Nov. 27, 1951 E. A. STALKER 2,576,814

COOLING MEANS FOR TURBINES

Filed May 28, 1946 2 SHEETS—SHEET 1

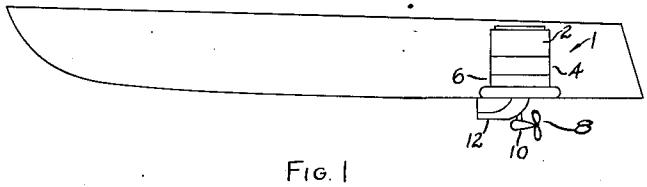


FIG. 1

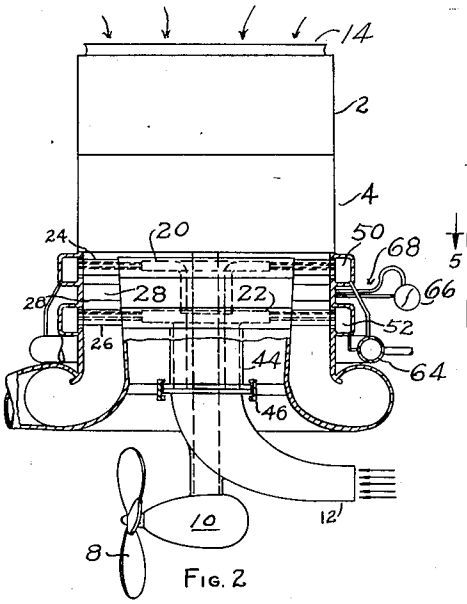


FIG. 2

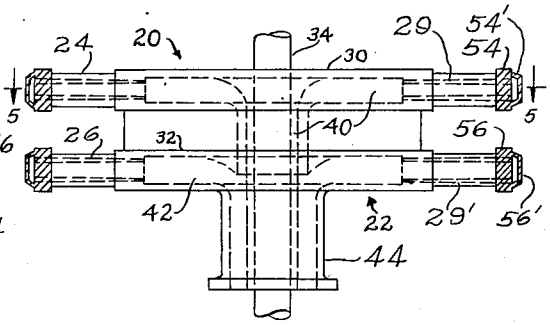


FIG. 4

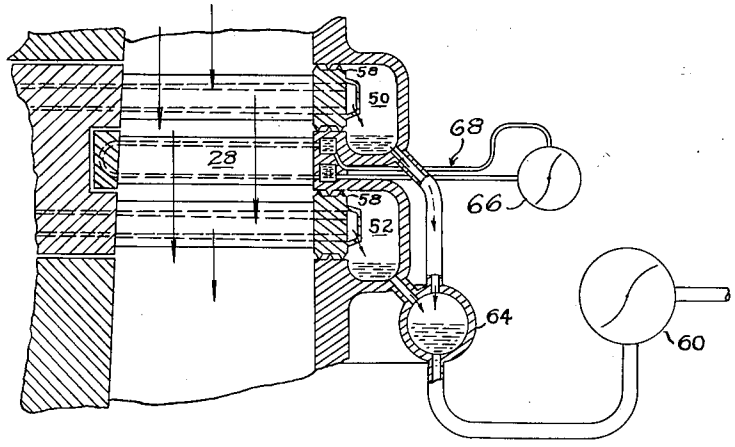


FIG. 3

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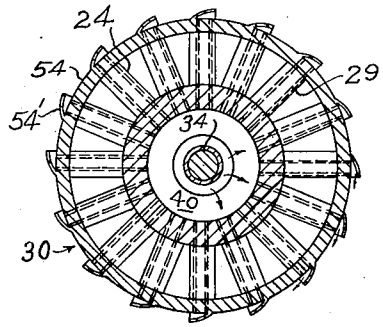


