June 28, 1960 M. J. CORBETT 2,942,413

TURBINE COOLING SYSTEM

Filed Oct. 28, 1954 2 Sheets-Sheet 1

Fig. 1

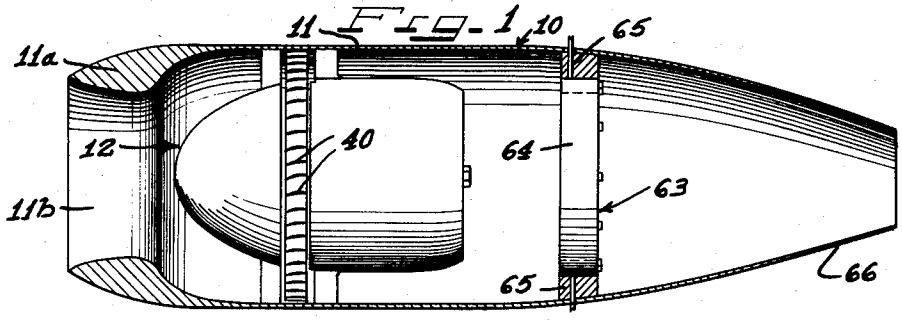
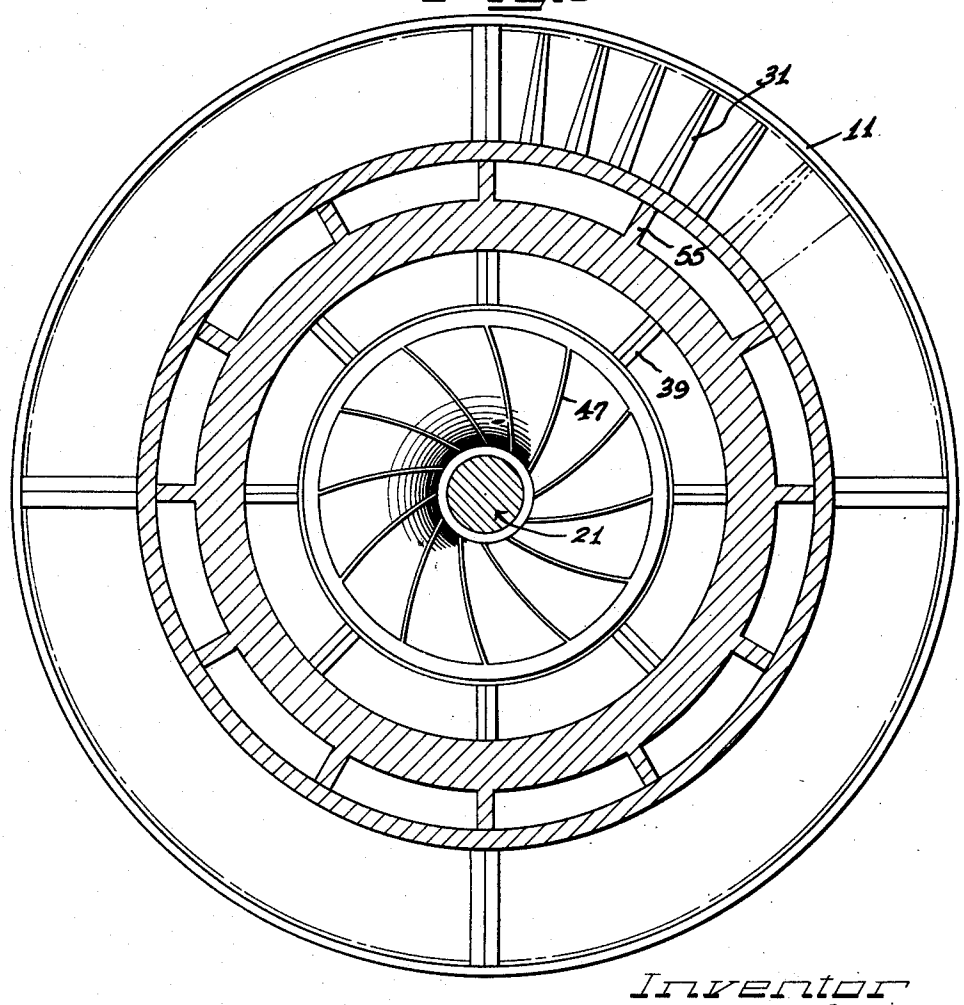


