The present invention relates broadly to means for rendering persons airborne, and is more particularly concerned with a turbo-fan lift device featuring maximum degree of simplicity, reliability and maneuverability.

There has long existed a need for lift means which would render combat personnel airborne for relatively short periods of time for such purposes as attack, observation or the like. Among the known devices conceived for these purposes are one-man helicopters the propeller of which is driven either by an internal combustion engine or blade tip thrust means, and flying platforms wherein the operator devices a directional change by moving the center of gravity away from the thrust means mounted on the platform under surface. Each of the mentioned and other lift means possess inherent disadvantages, and among the objections thereto are the lack of stability, danger to personnel, high degree of training required, and the difficulty of control during ascent, descent and hovering.

It is accordingly an important aim of the present invention to provide a novel lift device characterized by an absence therefrom of the deficiencies of known constructions.

Another object of the invention lies in the provision of a personnel lift device which is of relatively light weight and low cost, may be readily assembled and dis-assembled, and may be started with ease by the operator.

Another object of the invention is to provide new and improved lift means which imposes the maximum accelerations in both the vertical and horizontal, and which in addition to being highly reliable and maneuverable, contains no serious environmental limitations.

Still another object of the present invention is to provide a turbo-fan lift device which is inherently stable to thereby permit the use after relatively little instruction, normal descent if the operator is unable to employ the controls, and to permit operation by persons of varying weights.

A further object of this invention lies in the provision of lift means employing a tip-jet turbine utilizing compressed air and gasoline, the resultant force of which passes directly through the center of gravity of the lift means and operator, and in which the point of application of the force is above the center of gravity to produce a structure which is inherently easier to control.

A still further object of the invention is to provide lift means comprising a low pressure ratio, high mass flow compressor driven backward by a tip-jet turbine featuring in addition a magnitude of thrust force which is controlled by throttling fuel flow, and wherein the resultant force is pure thrust producing no reaction torque for which compensation must be made by auxiliary thrust devices.

Other objects and advantages of the present invention will become more apparent during the course of the following description, particularly when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

FIGURE 1 is an elevational view of the lift device of this invention, shown in mounted position upon the back of the operator;

FIGURE 2 is a side elevational view of the lift means similarly mounted, and illustrating in part the control means therefor;

FIGURE 3 is a detail view, with parts in section, showing the power package for the lift means of this invention;

FIGURE 4 is a sectional view taken substantially along the line IV—IV of FIGURE 3; and

FIGURE 5 is a diagrammatic view of the power plant, parts thereof being sectioned, and illustrating the air flow path through various portions of the power plant chambers.

Briefly stated, a thrust device constructed in accordance with the principles of this invention comprises a turbo-fan assembly to be mounted upon the back of the operator and provided with communicating compressor and turbine chambers. Fuel from one or more containers attached to the assembly is fed into combustion chambers surrounding the turbine, and the propulsive effort is directed downwardly through rotatable jet nozzles disposed outwardly of the sides of the operator's body. Rotation of the turbine derives a low pressure, high mass flow compressor which is mounted in back-to-back relation therewith. Rotation of the nozzles to provide a forward or rearward force component is effected by a hand control depending forwardly of the operator, and throttle means are embodied therein to regulate fuel flow and accordingly the magnitude of the thrust force. The invention incorporates other structural features, and these will be described in detail in the description now to follow.

Referring now to the drawings, and first to FIGURES 1 and 2 thereof, a turbo-fan lift device generally designated by the legend A comprises a power plant housing 16 supporting a compressed air container 11 and fuel container 12 by strap means 13—15, the housing further supporting in locations outboard of the operator's shoulders nozzles means 14 and 15 rotatable in a fore and aft direction by action of control means 16 and manipulated by the operator. The unit A is constructed to be mounted and carried upon the back of the operator generally centrally thereof, and strap means 17 formed to include connecting shoulder, waist and hip segments are provided for this purpose. The lift device is generally of all-metal construction, and is fabricated of materials having durability and lightness such that the maximum weight of the unit is 100 pounds with a full fuel supply.

The housing 10 mounts therein the preferred power plant, generally designated in FIGURES 3, 4 and 5 by the numeral 18 and comprising a low pressure ratio, high mass flow propulsion air compressor 19 driven backward by a tip-jet turbine or combustion air compressor 20 utilizing compressed air and a fuel which may be gasoline. Other ducted fan power plants are of course of possible application to the present invention, however, certain present objections lie in the use thereof. A small by-pass turbojet presents problems of weight, cost and complexity, while a monopropellant turbine driving a ducted fan, even when incorporating a mono fuel afterburning in the main airstream, has a high fuel consumption and weight requirement. Complexity, weight and cost are similarly the objections which presently dictate against the use of a reciprocating or free piston engine driving a ducted fan, as applied to flights of relatively short duration.