FIG. 5

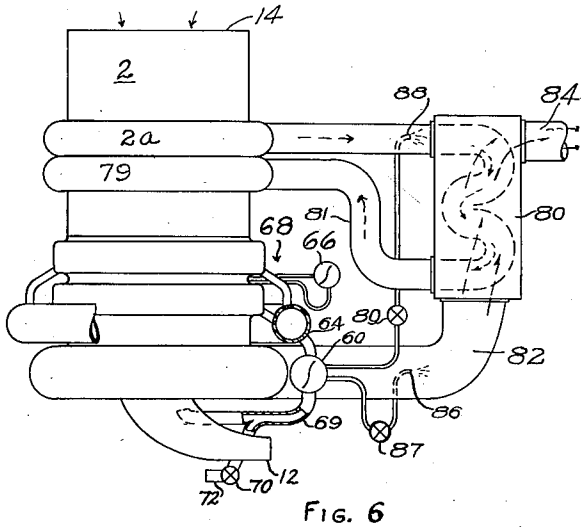


FIG. 6

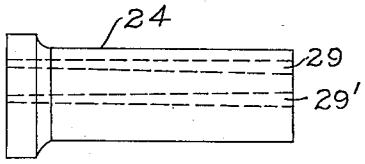


FIG. 7

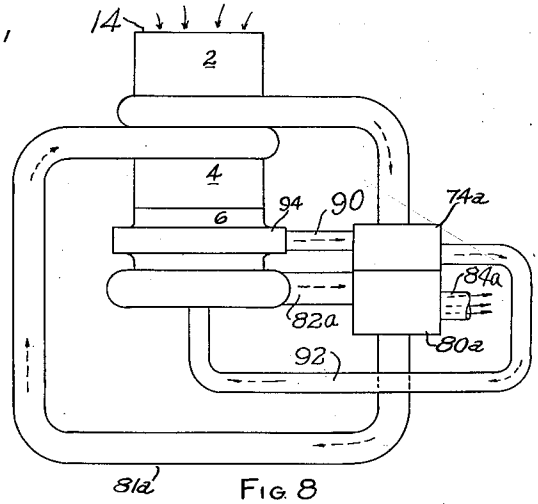


FIG. 8

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COOLING MEANS FOR TURBINES

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Application May 28, 1946, Serial No. 672,815

6 Claims. (Cl. 253—39.15)

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My invention relates to prime movers and particularly to gas turbine power plants.

It is an object of my invention to provide a means of liquid cooling the various parts of the turbine.

It is also an object to provide a gas turbine particularly adapted for operation where a supply of water is available at little or no cost as, for instance, on a boat or in industrial situations.

Another object is to provide a gas turbine particularly adapted to the re-use of a cooling fluid which cannot be discarded because of the cost or because of the unavailability of replacement fluid.

Still other objects will appear from the specification, drawings and claims.

In the drawings:

Figure 1 is a schematic drawing showing the power plant or prime mover installed in a boat;

Figure 2 is a side elevation partly in section of the power-plant;

Figure 3 is an enlarged section through a portion of the turbine case, showing the blades and associated ducts for the cooling fluid;

Figure 4 is a side elevation of the turbine rotors isolated from the remainder of the turbine and with the shroud rings shown in section;

Figure 5 is a section along the line 5—5 in Figure 4;

Figure 6 is a side elevation of the power-plant shown with a heat exchanger for conserving the fluid for cooling the blades;

Figure 7 is a side view of a blade showing the tapered passages within for the colling fluid; and

Figure 8 is an alternate arrangement of the power-plant, heat exchanger and radiator for the cooling flow of the blades and the like.

It can be shown that a gas turbine power-plant can be made more efficient and more productive of power for a given size if the gas temperature is increased. However, to achieve substantial increases, the turbine structure, particularly the blades, must be cooled. This is especially important in applications of the turbine to vehicles and industry since in these cases length of life of the turbine is a determining factor in competing with industrial engines which have a very long life.

This invention discloses means to pass a liquid through the structure for cooling. It is difficult to do in the case of the moving parts such as the blades. These are particularly difficult to cool while excluding the liquid from the main flow passage for the motive gas when the power-plant is inoperative, as well as operative. The

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invention also discloses a turbine which successfully excludes the liquid and conserves it so that it may be reused. This is important where other liquids than water are employed for cooling such as oils, silicones and other chemicals.

In Fig. 1 the power-plant is indicated as 1. It is comprised of the compressor 2, combustion or heating chamber 4, and gas turbine 6. The power from the power-plant drives the propeller 8 by means of a gear train housed in 10. Parts of the turbine including the blades are cooled by water taken in through the forward facing duct 12.

Fig. 2 shows that the compressor 2 takes in air through the inlet 14. The air is compressed and delivered to the combustion chamber 4 which is the prime means of heating the compressed air. These parts will not be described since they are well known in the art and may be like any such known parts.

