March 9, 1954 C. F. ROCHEVILLE 2,671,315

INTERNAL-COMBUSTION GEARED TURBINE

Filed Nov. 12, 1948 3 Sheets-Sheet 1

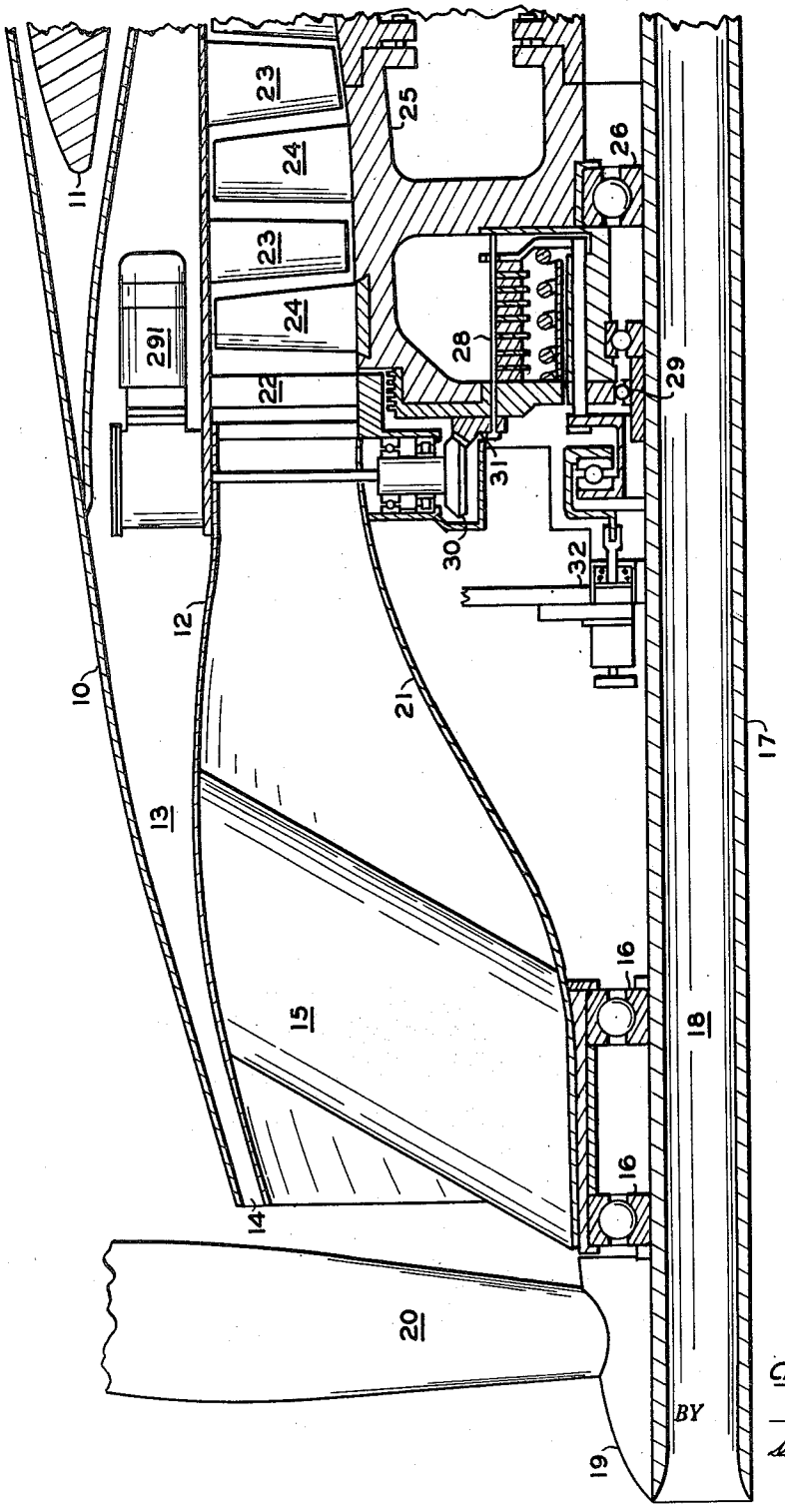


FIG. 1