The compressor 19 comprises a volute casing 21 defining therewithin a compression chamber 22 in which rotates an impeller 23 provided with blades 24 and mounted for rotation upon a shaft 25. The shaft is journaled in bearing means 26 and 27, and one end of the shaft may be substantially enclosed by a fairing 28 attached to the walls of the housing 10. The housing 10 interiorly thereof further supports the compressor casing 21 by suitable mounting means 29. Between the compressed air and fuel con-
tainers 11 and 12 the housing 10 is apertured at 30 to provide an air inlet to the compressor chamber 22. The turbine 20 comprises a casing 31 of volute shape defining therewithin a chamber 32 within which rotates a turbine impeller 33 provided with blades 34, the impeller 33 being mounted upon the shaft 25 also supporting the compressor impeller 23. Communication between the compressor chamber 22 and turbine chamber 32 may be effected in any desired manner, and in FIGURE 4 a tubular connection 35 is employed for this purpose. However, it is of course contemplated that a suitable diffuser construction may be employed.

Located radially outwardly of the turbine impeller 33 and supported by the turbine 20 is a combustion ring member 36 defining a plurality of chambers 37 (FIGURE 3). A plurality of flame holders 38 are circumferentially spaced within the combustor ring 36 and suitable electrical connections are made to the flame holding means. To ignite the fuel injected into the combustion chambers 37, a spark plug 39 may be employed and electrical connections 40 from the spark plug may lead to a portable battery (not shown).

The shaft 25 is apertured along a portion of its length as indicated by the numeral 41 in FIGURE 4 to provide a fuel passage communicating with a plurality of radially extending fuel tubes 42 which terminate at their opposite ends in each of the combustion chambers 37. The fuel passage 41 communicates with a valve passage 43 with valve means 44 which may be of the needle valve type. Fuel is supplied to the valve means 44 through a line or connection 45 (FIGURE 1) leading to a shutoff valve 46 at one end of the fuel container 12. As appears also in FIGURE 1, the compressed air container 11 is provided with a shutoff valve 47 controlling the flow of air through a tubular connection 48 which passes into the housing 10 as seen in FIGURE 4, terminating in the turbine chamber 32. The function of the compressed air container 11 and connections leading therefrom is to provide a source of relatively high pressure air to initiate rotation of the turbine impeller 33 prior to fuel ignition taking place in the combustion chambers 37. It is immediately apparent that other means may be employed to initially start the turbine, and a battery driven motor is an illustrative substitute for the compressed air supply 11. In the latter instance, the container 11 may then house an additional quantity of fuel, and connections may be made therefrom in the manner of the container 12.

The valve means 44 and accordingly the fuel supply to the combustion chambers is controlled by an axially moveable stem or rod member 49 received at one end in the valve means 44 and at the opposite end in a manifold member 50. Within the member 50 the stem 49 may be connected with suitable cable means running the length of the control means 16 and tightened or relaxed upon turning of a throttle handle 51 at one end of the control member 16. It may now be seen that rotation of the grip 51

4. to provide positive assurance that the fuel supply will not be exhausted at high altitudes and an unsafe descent result therefrom. A safety feature for this purpose may be directed to a shutoff automatically actuated by a position at which the thrust balances weight, unless the operator gives a command to the contrary. The altitude above ground level may be sensed by a relatively simple bourdon tube alimeter, set to 0 reading prior to takeoff. The amount of fuel remaining in the tank or tanks may be sensed by a gauge, actuated by the gas pressure on the fuel tank. This is reset prior to takeoff to compensate for gas pressure variation due to fluctuations in the daily temperature. Knowing the thrust specific fuel consumption of the lift device, a simple relation is obtained for the amount of fuel required to accomplish a descent at a safe rate from any altitude. If the indication from the fuel gauge is too low in comparison to the altitude, the fuel flow is automatically restricted to reduce thrust and initiate a controlled descent. A warning signal may also be sounded to warn the operator of the dangerous condition.

The control handle 16 is of tubular construction as earlier indicated and is bent into a generally U-shaped configuration as shown. The end of the control handle 16 opposite the throttle grip 51 makes a rigid connection in the manifold means 50 with a longitudinal or horizontal handle portion 52 from which downwardly depends a number of radial or lateral portions 53 which are tapered at their ends as designated by the numeral 54. The tapered ends are received between a pair of upstanding lugs 55 welded or otherwise secured to each of the jet nozzles 14 and 15. The jet nozzles at their inner ends are provided with formed flange portions 56 received in a bearing 57 on the open opposite ends of the housing 10. The nozzles 14 and 15 are thereby mounted for rotative swivel movement with respect to the housing 10, and it is to be seen that upon upward movement of the handle 16 by the operator the horizontal portion 52 pivots within the manifold means 50 to swing the flange portions 56 clockwise into contact with the forward lugs 55 and effect rearward rotative movement of the jet nozzles 14 and 15.

