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COMBUSTION GAS AND STEAM TURBINE ARRANGEMENT

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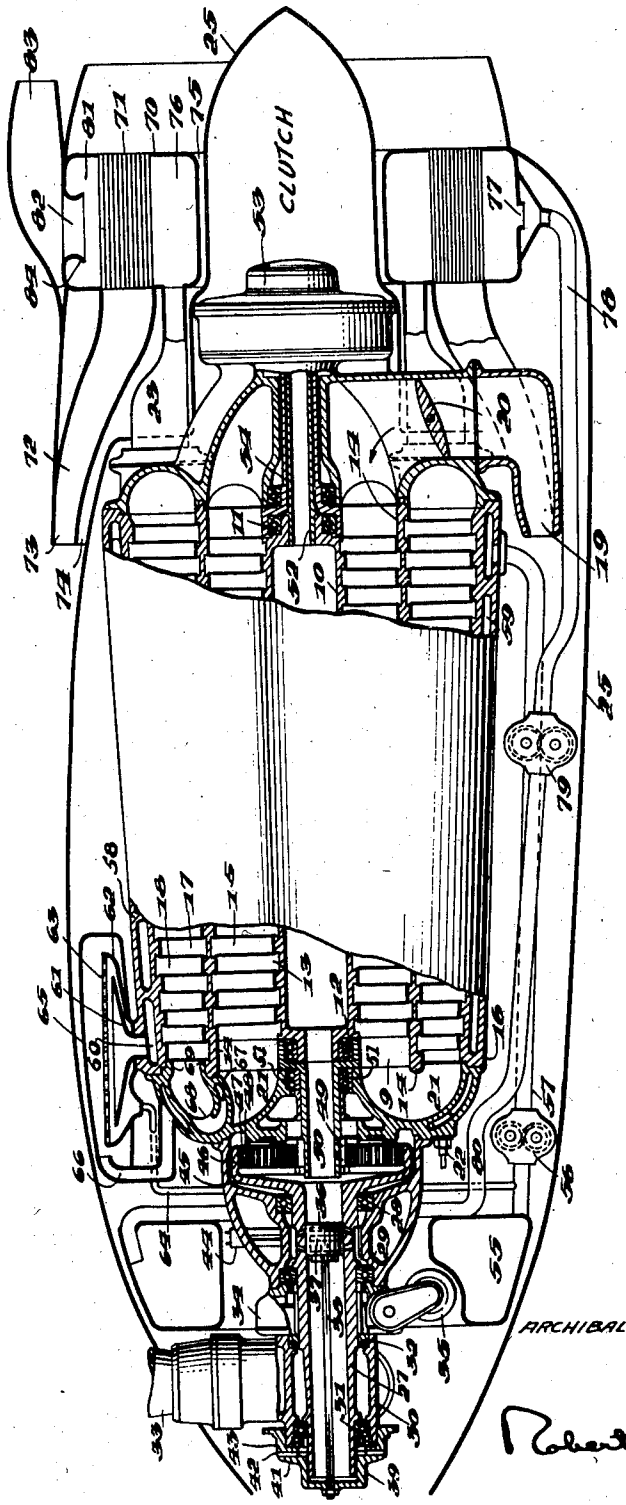

Fig. 1.