INVENTOR.
Charles F. Rocheville
BY
J. Madarus
Walter G. Miller
ATTORNEYS

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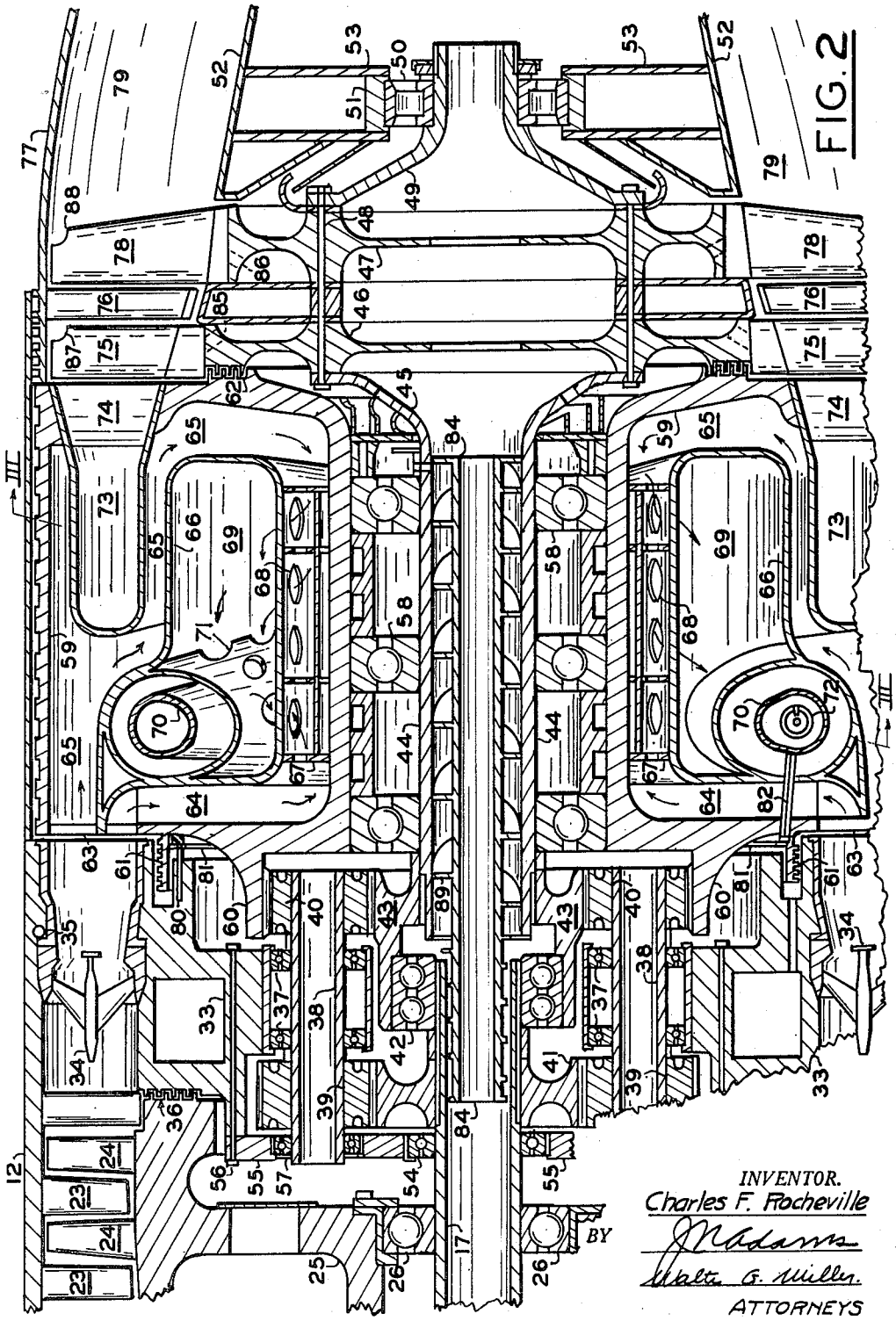