To operate the turbo-fan lift device A, counterclockwise rotation of the turbine impeller 33 is initially effected by bleeding compressed air from the container 11 through the connection 48 to the turbine chamber 32. After rotation of the impeller 33 is initiated in the manner described, or by use of an electric motor or equivalent means, fuel is fed into the combustion chambers 37 by turning the throttle handle 51, and by means of the igniter 39 combustion of the fuel is effected. Rotation of the turbine impeller 33 then proceeds, driving the compressor impeller 23, which compresses air received through the intakes 30 and compressed air from the chamber 22 is directed through the connection 35 to the turbine chamber 32. The combustion of the fuel-compressed air mixture produces gaseous products which are ejected from the combustion chambers 37 through the nozzles 14 and 15, the combustion effort further driving the compressor impeller 23 to maintain a complete cycle until fuel exhaustion takes place or the fuel supply is shut off. While particular combinations will of course produce different resulting forces from the turbine 20 of the lift device A draws approximately five pounds per second of air, gasoline is burned in the tip combustion chambers to a temperature of approximately 1500°F., and the air ejected through the nozzles 14 and 15 at 1800 f.p.s. develops about 225 H.P., to drive the compressor 19. Further, the tip speed is about 1100 f.p.s., and the residual jet velocity is recovered in a diffuser and mixed with the main air from the inlet 30 for maximum propulsive efficiency. A turbo-fan lift device of the character herein disclosed has a design speed of about 1400 r.p.m., the propulsive efficiency of the tip-jet turbine is 70% and the specific impulse of the unit is 3500 sec.
Numerous mathematical computations have been made which demonstrate the operational features of the lift device, and these calculations are set forth below.

Total air flow = 20#/sec.
Combustion air = 5#/sec.
Thrust = 350#

Required \( V_{\text{tip}} = \frac{350 \times 32.2}{20} = 565 \text{ f.p.s.} \)

Ideal pwr. required = \( \frac{15 \times 565}{2 \times 32.2} = 135 \text{ H.P.} \)

For \( \eta = 60\% \) (\( \eta_{0} = 70, \ \eta_{n} = 90 \))

Actual pwr. = \( \frac{135}{0.6} = 225 \text{ H.P.} \)

Required tip-jet pwr. = \( \frac{225}{5} = 45 \text{ H.P.} / \text{f.p.s.} / \text{sec.} \)

\( V_{\text{n}} = \frac{1100}{32.2 \times 550} = 0.6 \text{ for 1000 f.p.s. tip speed} \)

For 1500° F. jet-tip inlet temperature

\[ 1825 = [2p_{\text{in}} + (1 - (\text{P.R.})^{0.66})]^{0.5} \]

Combustor P.R. = \( \left[ \frac{1 - 1800}{12075 \times 1960} \right]^{0.5} = 0.596 \)

Main nozzle P.R. = \( \left[ \frac{1 - 565}{12075 \times 1960} \right]^{0.5} = 0.907 \)

Check main nozzle temperature

\[ 224 \times 550, 5 \times 1000 + 2 \times 32.2 \times 778 = 778 \times 778 = 650, 5 \times 1000 - 2 \]

\[ 24 \times 1500 - 100 = 20 \times 24 \times 0.9 = 503 \text{° F.} \]

Check P.R. for 1100 f.p.s. tip speed

Ideal P. R. available = \( \left[ \frac{1 - 1100}{12025 \times 560} \right]^{0.5} = 0.5 \)

Thus, 20% pressure drop is tolerable.

Check fuel flow rate

\[ 5 \times 24 \times 1500 - 100 = 0.9 \times 18,500 + 1100 \]

\[ W_{f} = \frac{60 \times 1660}{0.9 \times 18,500} = 66 \text{#/min. on gasoline} \]

It is to be seen that simplicity, reliability and maneuverability are among the most important features of the turbo-fan lift device of this invention. Use of a pair of jets, one to each side of the operator or passenger, gives a resultant force which passes directly through the center of gravity. Placing the point of application of this force well above the center of gravity produces a configuration which is inherently easier to control for the flexible linkage system consisting of man and machine. As disclosed herein, the unit A mounts directly on the back of the operator with a separate jet located just outboard of each shoulder. Simultaneous rotation of the jet nozzles 14 and 15 in the fore or aft direction gives a forward or rearward component to the force, to accelerate and maintain forward flight or to quickly deaccelerate. The magnitude of the thrust force determines if the operator rises or descends, and this variable is accurately and simply controlled by throttling the fuel flow as noted hereinabove, an additional safety feature may be provided in the form of a fuel supply signal and an altitude signal which are compared. Further, by spring loading the control handles 54, an automatic fuel flow restriction system is initiated and a controlled descent effected if the altitude becomes dangerously high in relation to the remaining fuel supply.