Fig. 3



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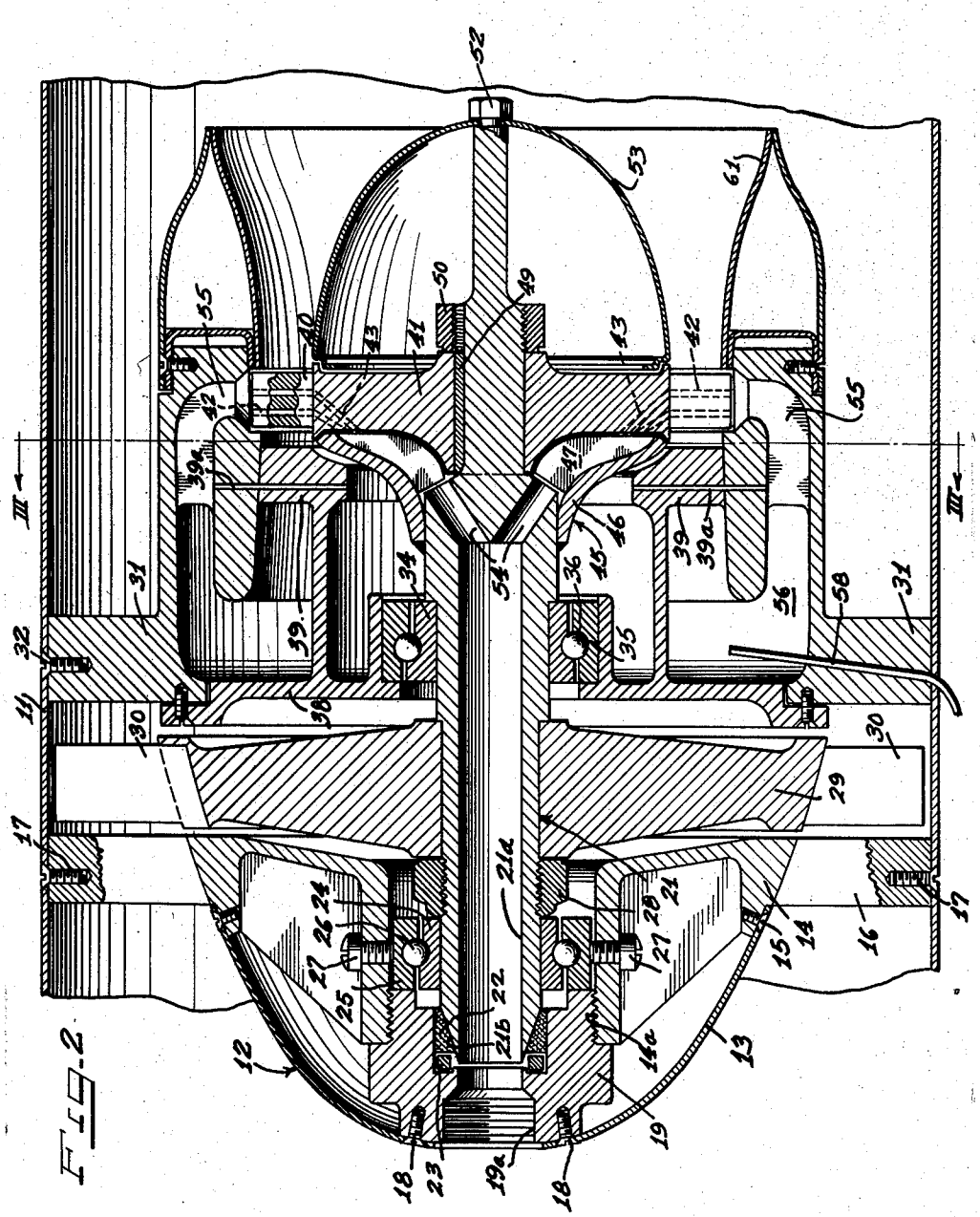


Fig. 2

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TURBINE COOLING SYSTEM

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The present invention is directed to turbine engines of the turborocket type, and is particularly concerned with an improved system for cooling the parts of the engine during its operation.