FIG. 2

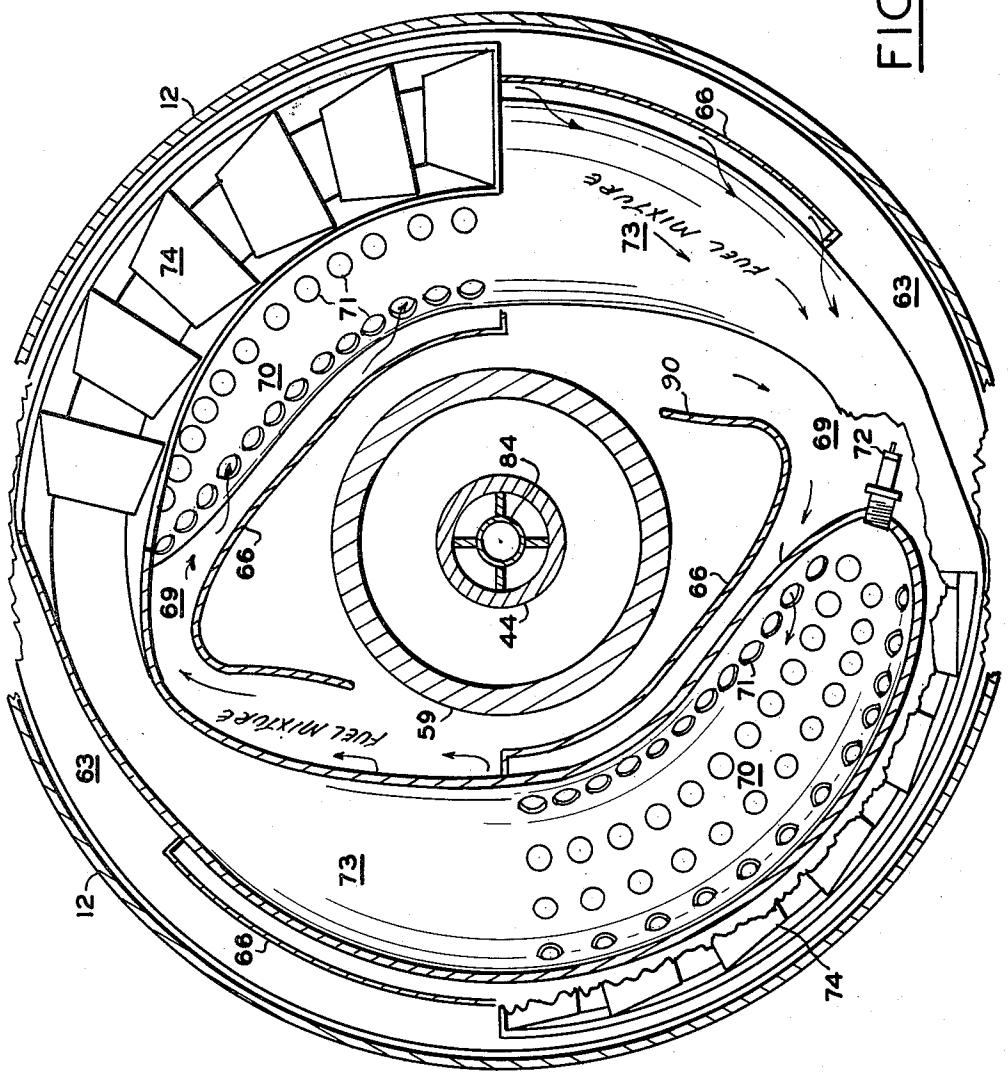
INVENTOR.
Charles F. Rocheville
BY
Adams
Walter G. Miller.
ATTORNEYS