The air and/or the products of combustion (both herein called the gases) from the chamber flow through the turbine rotors 20 and 22 between their blades 24 and 26. Suitable stator blades 28 are provided to direct the gases onto the rotor blades.

As shown particularly in Figs. 3 and 4, the blades have cooling ducts 29 and 29' extending radially through them. Since these connect through the hubs 30 and 32 of the rotors with the water inlet duct 12, water will be drawn by centrifugal action into the blades. It is discharged from the blades rearward substantially tangentially to the direction of rotation of the tip. By discharging the liquid in this fashion, no energy is expended by the rotor as a pump, except the frictional energy which is almost negligible, and the enery due to raising the water to the level of the rotors. There is no expenditure of velocity energy since in discharging the liquid rearward the rotor blades receive a forward thrust.

As shown in Figure 4, the rotors are fixed to the turbine shaft 34. Each rotor hub has a passage 40 (or 42) connecting the inner end of the blade passages with the common interior of duct 12. The rotor duct shaft 44 is operably connected to the stationary duct 12 by the slip joint 46.

As shown in Figs. 2 to 6, the water or other liquid leaving the tips of the blades is collected in the annular collectors 50 and 52. These have sufficient vertical depth below the rotor to accommodate a substantial amount of fluid. The shroud rings 54 and 56 about the blade tips have

the labyrinth seals 58 which also serve to restrain the passage of liquid from the collectors into the turbine interiors.

The rings 54 and 56 have the liquid discharge nozzles 54' and 56' located opposite each blade to discharge the liquid from passages 29 and 29' rearward.

The liquid in the collectors is withdrawn by means of pump 60 and suitable tubes 62 leading to a header 64. The pump 60 may be independently driven or may be driven from the turbine shaft.

The pump 60 is adapted to withdraw the liquid from the collectors 50 and 52 whether in liquid or vapor state.

Another pump 66 and tube system 68 circulates liquid through the stator blades 28 to keep them cool.

Where ordinary water is used as a coolant, it is apt to deposit particles on the internal surfaces of the passages within the blades. To prevent this accretion the passages are tapered (see Fig. 7) so that there is a centrifugal force tending to throw particles away from the surface.

The pumps 60 and 66 may discard the cooling water or recirculate it, in part, through the blades as shown in Figure 6 where the pump 60 discharges the hot water back into the inlet duct 12 through pipe 69. The amount recirculated is governed by the waste valve 70 in the waste tube 72.

Still referring to Fig. 6, the compressor 2 now equipped with a collector 2a delivers its compressed air to the upper end of the heat exchanger 80 and from it to the entrance to the combustion chamber via pipe 81 and collector 79. The exhaust from the turbine passes via pipe 82 to the exchanger and heats the air enroute to the combustion chamber. The pipe 84 carries the exhaust gases away from the exchanger.

Where the turbine operates with a high inlet temperature the exhaust gas temperature may be too high for an economical construction of the heat exchanger. In such an instance I inject water into the exhaust gases as shown at 86 in Fig. 6. The water flow is controlled by valve 87. To maintain an effective temperature difference between the air from the compressor and the exhaust gases in the exchanger where a large compression ratio would give rise to a high air temperature, I also inject water or other liquid into the high temperature compressed air approaching the heat exchanger as shown at 88. This liquid flow is controlled by valve 89.

Figure 7 shows that the passages 29 and 29' within the blades are tapered with the greatest cross sectional area at the blade tips. This is done so that the centrifugal force will keep particles from adhering to the walls of these passages. This is important where ordinary water is used since it may contain organic and mineral matter which may tend to precipitate on to the passage walls.

In an alternate form of the invention, Figure 8, I place the radiator 14a in the circuit from the compressor to the heat exchanger 80a whose duct 81a leads to the combustion chamber. The pipe 84a discharges the exhaust gases. The blade coolant circulates by ducts 90 and 92 to the blades. The circulating pumps and header are contained within the structure at 94.

This arrangement presents the advantage of conserving the heat put into the cooling fluid by the blades.