A particular advantage of the disclosed configuration is that the resultant force is a pure thrust which produces no reaction torque which must be compensated for by auxiliary thrust devices, as is the case with a motor driven helicopter. By suspending the operator between a pair of jets, it is seen that contact between hot exhaust gases and the operator is avoided. If forward or rearward flight is desired, the two jets are simultaneously rotated to produce a component of the thrust in the appropriate direction and a steady lateral motion is obtained as the drag force becomes equal to the lateral component of thrust. It is of course within the contemplation of this invention that the thrust of the two jets be differentially controlled to allow a rolling motion to be produced for a subsequent climb or a descent. A spin of the operator about his own vertical axis is thereby easily produced, and he may then either quickly turn right or left or completely reverse his direction. Differential control of the jet nozzles 14 and 15 is readily effected by minor modifications to the control means 16.

A turbo-fan lift device embodying the principles of this invention operates with substantial effectiveness with payloads varying between 150 and 225 pounds. As specific examples of certain characteristics of the present device, an illustrative embodiment weighs no more than 100 pounds and has a maximum altitude of 5000 feet and a service ceiling of 500 feet. The duration of flight is approximately one minute and the maximum cruise speeds are about 20 miles per hour and 5 miles per hour, respectively. The maximum acceleration in a vertical direction is 0.1 g, and in the horizontal 0.2 g. Time to rotate 360° when hovering is about 5 seconds, and the same length of time characterizes the time to reach full power. Disassembly and assembly of the unit requires not more than 30 seconds, and the propellant employed presents no storage life problems. The device A is operable at temperatures between minus 65° and plus 125° F., and no particular shock or vibration problems are presented.

It is to be understood that variations and modifications may be effected in the structures herein disclosed without departing from the novel concepts of the invention.

We claim as our invention:

1. A lift device for rendering persons airborne, comprising a housing to be mounted upon the back of the person, a turbo-fan power plant supported within said housing, a fuel container connected to said housing, means for supplying fuel from said container to said power plant, nozzle means communicating with said power plant and mounted by said housing for swivel movement thereon, and control means manually operable by the operator for regulating the flow of fuel to said power plant and to said swivel nozzle means to control the direction of thrust during ascent or descent.

2. A lift device for rendering persons airborne, which comprises a housing constructed to be mounted upon the back of the person, a high mass flow compressor and a turbine driving said compressor and supported in said housing, means connected to said turbine and providing a combustion chamber also in said housing, a fuel container carried by the housing, nozzles mounted for swivel movement at opposite ends of the housing and in communication with the combustion chamber, means for supplying fuel from said container to the combustion chamber, means for igniting fuel in the combustion chamber, the combustion products being directed outwardly and downwardly through the nozzles providing thrust to
lift the device and person mounting the same and means under control of the person to regulate the fuel supply to the combustion chamber and to swirl the nozzles to control the direction of thrust during ascent or descent.

3. A lift device for rendering persons airborne, which comprises a housing constructed to be mounted upon the back of the person, a central shaft journaled in said housing, a compressor and turbine supported in back-to-back relation on said shaft with the compressor axis perpendicular to the vertical axis of the person, the housing being generally centrally apertured to provide an air inlet to the compressor, means connected to said turbine and providing a combustion chamber also in said housing, a fuel container carried by the housing, nozzles mounted by the housing for swivel movement at opposite ends of said housing and in communication with the combustion chamber, means for supplying fuel from said container to the combustion chamber, and control means hand manipulable by the person to regulate the fuel supply to the combustion chamber and to swirl the nozzles to control the direction of thrust during ascent or descent.

4. A lift device for rendering persons airborne, which comprises a housing constructed to be mounted upon the back of the person, a central shaft journaled in said housing, a compressor and turbine supported in back-to-back relation on said shaft with the compressor axis perpendicular to the vertical axis of the person, a combustion ring connecting with the turbine and providing a plurality of combustion chambers radially outwardly thereof, a fuel container carried by the housing nozzles mounted by said housing for swivel movement at opposite ends of said housing and in communication with the combustion chamber, and means for supplying fuel from said container to the combustion chamber, control means hand manipulable by the person to regulate the fuel supply to the combustion chamber and to swirl the nozzles to control the direction of thrust during ascent or descent.