March 9, 1954 C. F. ROCHEVILLE 2,671,315

INTERNAL-COMBUSTION GEARED TURBINE

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FIG. 3



INVENTOR.
Charles F. Rocheville
BY
Walter G. Miller.
ATTORNEYS

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INTERNAL-COMBUSTION GEARED TURBINE

Charles F. Rocheville, Long Beach, Calif., assignor to Rocheville Engineering, Inc., Bellflower, Calif., a corporation of Nevada

Application November 12, 1948, Serial No. 59,496

7 Claims. (Cl. 60—39.35)

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This invention is directed to internal combustion turbine engines for aircraft, and particularly refers to an improved arrangement in which a plurality of fuel burners and combustion chambers are disposed in a rotor with their longitudinal axes substantially in the plane of rotation at right angles to the axis of the turbine, and are arcuately positioned in helically overlapping relation to discharge combustion products tangentially to induce rotation by reaction, the rotor being positively geared to counter-rotating vaned turbine wheels which receive the combustion products to be rotated thereby, both rotating elements being adapted to drive a propeller shaft. Desirably, but not necessarily, clutch provisions and free-wheeling means for driving air compressing means may be included.

It is an object of this invention to provide a construction of the nature set forth which will permit high relative speed of the combustion gas driven counter-rotating elements, with a substantially lower speed of the propeller drive shaft.

Another object is to provide an improved arrangement of the burner and combustion chambers of a turbine of this type, to give a relatively long path for combustion to take place, in a structure of relatively short axial length.

Another object is to provide an improved arrangement of stationary fuel-air nozzles around the periphery of the turbine, said nozzles feeding continuously into a heat exchange passage and thence into a perforated burner tube to initiate combustion, which is subsequently substantially completed in a combustion chamber.

Another object is to provide an improved arrangement of gearing and lubricating means for a turbine unit of this type.

Another object is to provide an improved control means for the air compressing means of a turbine of this type, that can be selectively connected to furnish air for combustion at air speeds below that which "ram-jet" action occurs, and may be disconnected from the power unit at speeds where air compression is not required to consume the fuel at the desired rate.

These and other objects and advantages of the invention will be further apparent from the following description and the attached drawings, which form a part of this specification, and illustrate a preferred embodiment as applied to an aircraft engine.

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In the drawings, Figure 1 is a longitudinal part sectional view of the upper half of the forward or compressor section of the engine of this example, and illustrates a preferred arrangement of starter, clutch and free-wheeling means. Figure 2 is a rearward continuation view of the central part of the arrangement of Figure 1, also in longitudinal and substantially complete cross section, illustrating the gearing, combustion chambers and turbine elements. Figure 3 is a diagrammatic and somewhat simplified transverse sectional view taken on line III—III of Figure 2, looking forward and taken substantially in the plane of the longitudinal axis of one of the two combustion chambers, showing the helically overlapping arrangement of the said chambers.

Referring to Figure 1, reference numeral 10 designates a generally cylindrical metal outer casing for the engine unit, which may be faired into the wing structure 11 of an airplane. An inner metal housing 12 is suitably spaced and supported from the outer casing and forms an annular passage 13, open at its forward end to admit cooling air for the housing and some engine parts to be described below. Extending inwardly from inner housing 12 are a plurality of struts 15 to support bearing 16 for the forward end of propeller shaft 17, the latter desirably being hollow as at 18 to admit cooling air. A conventional propeller spinner or hub 19 supporting propeller blades 20 is secured to the outer end of shaft 17.

