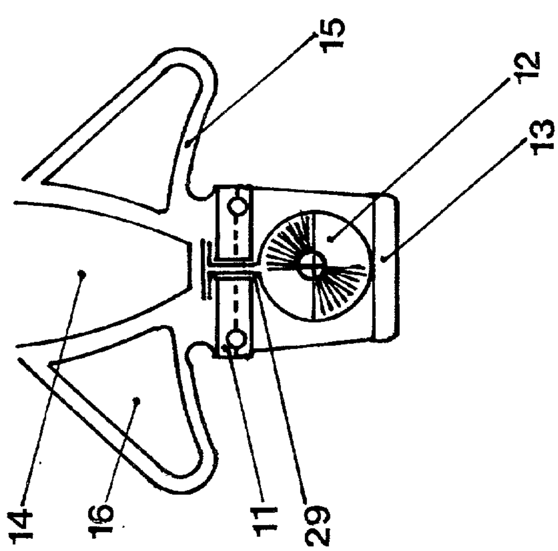

Fig 6

# CIRCULAR VERTICAL TAKE OFF & LANDING AIRCRAFT

[0001] The invention comprises a circular VTOL aircraft which is capable of vertical and horizontal flight by combining propulsive power from horizontal contra-rotating propellers powered by a turboprop engine giving vertical thrust, and a jet turbine engine or engines, giving horizontal thrust.

[0002] The stability of the craft is achieved by the gyroscopic effect of the high-speed rotation of two co-axial propellers, which are geared to contra-rotate at the same speed thus avoiding the torque effect produced by a single rotor or propeller.

[0003] The jet engine, (or engines) which provides horizontal thrust, is mounted on a steerable turntable pod at the centre base of the aircraft in order to achieve rapid changes in direction through 360 degrees during flight manoeuvres: for example, from forward to reverse flight, from forward to sideways flight through 90 degrees, or from side to side flight through 180 degrees change in direction. The jet turbine may be fitted with vectored thrust nozzles to provide additional thrust on take-off. Alternatively, the turbine may be mounted on a gimbal bearing so that the engine can be angled upwards from the horizontal axis to provide additional take-off thrust.

[0004] This rapid manoeuvrability in the horizontal plane combined with a high rate of ascent or descent in the vertical plane, together with inherent stability as a weapons or personnel recovery platform, is designed to make the craft extremely effective for both military application and for civilian rescue operations: particularly rescue from fire in high-rise buildings. For the military application the passenger compartment area may be used both for weapons payload and for additional fuel tanks in order to extend the normal operating range. Weapons can be arranged to give 360 degrees of effective fire cover.

[0005] The aircraft is designed to be constructed using composite GRP and carbon-fibre reinforced materials, which are both strong and light in weight, and will enable the craft to exhibit a low radar profile. A feature of the design is the high fuel storage capacity with fuel tanks installed around the circumference of the craft to make full use of the large outer area available; this high fuel capacity will enable the craft to out-range the conventional helicopter on passenger flights and rescue or military missions.

[0006] Another notable feature of the design is that the passenger compartment, cargo and fuel-tank loadings are all integrated into the main body of the craft, which combines the functions of both wing and fuselage in one inherently strong disc-shape aerodynamically streamlined to generate lift in forward flight, thus avoiding existing problems such as wing-flutter and spar-failure associated with high loading on conventional aircraft designs. The circular passenger compartment can be designed either to maximise seating capacity or to include a small service area. (For example, the prototype aircraft is 12 metres in diameter and is designed to carry 24 passengers and 2 flight crew, with a fuel capacity of 33 cubic metres). The area designated for the passenger compartment may also be used for cargo carrying purposes. Alternatively, with the passenger compartment area replaced by water or foam tanks the craft can be used effectively as a fire-fighter having the ability to lift and dump a large quantity of water/foam from the circular tanks on each mission. The flight-deck is completely separate from the passenger compartment and is therefore inaccessible to high-jacking attempts.

[0007] The horizontal speed of the aircraft described is not limited by aerodynamic problems caused for example by the difference in forward and retreating blade speeds of the helicopter rotor, because in horizontal flight with the rotor intake cover closed, the aerodynamic section of the disc-shaped craft produces an area of low pressure airflow over the trailing top half of the disc, generating lift in the same way as a conventional aircraft wing in forward flight.

[0008] With the rotor intake cover closed, the contra-rotating propellers are free to rotate at a reduced cruising rpm which is sufficient to provide the gyroscopic stability required for horizontal flight, and at the same time the rotor-chamber becomes partially vacated as air is expelled from the exit vent, allowing the propellers to rotate with reduced air friction, thereby conserving fuel for the turboprop's main purpose of vertical take-off and landing.