5. A lift device for rendering persons airborne, which comprises a housing constructed to be mounted upon the back of the person, a central shaft journaled in said housing, a compressor and turbine supported in back-to-back relation on said shaft with the compressor axis perpendicular to the vertical axis of the person, a combustion ring connecting with the turbine and providing a plurality of combustion chambers radially outwardly thereof, a plurality of radially extending fuel supply tubes communicating at one end with the combustion chambers, the shaft being apertured to provide a fuel passage communicating with the opposite ends of the supply tubes, a fuel container mounted by the housing and connected to said opposite ends of the supply tubes to supply fuel to said combustion chamber, jet nozzles mounted by said housing for swivel movement at opposite ends of said housing outwardly of the person's shoulders, and a control handle operable by the person to regulate the fuel supply to the combustion chambers and to swirl the nozzles fore or aft to control the direction of thrust during ascent or descent.

6. A personnel lift unit for relatively short duration flights, comprising a housing to be carried upon the person's back, the interior of said housing defining communicating volute compressor and turbine chambers, shaft means in each of said chambers and impeller means on each shaft means providing a compressor impeller and turbine impeller, a plurality of connecting combustion chambers supported by the turbine impeller and circumferentially surrounding the same, nozzle means communicating with said combustion chambers and connected to said housing, a fuel supply container on said housing connecting with the combustion chambers, ignition means in the combustion chambers, and means under control of the person to regulate the fuel supply to the combustion chambers and to swirl the nozzle means to control the direction of thrust during ascent or descent, the combustion products being directed downwardly through said nozzle means and outwardly to said person's shoulders and providing a resultant force passing directly through his center of gravity.

7. A personnel lift unit for relatively short duration flights, comprising a housing to be carried upon the person's back, the interior of said housing defining communicating volute compressor and turbine chambers, shaft means in each of said chambers and impeller means on each shaft means providing a compressor impeller and turbine impeller, a plurality of connecting combustion chambers supported by the turbine impeller, a fuel supply container on said housing connecting with the combustion chambers, a pair of jet nozzles in communication with said combustion chambers mounted on opposite ends of the housing outwardly of the person's shoulders and rotatable under the person's control to provide either a forward or rearward force component, and ignition means in the combustion chambers, the combustion products being directed outwardly from each jet nozzle and providing a resultant force passing directly through the person's center of gravity.

8. A personnel lift unit for relatively short duration flights, comprising a housing to be carried upon the person's back, the interior of said housing defining communicating volute compressor and turbine chambers, shaft means in each of said chambers and impeller means on each shaft means providing a compressor impeller and turbine impeller, a plurality of connecting combustion chambers spaced from the housing and mounted by the turbine impeller in circumferentially surrounding relation therewith, a fuel supply container on said housing connecting with the combustion chambers, a pair of jet nozzles in communication with said combustion chambers mounted at opposite ends of the housing outwardly of the person's shoulders and rotatable under the person's control to provide either a forward or rearward force component, ignition means in the combustion chambers, and a control handle depending forwardly of the person and pivotally mounted on the housing and effective upon vertical movement to rotate the nozzle fore and aft, the combustion products being directed outwardly from each jet nozzle and providing a resultant force passing directly through the person's center of gravity.

9. A personnel lift unit for relatively short duration flights, comprising a housing to be carried upon the person's back, the interior of said housing defining communicating volute compressor and turbine chambers, shaft means in each of said chambers and impeller means on each shaft means providing a compressor impeller and turbine impeller, a plurality of connecting combustion chambers spaced from the housing and mounted by the turbine impeller in circumferentially surrounding relation therewith, a fuel supply container on said housing connecting with the combustion chambers, a pair of jet nozzles in communication with said combustion chambers mounted at opposite ends of the housing outwardly of the person's shoulders and rotatable under the person's control to provide either a forward or rearward force component, ignition means in the combustion chambers, a control handle depending forwardly of the person and pivotally mounted on the housing and effective upon vertical movement to rotate the nozzle fore and aft, the combustion products being directed outwardly from each jet nozzle and providing a resultant force passing directly through the person's center of gravity, a plurality of radially extending fuel lines opening into the combustion chambers, fuel supply valve means connecting with the fuel supply and fuel lines, and throttle means on the control handle effective to regulate the flow of fuel through the valve means to the combustion chambers and thereby control the rate of ascent or descent.

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