A generally conical air guide or ram-jet cone 21 extends from the forward end of bearing 16 to a set of stationary guide vanes 22 at the inlet of a multi-stage air compressor formed by a plurality of rows of inwardly directed stationary vanes 23 and outwardly directed rotating vanes 24, the latter supported on compressor rotor 25 turning on bearings 26 and adapted to be selectively driven from shaft 17 through clutch 28 and free-wheeling means 29 which may be a conventional arrangement of spring-controlled balls on inclined wedges, so arranged that when more power is required than for idling or gliding, the increased speed of rotation of the gas actuated power elements to be described below will engage the free-wheeling means and drive the compressor rotor to give the desired air flow to the combustion chamber. Upon reaching air speeds in

the neighborhood of 400 M. P. H., the "ram-jet" action of the air intake between 12 and 21 will be adequate for air supply, whereupon clutch 28 may be disengaged, leaving the air compressor rotor to idle or "windmill." In this example a starting motor 291 is provided to drive the propeller shaft 17 through the medium of gears 30 and 31. The clutch control means generally designated 32 may be of the conventional hydraulic type.

Referring to the main section of the turbine engine, and particularly to Figure 2, there is illustrated the after end of compressor rotor 25, supported at this point on shaft 17 by bearing 26. A stationary spider 33 is secured within housing 12 and supports a plurality of circumferentially spaced air-fuel mixing nozzles 34, supplied with liquid fuel such as gasoline, kerosene or fuel oil through a conduit or passage 35, which may surround housing 12, and be connected to any desired type of pressure feed system, not shown. The forward face of spider 33 and the after face of compressor rotor 25 are desirably provided with sealing means, such as the labyrinth of interengaging grooves and lands 36, to prevent undue leakage of fluids at this point.

Stationary spider 33 also serves to support bearings 37 for a plurality of circumferentially spaced hollow shafts 38, each shaft supporting at its forward end a first planet gear 39, and supporting at its after end a second planet gear 40. At the rear end of propeller shaft 17 is keyed a sun gear 41, adapted to engage and be driven by the forward planet gear 39. On the rearmost portion of shaft 17 is supported a bearing 42 for the forward extension of a second sun gear 43, the latter also being keyed to the forward end of a hollow turbine shaft 44, which extends rearwardly to a flange 45, onto the rim of which turbine wheels 46 and 47 are secured by a plurality of circumferentially spaced through bolts 48. In this example, only two turbine wheels are illustrated, but it is obvious that any desired number could be employed. A flanged sleeve 49 is secured by bolts 48 to the rearmost wheel of the series, and is supported by a bearing 50, which is mounted in ring 51, the latter spaced inwardly from the stationary exhaust cone 52 by a plurality of radial struts 53.

In this manner, there is provided a turbine shaft 44, supported at its forward end by bearing 42 which is mounted on the rearmost end of propeller shaft 17, through the axially elongated annular sun gear 43, and supported at its after end by bearing 50, through the medium of the turbine wheels 46 and 47 and flanged members 45 and 49. A supplemental bearing for the after end of propeller shaft 17 may be installed at 54, this bearing being supported by a plate 55 secured to the forward face of the stationary spider 33 by through bolts 56, and also acting as a support for the forward ends of shafts 38 through the medium of bearings 57.

A plurality of bearings 58 on turbine shaft 44 serves to support a generally cylindrical hollow combustion chamber rotor 59, which is positioned between the after face of stationary spider 33 and the forward face of turbine wheel 46. An annular flange 60 projects forwardly from the front of rotor 59, and is provided with internal gear teeth to engage the after planet gears 40. This arrangement, whereby sun gear 43 on turbine shaft 44 engages planet gears 40 at their inner pitch circle, and the teeth of annular flange gear 60 engages the same gears 40 at their outer pitch circle, insures that the turbine shaft 44 and the turbine wheels 46 and 47 carried thereby, will rotate in the opposite direction from the combustion chamber rotor 59, for reasons which will be further apparent below. Desirably, the forward face of combustion chamber rotor 59 is sealed from stationary spider 33 by means such as the grooved labyrinth 61, and the after face of rotor 59 is sealed from the turbine wheel 46 by means such as the interengaging grooves and lands 62.

