

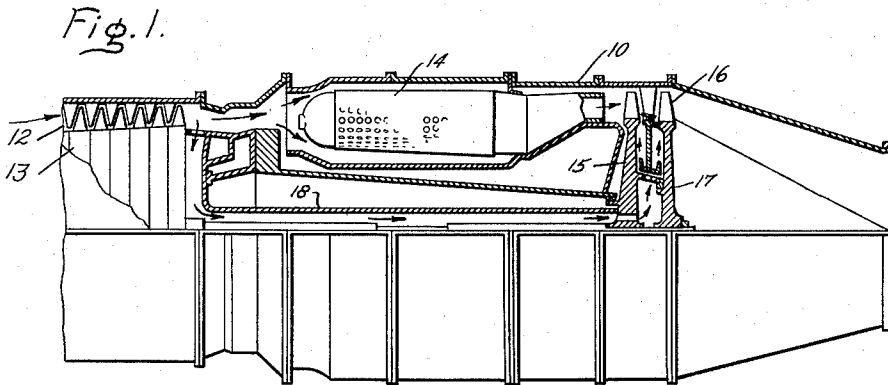
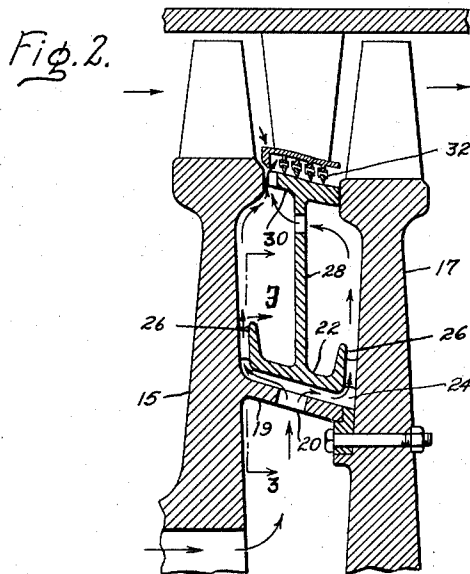
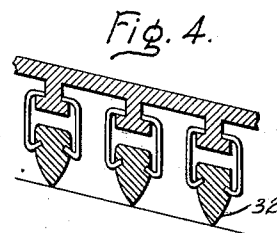
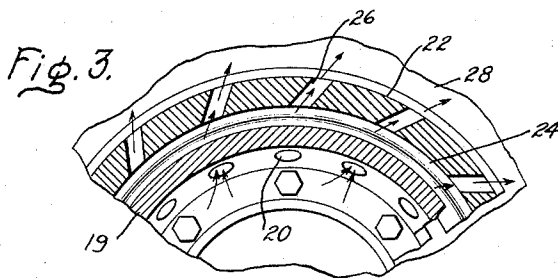
Oct. 28, 1958

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2,858,101

COOLING OF TURBINE WHEELS

Filed Jan. 28, 1954



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COOLING OF TURBINE WHEELS

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Application January 28, 1954, Serial No. 406,851

3 Claims. (Cl. 253—39.15)

This invention relates to a gas turbine, and in particular, to a means for cooling the turbine wheels.

In general, a gas turbine operates by atmospheric air being taken into a compressor and compressed, then the air discharged from the compressor passes into the combustion chambers where it is mixed with fuel sprayed from nozzles and burned. The hot combustion gases leaving the combustion chambers pass through the turbine wheel buckets, where sufficient energy is extracted from the gases to drive the compressor. The remainder of the energy is used to provide thrust. Now, the hot gases acting on the turbine buckets present a problem in that the turbine wheel discs become too hot and thereby decrease their strength. It is therefore an object of this invention to provide a means for cooling the turbine wheel.