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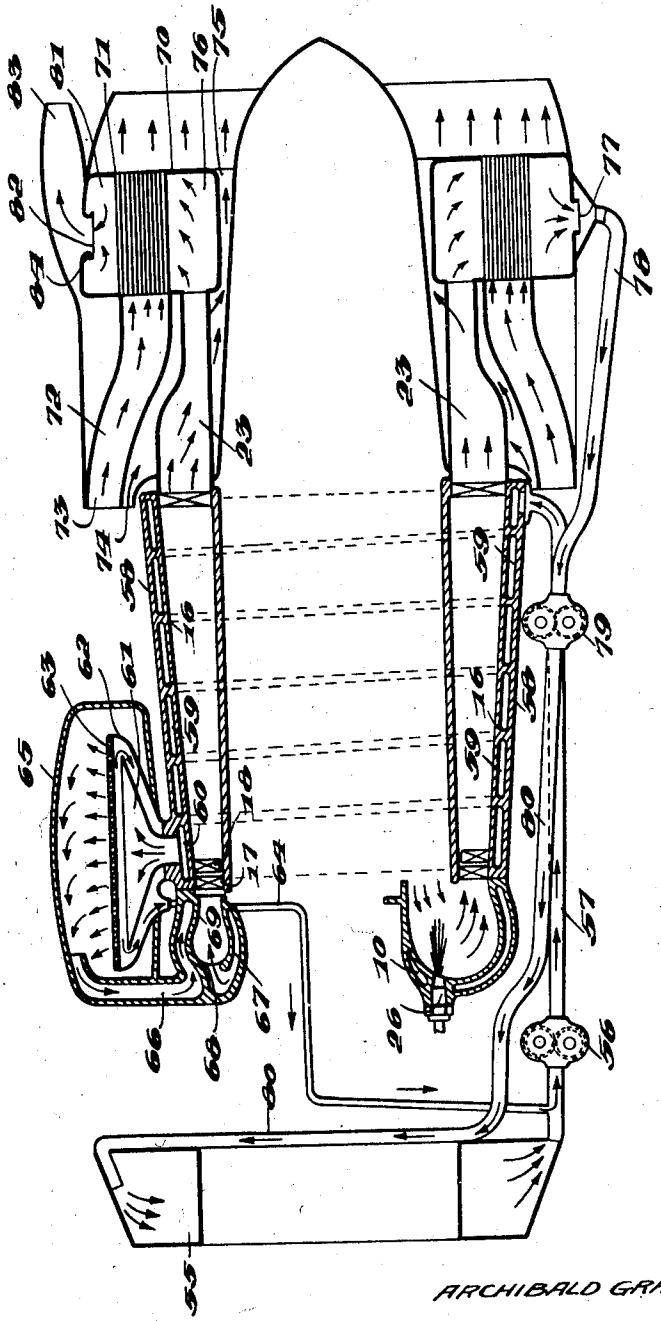
Filed Dec. 13, 1944 2 Sheets-Sheet 2

Fig. 2.



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COMBUSTION GAS AND STEAM TURBINE ARRANGEMENT

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1 Claim. (Cl. 60—49)

1

This invention relates to turbines of the type used as prime movers in self propelled vehicles, and more particularly for use in aircraft. The invention has particular reference to turbines driven by products of combustion and to means for rendering such turbines more efficient. More explicitly, the invention includes a water cooling jacket for the turbine so arranged that the cooling water in its path of travel is highly heated and converted into steam and means are provided to superheat such steam and cause it to impinge upon the turbine blades to assist in driving and cooling the same. Both the steam and water vapors created by combustion and present in the products of combustion are then condensed to water and the water reused.

It is a general object of the invention to provide an arrangement which will accomplish such aims. In accordance with the invention the water of the cooling jacket is thus put to an additional use in the form of steam under pressure.

The invention has for a further object the provision in such a system of means for extracting water from the exhaust gases which drive the turbine after such gases have passed through the turbine and for condensing water from the steam formed in the water jacket after the steam has performed its work on the turbine blades, such extracted and condensed water being added to the water supply for the cooling system.

Still another object of the invention resides in effecting such objects in a compressor-turbine system in which the compressor and turbine are mounted coaxially and with the turbine surrounding the compressor.

These and other objects of the invention will become more apparent from the following description and claim when read in conjunction with the accompanying drawings in which:

Figure 1 is a longitudinal sectional view through a compressor-turbine arrangement in which the invention has been incorporated, portions of the device being shown in elevation for purposes of simplification, and

Figure 2 is a diagrammatic view of the invention, showing the circuit paths of the exhaust gases, steam and water.