The forward face of rotor 59 is provided adjacent its periphery with an annular opening 63, extending substantially throughout its circumference, whereby the fuel-air mixture from the nozzles 34 may enter the interior passages 64 and 65 of the rotor. These passages are formed by symmetrical annular metal housings 66 supported within the rotor by ported rings 67, the housings being generally rectangular in cross-section, with an enlarged entrance scoop 90 (Figure 3) and, in addition, similarly ported as at 68 (Figure 2) to permit the fuel-air combustible mixture, after it is heated by the means to be described below, to pass into the spaces 69 within the housings and thence into the circumferentially arranged burner tubes 70 (Figure 3) which lie in helically overlapping relation within the housings 66 and rotor 59. In this example, only two of such housings and tubes are illustrated, and the transverse section of rotor 59 in Figure 3, which illustrates diagrammatically how they are disposed, has been somewhat simplified to facilitate this description. Obviously, if additional burners are desired, they would be symmetrically arranged in similar helically overlapping relation within the rotor. Desirably, but not necessarily, the inlets and outlets of rotor 59 are at the same distance from the axis of its rotation, thus reducing the diameter of the unit, and facilitating its construction and maintenance.

Referring to Figure 3, it will be noted that the fuel-air mixture from space 69 enters the burner tubes 70 through the ports 71, to be ignited by means such as the spark plug 72, the latter supplied by high voltage electric current by means which will be described below. After the combustion is initiated in burner tube 70, the heated gases pass into the combustion chamber or space designated 73, where expansion takes place to give a high velocity to the gases, which are then directed out of the discharge end of the combustion space by vanes 74 to impinge against the blades 75 of the first wheel 46 or stage of the turbine element of the unit (Figure 2). After leaving that stage, the gases are straightened by stationary vanes 76, the latter supported by the after extension 77 of housing 12, and are directed into the vanes 78 of the second wheel 47 or stage of the turbine element of the engine unit. In this example, where only two such stages are illustrated, the exhaust gas, from which the greater part of the energy has been abstracted by the turbine vanes, emerges into the exhaust passage 79 formed between the housing extension 77 and exhaust cone 52, to be released to the atmosphere, where it may impart added energy to the airplane by its reaction as a jet.

The helically overlapping arrangement of the housings 66, burner tubes 70 and combustion chambers 73, with the surrounding passages 64 and 65, insure a maximum heat transfer from these highly heated surfaces to the incoming fuel-air mixture, thus serving to cool the parts below those temperatures at which damage would occur and also adding heat energy to the combustible

mixture and increasing the overall efficiency of the turbine engine. From Figure 2 it is apparent that the last-named mixture divides, as it enters the rotor, part of it going into passages 64 and the remainder of it into passages 65 to circulate within the rotor as indicated by the arrows and finally to merge again as it passes through ports 68 into spaces 69 inside housings 66. From those spaces the now-heated fuel-air mixture enters the burner tubes 70 of the next circumferentially adjacent housings 66, as best shown schematically in Figure 3. The materials of these parts are desirably of heat-resistant alloy, such as an alloy of chromium, iron and molybdenum.

After the turbine engine is once in operation, it will not ordinarily be necessary to continue the supply of high tension electric current to spark plugs 72, but for starting, and for reignition the current is transmitted from any suitable source through a brush 80 (Figure 2) to an insulated annular metal collector ring 81 on the forward face of combustion chamber rotor 59. An insulated lead 82 extends from ring 81 to the terminal of each spark plug 72.

As stated above, the propeller shaft 17 is desirably hollow throughout its length. In this example a sleeve 84 is mounted within the turbine shaft 44, and extends within but is spaced from the bore 18 of propeller shaft 17. This not only serves to conduct cooling air into the turbine shaft, to cool its bearings 50 and 58, but also supplies cooling air to the turbine wheels 46 and 47, which may be ported as at 85 and 86, respectively, to admit air to the hollow vanes or blades 75 and 78, from which it escapes into exhaust passage 79 through notches 87 and 88 in the trailing edges of the blades. Sleeve 84 also serves to conduct lubricant from the gear and bearing space within the stationary spider 33 through the helical passage formed by blades 89 to bearings 58.