It is customary in the prior art to cool the turbine wheel discs by bleeding off or extracting small amounts of air from the compressor and directing this air against the side of the wheel. Compressed air is used for this cooling operation since the hot gases above the rim of the turbine wheel are under pressure. However, prior systems of bleeding air from the compressor have been inefficient, thereby seriously affecting the operation of the compressor in supplying the compressed air to the combustion chambers. It is therefore a further object of this invention to provide a more efficient means of cooling the turbine wheel disc by taking less air from the compressor than that required to obtain the same cooling obtained by prior art methods, thereby giving more air to the combustion chambers to produce greater thrust and reduce fuel consumption.

It is a still further object of this invention to direct cooling air to the turbine wheel, to provide an air deflector sleeve adjacent the turbine hub, the sleeve being adapted to receive the air and to blow it against the sides of the turbine wheel discs, the sleeve preferably having a cylindrical shape with openings therein so directed that the air flow will be radial instead of curved so as to travel the least distance to reach the rim of the wheel.

These and other objects will become more apparent when read in the light of accompanying specification and drawings wherein:

Fig. 1 is a cross-sectional view of a gas turbine showing the general means of carrying the air flow to the turbine wheel.

Fig. 2 is a cross-sectional view of the gas turbine wheel disc showing the cooling means for obtaining a thin, wide flow of air.

Fig. 3 is a cross-sectional view taken on line 3—3 of Fig. 2 in which the direction of the openings are shown.

Fig. 4 is a cross-sectional view of the hot gas seals.

Referring to the figures, 10 generally designates a gas turbine engine having a compressor 12, combustion chambers 14 and a turbine 16. The compressor rotor 13 is drivingly connected to the turbine wheels 15 and 17 through a hollow drive shaft 18. The hollow drive

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shaft 18 opens into the space between the turbine wheels 15 and 17. The turbine wheels 15 and 17 are drivingly connected by a wheel connecting member 19. The wheel connecting member is provided with a plurality of radial openings 20. A cooling air deflector sleeve 22 is spacedly positioned substantially concentrically about the wheel connecting member 19 so as to form a narrow annular passage 24. The deflector sleeve contains a plurality of canted metering nozzles or openings 26 extending through the sleeve at acute angles with radii of the turbine wheels such as to provide a radial trajectory or path of the discharged air. These metering nozzles 26 can be orientated according to the following formula as shown in Fig. 3 for any given wheel speed:

$$V_0 \sin \alpha = \pi DN$$

Where

$$V_0 = \sqrt{2g\Delta h}$$

= air velocity developed by the pressure drop through the metering nozzles.

α = angle between the nozzle axis and a radial line.

D = outside diameter of the sleeve.

N = rotating speed of turbine.

By establishing the centerline of the metering nozzles 26 through angle α in a direction opposite to the rotation of the turbine wheel, the tangential velocity of the thin jets of air can be made to approach zero, and the resultant flow will then be radial. It is understood that some tangential velocities will be developed at the larger radii since fluid shear stresses between the thin jet and wheel surfaces will still exist.

It is noted that the above vector relations should be favored for full speed operation when maximum cooling effectiveness is desired.

The deflector sleeve is further provided with a web 28 extending radially from the deflector sleeve and terminating in a baffle portion 30. The web and baffle are provided with openings for permitting air flow there-through. A hot gas seal is provided at 32 so that the cooling air is disposed directly upstream therefrom.

In operation air is bled off from the compressor through the hollow connecting shaft 18 to the wheel connecting member 19. The air then passes up through the radial openings 20 into the annular passage 24. The flow of air passes from the annular passage into the metering nozzles 26 which are so positioned to provide a thin jet of air to travel a minimum trajectory approaching a radial line so as to take the least distance in reaching the rim of the wheel. It is very desirable for the air to follow such a path so as to have the least attenuation of the thin jet before it reaches the rim, the most important area to be cooled. The air is then discharged from the metering nozzles 26 along the faces of the two wheels at such a radial velocity and tangential velocity as will cause the spreading jet to maintain intimate contact and effective cooling over the whole surface of the wheel. The cooling air then passes through the openings in the web 28 and baffle portion 30 and is discharged directly upstream of the hot gas seal which is closely positioned radially to the baffle portion between the rims of the wheels. The pressure of the cooling air being under higher pressure than the hot gases, the cooling air will flow through this seal. In other words the cool air will pass through the hot gas seal instead of the hot gases, thereby reducing the leakage of hot gases through this seal.