While the invention, as will be later appreciated, can be applied to various types of turbines, it has here been illustrated and will be described as applied to a compressor-turbine arrangement in which the compressor and turbine are coaxially mounted with the turbine surrounding the compressor and in which the turbine is connected to drive the propeller of an aircraft.

2

In my copending applications, Serial No. 544,788, filed July 13, 1944, (now Patent No. 2,423,183, issued July 1, 1947,) and Serial No. 515,013, filed December 20, 1943, the latter now abandoned, jet propulsion units employing coaxially mounted compressors and turbines have been shown. In such applications the products of combustion emerging from the turbine are employed for jet propulsion. In accordance with the example of the present invention as illustrated, the emerging gases are not used for jet propulsion purposes, but are passed through a condenser which condenses water present in the products of combustion. The turbine is here employed solely for driving a propeller.

So that the invention will be better understood it is believed expedient to describe first the compressor-turbine arrangement illustrated. The application of the invention to such a system can then be made clear.

The power unit includes a center longitudinal hollow shaft 10 mounted for rotation about its longitudinal axis. The shaft 10 is supported for rotation by the bearings 11 and 12. Secured to the shaft 10 to rotate therewith are a series of evenly spaced compressor blades 13 which extend radially outwards from the shaft to a cylindrical tubular member 14 which is fixed to a rotatable sleeve 50 by spider 9 or, if desired, is formed integral with the sleeve.

Disposed concentrically with respect to the cylindrical tubular member 14 and the shaft 10 is the outer part of the casing 16, which outer part is frusto-conical in form with its larger diameter toward the rear end of the unit (the right end in Figure 1).

The inner surface of the cylindrical tubular member 14 is provided with evenly spaced compressor blades 15. These are disposed alternately with the blades 13 on the shaft 10.

The outer surface of the cylindrical tubular member 14 is provided with evenly spaced turbine blades 17, rigidly secured thereto. These blades 17 extend radially outward toward the inner wall of the casing 16 and it will be noted that they progressively increase in length, the blades at the rear end being somewhat longer than those at the front. The inner wall of the casing 16 is also provided with turbine blades 18 rigidly secured therewith. These blades are evenly spaced and are disposed alternately with respect to the blades 17 on the cylindrical tubular member 14. The length of the blades 18 also increases progressively from front to rear of the device.

The shaft 10 is adapted to be driven in a direc-

tion contra to the direction in which the cylindrical tubular member is to be rotated.

The blades 13 on the shaft 10 and the blades 15 on the inner wall of the cylindrical tubular member 14 form a multi-stage compressor. This compressor is supplied with air from the atmosphere which enters through the inlet 19 and then passes to the rear end of the compressor, as indicated by the arrow. A butterfly valve 20 or the like, actuated by the pilot is adapted to control the amount of air entering the compressor. Air compressed by the compressor is expelled toward the front into a number of combustion chambers 21 which have smoothly curved walls. Fuel jets 22 are adapted to inject a fuel mixture into the combustion chambers, thus effecting combustion.

The space between the outer wall of the cylindrical tubular member 14 and the casing 16 and the blades 17, 18, disposed therein, comprise a turbine. Products of combustion from the combustion chambers 21 are directed through this turbine toward the rear and finally enters outlet passages 23.

The propeller hub and shaft arrangement is disposed forwardly of the turbine and the propeller is connected to be driven by the turbine through an epicyclic gear train. Disposed on the hollow shaft 27 for free retention thereon is the propeller hub 30. Bearings 31 and 32 are provided for this purpose. The propeller hub 30 supports a plurality of propeller blades, such as 33, the pitch of which may be varied by pitch-changing means 34 driven by a small electric motor 35 or the like. The details of the pitch-changing mechanism form no part of the instant invention and therefore need not be described.