While the problem of cooling is of primary importance in every type of turbine engine, it becomes of the greatest importance in turborocket motors in which the engine parts and the housing must be capable of withstanding extreme temperature changes in a short period of time following the combustion or detonation of the fuel. It is estimated, for example, that about 5% of the heat liberated by the exothermic reaction of the propellants in a turbine rocket must be absorbed by the motor and the nozzle walls. Attempts to overcome the problem by making the motor parts of a heavy refractory material capable of absorbing the heat load or by lining the motor walls with refractory materials have not always proven satisfactory because these materials frequently add an excessive amount of weight to the turborocket.

Some attempts have also been made to cool the engine by the use of a regenerative cooling system in which the fuel or one of the components of the injected fuel is circulated along the hot surfaces prior to being burned. This type of cooling system seems to provide the best hope for a solution to the cooling problem and it is with this type of cooling system that the present invention is particularly concerned.

The present invention is concerned with turborocket engines which employ, as a fuel, a propellant mixture consisting of a combustible organic compound and an oxidizer, and also with turborocket power plants which employ a monopropellant as a fuel.

An object of the present invention is to provide an improved turborocket engine utilizing an efficient regenerative cooling system.

A further object of the present invention is to provide a turborocket power plant with a self contained regenerative cooling system including a pump mechanism and diffuser system for directing the coolant into the desired paths of flow.

Another object of the invention is to provide an improved turborocket power plant, with means for simultaneously cooling the turbine blades and the turbine stator vanes.

Other objects and features of the present invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which illustrate one preferred embodiment of the invention.

In the drawings:

Figure 1 is a view with parts in elevation, and partially in cross-section, illustrating the turborocket engine of the present invention;

Figure 2 is a cross-sectional view of the air compressor and turbine wheel portion of the turborocket power plant; and

Figure 3 is a cross-sectional view taken substantially along the lines III—III of Figure 2.

In Figure 1, reference numeral 10 indicates generally the turborocket engine of the invention, including a shell-like outer housing 11 having a restricted throat portion 11*a* which defines an inlet nozzle 11*b* for the turbine engine.

Disposed within the housing 11 is a rocket motor generally indicated at numeral 12 in Figure 1 and illustrated more particularly in Figures 2 and 3 of the drawings. As seen in these two figures, the rocket motor 12 includes a relatively thin shell nose plate 13 secured to a spider 14 by means of spaced screws 15. Extending from the spider 14 about its periphery are a plurality of peripherally spaced inlet guide vanes 16 which are located in position about the inner periphery of the housing 11 by means of spaced screws 17.

The forward end of the nose 13 is secured by means of screws 18 to a hollow collar 19 which is received in threaded engagement within an internally threaded portion 14*a* of the spider 14.

The forward end of the collar 19 is internally threaded as indicated at 19*a* to receive a fitting for supplying fluid, preferably in liquid form, from a suitable source. The engine shown is one using a fuel of the monopropellant type, so that its fuel would be a material which has available oxygen in its chemical composition in sufficient amounts to be self detonating. Among the materials which have been used as monopropellants are nitroglycerin, picric acid and its derivatives, trinitrotoluene, ethylene glycol dinitrate, nitromethane, and the like. These materials are reasonably stable at ordinary conditions but decompose completely with the liberation of large amounts of gases once they have been introduced into the combustion chamber.

The threaded portion 19*a* of the collar 19 is in open fluid commmunication with the hollow interior 21*a* of a shaft 21 supported for rotation within the turborocket engine. The shaft 21 has a tapered portion 21*b* which is engaged by a rotary fuel seal 22 composed of carbon or the like. A loading spring 23 constantly urges the seal 22 against the surface of the shaft 21.