Therefore, a means has been provided for obtaining a wide, thin jet or sheet of cooling air that is discharged parallel to the sides of the turbine wheels with such radial and tangential velocity components as to extend the radial distance over which the thin jet or sheet of air

can effectively cool the wheel surfaces. As a result less air is required to be bled off from the compressor to effectively cool the turbine wheel discs and more air is made available for the combustion chambers to produce more thrust.

Although the specific apparatus embodying this invention has been shown and described, it will be understood that such a showing has been made in order that the invention may be more completely understood, such a showing is not to be considered as in any way limiting this invention. Many other types of apparatus may be used to carry out this invention as well as many modifications, additions and omissions from the particular apparatus shown and described which are to be included within the spirit and intent of this invention.

What is claimed is:

1. In a turbine for a turbo-machine which includes at least one turbine wheel rotatable in one direction by working fluid, means for cooling said turbine wheel, comprising, in combination; a member secured to said wheel and extending axially from a surface thereof, a deflector sleeve secured to said wheel and extending axially from said surface thereof, said sleeve radially spaced from said member to form a passageway therebetween, a source of cooling air, means for directing said cooling air into said passageway, said deflector sleeve being formed with metering nozzles extending therethrough at an end thereof adjacent said surface of said wheel, said nozzles canted in a direction opposite to said direction of rotation of said wheel and extending at an acute angle with a radius of said turbine wheel such that said nozzles radially direct a thin jet of cooling air from said passageway against said surface of said turbine wheel.

2. In a turbine for a turbo-machine which includes at least one turbine wheel rotatable in one direction by working fluid, means for cooling said turbine wheel, comprising, in combination; a source of cooling air, means in flow relation with said source for conducting said cooling air to said wheel, a member secured to said wheel and extending axially from a radial surface thereof, an annular deflector sleeve secured to said wheel and extending axially from said surface, said sleeve spaced about said member to form a passageway therebetween, said member formed with openings for admitting said cooling air into said passageway, said sleeve formed with

metering nozzles at an end thereof adjacent to said surface of said wheel, said metering nozzles canted in a direction opposite to said direction of rotation of said wheel and extending through said sleeve at an acute angle with a radius of said turbine wheel extending thereto, such as to direct thin jets of cooling air from said passageway radially over said surface of said wheel in a direction opposite to said direction of rotation of said turbine wheel.

3. In a turbine for a turbo-machine which includes at least one turbine wheel rotatable in one direction by working fluid, means for cooling said turbine wheel, comprising, in combination; a source of cooling air, means in flow relation with said source for conducting said cooling air to said wheel, an annular member secured to said wheel and extending axially from a radial surface thereof, an annular deflector sleeve secured to said wheel and extending axially from said surface, said sleeve spaced about said member to form an annular passageway therebetween, said member formed with openings for admitting said cooling air into said annular passageway, said sleeve formed with metering nozzles at an end thereof adjacent to said surface of said wheel, said metering nozzles canted in a direction opposite to said direction of rotation of said wheel and extending through said sleeve at an acute angle α with a radius of the sleeve extending thereto, said angle being determined according to the formula

$\alpha = \arcsin \pi DN/V_0$ wherein

D = outside diameter of said sleeve

N = rotating speed of the turbine

V_0 = tangential component of the absolute nozzle air velocity in a direction opposite to said direction of rotation of said wheel,

such that said nozzles direct thin jets of cooling air from said annular passageway over said surface of said wheel.

References Cited in the file of this patent

UNITED STATES PATENTS

1,255,924	Peaslee	Feb. 12, 1918
2,488,867	Judson	Nov. 22, 1949
2,584,899	McLeod	Feb. 5, 1952
2,632,626	McClintock	Mar. 24, 1953
2,684,831	Grantham	July 27, 1954