[0009] In the event of engine failure the contra-rotating propellers may be geared to auto-rotate to control the rate of descent of the craft for an emergency landing. The horizontal jet thrust may also be vectored downwards by vectored thrust nozzles, or by extending a flap from the underside of the craft in order to deflect thrust to cushion the landing; or when the jet engine is gimbal mounted, thrust can be angled downwards to control the rate of descent. In the event of the horizontal jet turbine engine failing, an emergency landing can be made with the controlled thrust of the turboprop engine and propellers.

[0010] The craft is designed to fly with the main disc-shaped body maintaining a level horizontal position through all stages of flight, thereby alleviating passenger discomfort experienced during pitch and bank changes in conventional aircraft. However, the craft is fitted with control vanes which are used to change or trim the pitch and roll movement of the disc in flight. A combination of thrust from both vertical and horizontal power units will achieve a 45 degree angle of ascent to cruising altitude with the craft maintaining a horizontal attitude. Vertical ascent from a helicopter pad or small clearing area can be made using the vertical thrust power unit alone.

[0011] A specific embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

[0012] **FIG. 1** shows a cross sectional elevation of the craft and illustrates the vertical and horizontal propulsion systems.

[0013] **FIG. 2** shows a plan view of the top of the craft.

[0014] **FIG. 3** shows a plan which illustrates the contra-rotating propellers, the passenger compartment, fuel tanks and undercarriage.

[0015] **FIG. 4** shows a plan view of the underside of the craft and illustrates the jet turbine, the circular rotor chamber vent, control vanes, thrust deflecting flaps and undercarriage.

[0016] **FIG. 5** shows a cross-sectional elevation of the craft with an alternative design adapted for airship methods of construction.

[0017] **FIG. 6** shows a cross-sectional view of the fuel supply to the single turbine engine.

[0018] **FIG. 7** shows a cross-sectional view of the fuel supply to the twin engine configuration.

[0019] **FIG. 8** shows a vectored thrust valve system for the jet turbine engine.

[0020] N.B. Turn-Table, Gimbal, Valves & Bearings Shown in the Drawings are Representational

[0021] In **FIG. 1 a** turboprop engine **14** is mounted vertically in the centre of the craft and is geared to turn two multi-bladed co-axial contra-rotating propellers **24** within the rotor-chamber **6**, which is formed by the circular space between the passenger compartment **21** and the main engine frame **15**.

[0022] The propellers draw air into the circular air intake **5** at the top of the craft and then compress the air downward through the funnel-shaped rotor-chamber to the circular exit vent **10**. Air is guided into and through the rotor-chamber by flow vanes **25** and **22** which span the top and bottom of the rotor-chamber respectively and these vanes also serve as structural support frames linking the engine frame with the main body of the craft. Aerofoil vanes **23**, which are mounted upon flow vanes **22**, are angled into the airflow below the propellers to generate an additional lift force. Vanes **23** may also be hinged as control surfaces to effect pitch and bank control of the craft. Similarly, aerofoil vanes **17** are hinge-mounted beneath vanes **22** to effect directional rudder trim control of the aircraft.

[0023] The said turboprop engine is mounted on structural engine frame **15**, which is connected to the main body of the craft by structural frames **22**. For servicing and repairs the central engine unit can be unbolted and completely removed from below the main body of the craft. Ancillary engine systems such as cooling plant, fuel pumps and electrical services are housed within the circular engine frame compartment **16**. Structural support frames **20** separate the internal compartments of the main body of the craft. The circular flight-deck **2** is supported above the central engine unit by structural frames **25** and is enclosed by hemispherical cockpit canopy **1**.

[0024] The top fanshaft bearing **3** connects the top of the turboprop engine to the upper structural framework **25** and the engine intake **4** draws air from the main circular air intake **5**, with the engine exhaust **26** discharging into the rotor-chamber. A lubrication point (not shown) may be installed in the top centre of fanshaft bearing **3**.

[0025] The jet turbine engine **12** is mounted to a rotatable turntable **11** which enables the pilot to turn the engine (via steering control) through 360 degrees then lock the turntable to the required course. The jet turbine is secured by a protective base plate **13**, bolted through to the turntable above the engine.

[0026] As shown in **FIG. 7**, provision may be made for the single jet turbine-engine **12** to be supplanted by twin or multiple engines connected to the central turntable **11** in order to provide additional horizontal thrust. In **FIG. 8**, vectored thrust valve **33** (hinged to operate electrically or hydraulically) may be installed in the turbine vent to provide vectored thrust to horizontal thrust nozzle **31**, or vertical thrust nozzle **32**, in order to provide additional vertical thrust on take-off.

[0027] In **FIG. 5** an alternative engine mounting is shown whereby the jet-turbine engine **12** is secured to a gimbal bearing **29**, which is connected to rotatable turntable **11**. This allows the jet engine to be angled upward, thereby directing thrust downward for vertical take-off.

[0028] **FIG. 2** shows the central flight deck **2** in relation to the surrounding circular rotor air-intake **5**. The rotor intake covers **27** (only one typical section shown) are housed inside the top section of the main body **8**, and are hydraulically controlled from open to closed or locked into the position required by the pilot to control the amount of airflow into the rotor-chamber.