The shaft 21 is supported for rotational movement within the motor by means of bearing elements which may include ball bearing members including an inner race 24, an outer race 25, and a plurality of ball bearing members 26 disposed therebetween. A plurality of set screws 27 is provided to prevent separation of ball bearing members, and a collar 28 is threaded onto the shaft 21 to prevent axial movement of the ball bearing members.

Keyed or otherwise secured to the shaft 21 is a compressor rotor 29 to which is secured a plurality of peripherally spaced compressor blades 30. The latter cooperate with a plurality of peripherally spaced compressor stator vanes 31 which are secured to the housing 10 by means of spaced screws 32, to direct air under pressure to the afterburners.

A second bearing member, including an inner race 34, an outer race 35, and a plurality of ball bearings 36 is situated on the opposite side of the rotor 29 from the first pair of ball bearing members.

The compressor stator vanes 31 are secured to a framework 38 which is suitably shaped so as to provide a plurality of spaced turbine stator vanes 39.

The vanes 39 are arranged to cooperate with a plurality of turbine blades 40 secured in spaced relation about the periphery of a turbine rotor 41. In order to provide paths for the flow of coolant through the turbine wheel, the blades 40 are each provided with a plurality of longitudinally extending passageways 42 which communicate with angularly disposed passageways 43 formed in the rotor 41.

The liquid fuel, prior to detonation, is forced through the passages 43 and 42 under a positive pressure by the operation of a pump 45 best illustrated in Figures 2 and 3 of the drawings. The pump 45 may include an arcuate shroud 46 welded or otherwise secured to the shaft 21 and a plurality of radialy extending arcuate impeller vanes 47 which provide the pumping action.

The tubine wheel or rotor 41 is secured by means of a key 49 to a solid extension of the shaft 21, and a collar 50 is received in threaded engagement thereon to prevent axial movement of the rotor 41 along the shaft. The end of the shaft 21 receives a threaded bolt 52 which extends through a shell-like rounded tail portion 53.

Liquid fuel introduced from a suitable fitting in the threaded inlet portion 19*a* passes through the hollow interior 21*a* of the shaft 21 and is introduced into the pumping area provided by the impeller vanes 47 by means of angularly disposed fluid passages 54. When the fluid enters the pumping area, it is forced by the rotation of the impellers 47 through the passages 43 in the rotor 41 and then through the hollow passages 42 in the turbine blades 40. The passage of the liquid fuel through the turbine blades 40 serves to substantially reduce the temperature of the blades by heat exchange with the fluid passing through them.

After the fluid thas been ejected from the blades 40 by a combination of the positive pressure provided to the fluid and by centrifugal action, the fuel is caused to impinge upon a plurality of peripherally spaced diffuser vanes 55 which direct the fuel into a combustion space 56 located behind the turbine stator vanes 39. Most of the fuel leaving the blades 40 will be introduced directly into the combustion space 56, but provision is made by means of passages 39*a* for bleeding off some of the fuel passing it through the stator vanes 39 to assist in cooling the vanes.

In the combustion space 56, the fuel is detonated by conditions of temperature existing in that space, or by the action of a detonation catalyst in that space. To initate the ignition of the fuel, the engine may be provided with an igniter tube 58 extending into the combustion space 56.

As the fuel spontaneously decomposes, it liberates very substantial quantities of gases, which in themselves, are further combustible because they contain a relatively large percentage of carbon monoxide and hydrogen. These liberated gases leave the combustion space 56 at tremendous velocities and impinge upon the turbine blades 40, causing the turbine rotor 41 to rotate at a very high velocity. The combustion gases are further expanded leaving the rocket motor by providing an outwardly flared end portion 61 to the turborocket engine, thereby providing a pressure reducing exit nozzle for the decomposition products leaving the combustion space 56.

The gases leaving the turborocket engine are mixed with the air supplied by the pumping action of the compressor blades 30 and the mixture is directed to the afterburner section generally indicated at numeral 63 in Figure 1. The afterburner 63 may consist of a manifold arrangement of burners in a ring 64 with a plurality of inlet tubes 65 being provided to introduce additional quantities of a combustible fuel or additional quantities of air, or both.