Secured within the hollow shaft 27 is a cylinder 36 provided with a piston 37 connecting with a rod 38 which extends through the front wall of the cylinder 36 and forwardly to the front end of the hollow shaft 27. The rod 38 is secured to the member 39 which is in the form of a cap splined to the hollow shaft 27. This cap 39 is provided with an annular flange 41 formed with gear teeth 42 adapted to engage teeth on a ring member 43 rigid with the propeller hub 30.

The cylinder 36 in the hollow shaft 27 is connected by passageways with a hydraulic system generally indicated by the reference numeral 44 and adapted to supply fluid under pressure to the cylinder 36 on either side of the piston 37 to move it selectively, either to the right or to the left. When the left piston 37 is moved to the left the cap member 39 will also be moved to the left so that the teeth 42 on its flange 41 will disengage the teeth on the ring member 43. The propeller hub 30 will then be free from any rotary movement imparted to the hollow shaft 27. When, however, the piston 37 is moved to the right, the teeth will engage and the propeller hub 30 must partake in any rotation imparted to the hollow shaft 27.

The inner end of the hollow shaft 27 is provided with an outwardly extending flange 45 terminating in an annular ring gear 46 having teeth 47 in its inner periphery. The casing 16 supports a plurality of freely rotatable pinion gears 48 adapted to engage the ring gear 46 and also gear teeth 49 on a sleeve member 50 supported for rotation in the casing 16 by the bearings 51, and with respect to shaft 10 by the bearings 12. The sleeve member 50 is rigidly connected by spider means 9 with the cylindrical tubular member 14 or may be integral therewith.

It will be noted that the mechanism described includes the epicyclic gear system, which, when the cylindrical tubular member 14 is rotated, imparts rotation to the hollow shaft 27, thus driving the propeller.

In accordance with the present invention, however, the drive between the cylindrical tubular member 14 and the propeller hub may be direct and devoid of the clutching and declutching arrangement described.

At the rear end of the unit there is a shaft 52 splined to the shaft 10 at its forward end. This shaft 52 extends rearwardly to a clutching arrangement generally indicated by the reference numeral 53. Surrounding the shaft 52 is a sleeve 54, the forward end of which is rigid and rotates with the cylindrical tubular member 14. The rear end of the sleeve 54 extends into the clutch mechanism 53.

The clutching mechanism to which reference has been made may be of any desired form and, for example, may be similar to that disclosed in my said copending application Serial No. 544,788, filed July 13, 1944. The purpose of the clutching mechanism is to render it possible to provide two degrees of compression. When the clutching mechanism is in clutched position the cylindrical tubular member 14 upon rotating will, through the clutching mechanism 53, cause the shaft 10 and its compressor blades 13 to rotate in the direction contra to the blades 15 of the cylindrical tubular member 14. If, however, the clutch mechanism is in declutched position, the shaft 10 and its blades 13 will remain stationary and only the cylindrical tubular member 14 and its blades 15 will rotate and a lesser degree of compression will consequently be effected.

The present invention as applied to such a system will now be described.

Directly to the rear of the propeller 33 is an annular water tank 55 which comprises the reservoir for the cooling water. The water is drawn from the tank 55 at the bottom by the pump 56 and is forced by the pump through the pipe 57 (in the direction of the arrows in Figure 2) to the rear of the water cooling jacket 58 in the casing 16.

The cooling jacket 58 is provided with a passage 59 which is spiral in form so that the water travels in a spiral path from the rear to the front. During such travel it is heated by the heat from the turbine and by the time it reaches the end of the passage indicated by 60 it has been converted into steam.

It should be mentioned at this point that the pump 56 is a metering pump which can be adjusted so that it will pump into the cooling jacket 58 only such amounts of water as the heat from the turbine is capable of converting into steam during the time of travel of the water through its spiral passage 59.

The steam to which the water has been converted emerges under pressure at the end 60 of the spiral passage 59 into a funnel-shaped member 61. This member is disposed within the larger chamber 62, the upper surface 63 of which is perforated. As the steam passes upwardly through the perforations any remaining water will be caught and will run to the bottom of the chamber 62 where it enters the pipe 64 leading to the suction side of the pump 56.