[0029] The retractable undercarriage units **9** are shown in plan position in **FIG. 3**, and have castoring main-wheels to allow free directional movement of the craft when taxiing. The space above the undercarriage bay may be used to accommodate additional fuel tanks **7**.

[0030] The main fuel tanks **19** are situated in the area shown at the circumference of the craft. Fuel is pumped to the engines via structural frames **22**. In **FIGS. 6 & 7** fuel and oil inflow pipes which may be fitted with flow valves as required, deliver pressurised fuel and oil to the turbine-engine **12** and are installed to pass vertically through the centre of rotatable turntable **11** in order to allow the free rotation of the turntable and engine through 360 degrees of steerage in the horizontal plane.

[0031] In **FIG. 3**, the contra-rotating propellers **24** are fitted with a variable pitch control so that fine-pitch plus high engine rpm can be selected for take-off and landing when maximum lift is required, and coarse pitch can be selected for cruising flight at a lower rpm setting. The direction of the craft may also be controlled by varying the rpm of the propellers allowing the resulting torque to spin the craft.

[0032] Passenger compartments **21** are situated in the main body of the craft and may be linked by a circular access corridor (not shown) and may have access hatches and retractable steps which allow passengers to enter and exit from the underside **18**, of the craft. In the fire-rescue version personnel access is via the upper-surface **8** of the craft.

[0033] A plan view of the craft is shown in **FIG. 4** illustrating the position of the jet turbine engine **12** which is mounted between turntable **11** and base-plate **13**. This plan also shows the juxtaposition of trim vanes **17** and aerofoil vanes **23** which are effective in the airflow forced by the propellers through the rotor-chamber exit vent **10**. Thrust deflecting flaps **30** may be lowered into the horizontal jet-stream to provide additional lift on take-off and landing and may also be deployed as air-brakes if required.

[0034] A further application of the invention described above is illustrated in **FIG. 5** with an alternative design adapted for use as an airship, employing an inert gas such as helium as a buoyancy agent, where the main body of the craft is filled with gas buoyancy chambers **28**. For example a 15 metre diameter craft can accommodate 1200 cubic metres of helium gas which gives buoyancy equivalent to 1200 kg weight. (1 cubic metre of helium supports 1 kilogram weight). The craft can therefore be designed to be weightless at ground level, rather than lighter than air as a conventional airship, so that minimal thrust is required from the contra-rotating propellers to achieve vertical take-off. With the contra-rotating propellers in reverse providing a controlled downward force, existing problems of airship control and tethering on landing would be eliminated.

**1**. A disc-shaped VTOL aircraft wherein a central turbo-prop engine turning contra-rotating co-axial propellers is mounted in the vertical axis position above a turbojet engine (or engines) mounted horizontally on a central turntable unit which can be steered through 360 degrees; the said turbojet engines having vectored thrust nozzles to provide additional vertical thrust for take-off and landing.

**2**. A VTOL aircraft as claimed in claim 1 wherein a turbojet engine is mounted on a gimbal frame so that the engine can be elevated or lowered relative to its horizontal axis.

**3**. A VTOL aircraft as claimed in claims 1 to 2, wherein contra-rotating propellers draw air down into a circular funnel shaped rotor chamber, compressing the air to provide vertical take-off thrust from a lower annular vent.

**4**. A VTOL aircraft as claimed in claims 1 to 3, wherein central contra-rotating propellers provide gyroscopic stability in the horizontal plane.

**5**. An aerodynamic disc-shaped VTOL aircraft as claimed in claims 1 to 4, which in forward horizontal flight generates a lift force resulting from the low pressure airflow over the trailing upper surface of the disc.

**6**. A VTOL aircraft as claimed in claims 1 to 5, having rotor intake covers which when closed prevent the inflow of air through the rotor-chamber thereby allowing the propellers to rotate in a partial vacuum.

**7**. A VTOL aircraft as claimed in claims 1 to 6, wherein aerodynamic control vanes are positioned in the airflow from the propellers within, or at the base of, a rotor-chamber to effect pitch roll and yaw control, as well as to generate an additional lift force; and wherein thrust deflecting flaps may be lowered from the underside of the craft.

**8**. A VTOL aircraft as claimed in claims 1 to 7, wherein a circular passenger compartment, as well as payload, fuel-tanks and weapon-bays are incorporated in the main circular body of the craft.

**9**. A VTOL aircraft as claimed in claims 1 to 8, wherein fuel tanks are incorporated around the circumference of the main body of the craft.

**10**. A VTOL aircraft as claimed in claims 1 to 9, which has a central flight-deck situated above central vertical and horizontal mounted engines.

**11**. A VTOL aircraft as claimed in claims 1 to 10, wherein the central engine frame can be detached from the main outer body of the craft.

**12**. A VTOL aircraft as claimed in claims 1 to 11, wherein the main body of the craft may contain gas buoyancy chambers.

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