The gases produced by the decomposition of the propellant in the turborocket engine are burned in the afterburner 63 to produce an additional thrust as the waste gases are vented to the atmosphere.

The apparatus described has several distinct advantages. For one, it provides a cooling effect to the turbine blades and to the turbine stator vanes without increasing the weight of the parts and without the necessity of adding a suplemental fluid to the turborocket purely for cooling purposes. Furthermore, the pump impeller being an integral part of the shaft upon which the turbine wheel or rotor is located, varies in speed directly as the speed of the rotor so that as the temperature increases due to the detonation of larger quantities of propellant, the speed of the pump impeller is also automatically increased, thereby providing an increased cooling effect.

It will be evident that various modifications can be made to the described embodiment without departing from the scope of the present invention.

I claim as my invention:

1. A regeneratively cooled turborocket comprising a turbine wheel, a plurality of turbine blades secured in spaced relation about the periphery of said turbine wheel, each of said turbine blades having a plurality of passageways extending therethrough to the tip end thereof, a pump impeller rotatable with the turbine wheel arranged to direct fuel through said passageways, means in said turborocket defining a combustion space for said fuel, a ring of circumferentially spaced pump diffuser blades surrounding the turbine blades arranged to direct fuel discharged from the tips of said turbine blades into said combustion space, a ring of circumferentially spaced stator vanes arranged to direct gases from the combustion space to the turbine blades for driving the turbine wheel, and passages in the stator vanes receiving fuel from the spaces between the diffuser blades to cool the vanes.

2. A regeneratively cooled turbine engine comprising an elongated rotatably mounted hollow shaft, a turbine wheel mounted on said shaft having circumferentially spaced turbine blades around the periphery thereof, said turbine blades having passages therethrough extending from the radial inner ends thereof through the outer tip ends thereof, a ring of circumferentially spaced pumping vanes mounted upon and surrounding said shaft adjacent one face of the turbine wheel, said pumping vanes providing radially extending pumping passages therebetween, passages through said hollow shaft connecting the radial inner ends of the pumping passages with the hollow interior of the shaft, passages in the turbine wheel connecting the outer ends of the pumping passages with the radial inner ends of the passages through the turbine blades, means for introducing fuel into said shaft under positive pressure to be pumped by said pumping vanes through said turbine blades, a ring of circumferentially spaced diffuser blades surrounding said turbine blades to receive fuel from the passages in the turbine blades in the spaces therebetween and arranged to direct said fuel, an annular combustion space having an outer peripheral portion receiving fuel from said diffuser vanes and an inner annular discharge portion, a ring of circumferentially spaced stator vanes in said inner discharge portion of the combustion space for directing expanding gases from the combustion space against the turbine blades to drive the turbine wheel, and passageways joining the spaces between the diffuser blades with the interior of the stator vanes to bleed off fuel through the stator vanes before the fuel reaches the combustion space.

3. In a regeneratively cooled turbine engine having a first path for air flow and a second path for gas flow merging into said first path, an elongated hollow shaft, bearings supporting said shaft for free rotation, a turbine wheel mounted on said shaft for rotation therewith, means surrounding said shaft defining an annular combustion space around the shaft, a compressor rotor upstream of said means having radially extending blades arranged to direct a stream of air around said means through said first path into said second path, said turbine wheel having circumferentially spaced turbine blades radiating therefrom and equipped with axially extending passages therethrough communicating with the hollow interior of the shaft, a ring of stator vanes in said combustion space upstream from said turbine blades for directing burning gases against the blades to drive the tur-

bine wheel and thereby rotate the compressor rotor, said combustion space having an inlet end communicating with the tip ends of the turbine blades and an outlet end communicating with said stator vanes, and means for flowing fuel through said hollow shaft and through the passages in the turbine blades into said combustion space for forming burning gases in said space to flow past the stator vanes against the turbine blades and thence through the second path to merge into the air stream formed by the compressor rotor in the first path.

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