In those applications of this invention which are not carried out in a structure, such as an airplane, which moves relatively to the air used for combustion, the clutch means 28 would ordinarily not be required as the compressor rotor 25 would operate at all times that the power shaft 17 is rotated. Similarly, circumstances might also be encountered wherein the free-wheeling means 29 could be omitted, as will be obvious to those skilled in the art.

In conclusion, it will be appreciated from the foregoing description that this invention comprehends broadly the combination, in an internal combustion turbine engine, of rotating burner tubes and combustion chambers operating by the reaction of gases and discharging into vaned turbine elements, said chambers and elements being positively and compactly geared to rotate in opposite directions and to jointly drive a single shaft at a lower speed than that at which either rotates to deliver useful power, for example, to an airplane propeller. It includes also the circumferential helically overlapping arrangement for the housings, burner tubes and combustion chambers with preheating and heat transfer passages for the fuel-air mixture. Although a single embodiment is described and illustrated as applied to an aircraft engine, it is obvious that numerous modifications and changes could be made in its construction and application to other uses without departing from the essential features of the invention, and all such as fall within the scope of the appended claims are understood to be embraced thereby.

I claim:

1. In combination in an internal combustion turbine engine, a rotor supporting a plurality of combustion chambers, means for supplying a combustible mixture to said chambers, at least one turbine wheel for receiving products of combustion from all of said chambers, a power shaft coaxial with said rotor, and direction reversing gear means separately connecting said shaft to said rotor and said turbine wheel to rotate them in opposite directions to deliver power to said shaft.

2. A combination according to claim 1, in which said combustion chambers are arcuately disposed in helically overlapping relation around said rotor.

3. A combination according to claim 1, with the addition of a rotatable air compressor means surrounding said shaft, and means for selectively connecting said compressor means to said shaft.

4. In combination in an internal combustion turbine engine, a plurality of circumferentially arranged fuel-air nozzles, axial flow means for supplying air to said nozzles, a rotor having an annular inlet for continuously receiving a combustible mixture from said nozzles, a plurality of helically arranged burner tubes and combustion chambers in said rotor, a vaned turbine wheel for continuously receiving heated gases from said combustion chambers, a power shaft, and gear means connecting said rotor and said turbine wheel to rotate in opposite directions, and to rotate said power shaft.

5. A combination according to claim 4, with the addition of a housing in said rotor for said tubes and chambers forming passages to conduct said combustible mixture in heat exchange relation thereto prior to its introduction into said burner tubes.

6. In combination in an internal combustion turbine engine having an annular air passage and a plurality of fuel-air mixing nozzles at the end of said passage, a rotor adjacent the end of said passage having an annular inlet for combustible mixtures in one end face, a plurality of heat exchange housings in said rotor in helically overlapping relation, a perforated burner tube communicating with and contained in each of said housings, ignition means in each of said tubes, a combustion passage leading from each of said tubes, means for passing said combustible mixture from said annular inlet first through said housings, around said combustion passages to be heated thereby, and then into said burner tubes to be ignited therein, and a combustion gas outlet for each said passage in the opposite end face of said rotor.

7. A combustible mixture igniting and consuming means for an internal combustion engine having a turbine element to receive the products of combustion from said means, comprising a rotor having opposed axially spaced faces, an annular passage formed in one of said faces, a plurality of circularly disposed helically overlapping housings in said rotor for continuously receiving a combustible mixture from said passage, a perforated burner tube in each of said housings, an enclosed combustion chamber for each of said burner tubes, an outlet for each of said combustion chambers, each of said housings adapted continuously to conduct a portion of said combustible mixture in heat exchange rela-

tion with its associated combustion chamber and direct said portion of said combustible mixture to a succeeding housing and burner tube to be ignited therein.

CHARLES F. ROCHEVILLE.

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