The chamber 62 is disposed within a header 65. The steam which passes through the perforations in the upper surface 63 of the chamber 62

enters the header 65 and then travels through the passage 66. The passage 66 emerges into jackets 67 which are disposed in heat transfer relationship to the combustion chambers 21. The steam in the jackets 67 is thus superheated by the heat in the combustion chambers 21.

The steam from the jackets 67 then passes through the openings 68 and into the nozzle-shaped chambers 69 which eject the steam into the turbine passage against the turbine blades 17, 18. In the arrangement illustrated the fuel jets 26 may be disposed in a circle alternately with respect to the nozzle-shaped chambers 69.

From the rear of the turbine passage the steam is exhausted (together with the products of combustion) through the passage 23 into an annular tank 70.

The annular tank 70 is provided with an annular condenser 71 which is cooled by atmospheric air directed through it by the annular conduit 72 having an inlet opening 73 facing forwardly in the direction of flight of the aircraft. The tank 70 is further cooled by atmospheric air entering through the opening 74. The air entering through this opening passes around the turbine exhaust pipes 23 and finally emerges through the outlet opening 75.

The steam and products of combustion entering the inner annular space 76 in the tank 70 must pass through the condenser 71. The water resulting from condensation of the steam and water vapors in the products of combustion within the tank 70 and by the condenser 71, emerges from the tank 70 at the bottom through an opening 77 which connects with the return pipe 78 where it is forced by the return pump 79 through pipe 80 back to the upper end of the annular water tank 55.

The uncondensed products of combustion which pass through the condenser 71 to the upper portion 81 of the annular tank 70 will emerge through the opening 82 and will be dissipated to the atmosphere through the outlet passage 83.

Any water which may pass with the uncondensed products of combustion through the condenser 71 into the upper part 81 of tank 70 is caught by the downwardly curved lips 84 surrounding the opening 82. Such water will eventually make its way to the bottom of the tank 70 where it will pass through opening 77 into the return pipe 78.

The system describe. thus utilizes the heat of the turbine to convert the cooling water into steam, which steam is directed against the turbine blades to assist in driving them. This steam also aids in cooling the turbine blades. The steam after performing its useful work is again converted to water and returned to the water reservoir for the cooling jacket of the turbine. Moreover, and very important in self propelled vehicles and particularly in aircraft where lightness of weight is of great importance and large supplies of water cannot be carried, the system recovers water formed during combustion and present in the products of combustion passing through the turbine and adds such water to that originally in the water reservoir. This makes possible long duration operation of the turbine at high efficiency on a small quantity of water, thereby overcoming a defect in previous turbines whose water supply diminished continuously during operation, and which therefore were incapable of long duration continuous operation on a small capacity water supply.

The arrangement shown by way of example is direct, simple and efficient. Manifestly, the invention may be applied to other types of turbine arrangements, and the invention should not be limited in scope except as limited in the following claim.

What I claim is:

A turbine for use as a power source in aircraft, comprising a rotatable drive shaft, a rotatable hollow cylindrical turbine member operably connected to said drive shaft, turbine blades extending radially inwardly and outwardly from said member, conduit means for directing air through said inwardly extending blades, combustion means utilizing said air after movement through said inwardly extending blades and arranged to direct products of combustion against said outwardly extending blades, an annular water tank surrounding said drive shaft, a water jacket surrounding the area defined by the outwardly extending turbine blades of said hollow member whereby said area is cooled and the water in said jacket is converted to steam, means for injecting steam formed during passage of the water through said jacket against said outwardly extending turbine blades at the point where said products of combustion begin passage through said outwardly extending turbine blades, condensing means receiving the fluids emerging from passage through said outwardly extending blades for condensing water from said steam and products of combustion, and means for forcing water recovered in said condenser to said water tank, whereby a substantially closed water circuit is defined permitting operation of said turbine over considerable periods of time without stopping for replenishment of said water.

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