It is important to be able to employ a liquid for cooling the blades because of its great ability to pick up heat from hot surfaces. This invention provides a practical method applicable to cooling all the parts but is particularly directed to the blades of the rotor. A structure has been disclosed whereby the energy put in the coolant by the rotor rotation is recovered in a simple manner. Means has also been shown for preventing a flow back into the gas passages of the turbine, which would dissipate valuable liquid and lead to injury within the turbine. The turbine is mounted with its axis vertical to cooperate with the type of liquid collector shown. Also the power-plant incorporates radiators and heat exchangers in new relationships.

While I have illustrated a specific form of this invention it is to be understood that I do not intend to limit myself to this exact form but intend to claim my invention broadly as indicated by the appended claims.

I claim:

1. In combination in a gas turbine, a hub and a plurality of turbine blades mounted thereon to form a turbine rotor, means mounting said rotor for rotation about a vertical axis, a shroud ring encircling and fixed to the tips of said blades, each of said blades having a radial passage discharging through said ring with a substantially backward direction, means to admit a liquid into the inner ends of said blades, a collector encompassing said rotor to receive said liquid discharged from said blades, said collector having an annular opening to accommodate the rotation of said shroud ring therein, said collector having a fillable space below the level of the lower edge of said shroud ring, and means to withdraw the liquid from said collector.

2. In combination to form a gas turbine, a turbine rotor having a plurality of blades, means mounting said rotor for rotation about an upright axis, a case to house said rotor and direct a flow of motive gas to said rotor to rotate it, means to supply a flow of heated compressed gas to said case, said blades having radial passages therethrough leading out of said hub, an annular collector adjacent to said blade tips and encircling said blades, means to supply cooling liquid to said hub for discharge through said passages into said collector, said collector having an annular opening in its inner vertical face, a shroud ring encircling said blade tips and fixed thereto, said ring being accommodated in said opening, labyrinth means to slideably seal the gap between said collector and said ring, and means to withdraw liquid from said collector.

3. In combination, a gas turbine having blades, means to direct heated compressed gas through said turbine to produce power, said gas heating said blades, each said blade having a radial passage therethrough for the flow therein of cooling liquid discharged from each blade tip, means to supply liquid to the said passages, means to collect the liquid at the tips of said blades and means to discard a portion of said liquid while recirculating another portion thereof through said blades to maintain a proper blade temperature.

4. In combination in a gas turbine having a main passage for the flow of a motive gas therethrough, a plurality of turbine rotors each comprising a hub, a plurality of turbine blades mounted thereon, a shroud ring encircling and fixed to said blade tips, means mounting said rotors in tandem for rotation about a common axis, each of said blades having a radial passage for dis-

charging liquid radially therethrough, a collector means encompassing said rotors, means to admit a liquid into the inner ends of said blades, and means to direct said liquid substantially rearward from said blade tips into said collector means, said collector means having annular openings adapted to receive said rings therein in slideably sealed relation, the inner surfaces of said rings being substantially flush with the surface of said main passage on opposite sides of said ring, said flush surfaces being surfaces bathed by said motive gas.

5. In combination in a gas turbine having a main flow passage, a hub and a plurality of turbine blades mounted to form a turbine rotor with said blades in said passage, means mounting said rotor for rotation about an axis, a shroud ring encircling and fixed to the tips of said blades, each of said blades having a radial passage discharging through said ring with a substantially backward direction, means to admit a liquid into the inner ends of said blades, a collector encompassing said rotor to receive said liquid discharged from said blades outside said ring, said collector having an annular opening to accommodate the rotation of said shroud ring therein, and means to withdraw said liquid from said collector, the inner surfaces of said ring being substantially flush with the surfaces of said main passage on opposite sides of said ring, said flush surfaces being surfaces bathed by said main flow.

6. In combination in a gas turbine, a case having a main passage therethrough for the flow of a hot motive gas therethrough, a plurality of turbine rotors mounted in tandem for rotation in substantially horizontal planes about a common

upright axis, each said rotor having a hub mounted in said case with a plurality of blades fixed thereon and positioned in said passage to be rotated by said gas flow, a shroud ring encircling and fixed to said blade tips of each said rotor, a collector means encompassing each said rotor, each said blade having a radial channel therethrough to discharge a cooling liquid from said blade tip into said collector means, said collector means having annular openings adapted to receive said shroud rings therein in slideably sealed relation, the inner surface of each said ring being substantially flush with the surfaces of said case on opposite sides of said ring, said flush surfaces being the surfaces bathed by said motive gas.

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