MEMORANDUM

TO: KSI/Scientific & Technical Information Division
   Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code US1 memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 2,956,772

Corporate Source : Lewis Research Center

Supplementary Corporate Source :

NASA Patent Case No.: XLE-00027

Enclosure: Copy of Patent

Gayle Parker
LIQUID-SPRAY COOLING METHOD

Filed Aug. 19, 1955

INVENTOR
JOHN C. FRECHE

BY

ATTORNEYS
At equally spaced circular intervals along the inner ring 11 of the stator, on the down stream edge 17 thereof and in line with the trailing edges of the stator blades, are a number of small openings 27, four being shown by way of example, and in these openings are fitted the terminal orifices such as 25 and 26 of four coolant ducts 20, 21, 22 and 23, each duct being connected to an appropriate common coolant source. The orifices of successive ducts, as 20 and 21, are of different capacity so that the mass of coolant transmitted by the orifices may be varied. For example, orifice 25 may be of lesser area than that of orifice 26 of duct 21, as in the ratio of about 0.078 inch to 0.135 inch diameters, so that for the same pressure the penetration of the jet from orifice 26 into the gas stream will be appreciably greater than the penetration of the jet from orifice 25. This follows from the fact that the degree of penetration of the jet stream into the gas flow depends on the momentum of the jet, that is, the mass times the velocity, and since the velocity through both orifices is the same the penetration varies with the mass of fluid, or orifice cross-section. In operation, the jets from alternate ducts 20 and 22, with lesser penetration, operate to spray the blade root region with coolant, whereas the jets from alternate ducts 21 and 23 serve to spray the mid-span and tip regions of the blades with coolant. It is noted that since the coolant orifices are positioned at the trailing edges of the stator blades, a minimum of evaporation of the coolant liquid particles occurs prior to impingement thereof on the rotor blades. On impingement, the coolant is vaporized, extracting latent heat of vaporization from the blades.

In installing the cooling apparatus on a turbine equipped with the usual statior diaphragm construction, it is necessary only to drill openings through the inner ring of the diaphragm at the desired locations and attach the coolant ducts from the liquid supply at these openings, as by welding or brazing. This may be done during the initial fabrication of the turbine stator or after the turbine construction has been completed. The number of openings with coolant connections as well as the diameters of the orifices thereof would be a function of the requirements of the particular installation. Water, with its relatively high latent heat of vaporization, is employed, preferably, as the spray coolant, connected to the supply ducts 20, 21, 22 and 23 being made through a manifold 24 to a pump and supply source, the pump permitting pressure variation at the orifices, as desired.

The utility of the cooling apparatus appears from the curves shown in Figs. 4 and 5 wherein the blade temperatures spanwise and chordwise are indicated with and without the spray application. In developing data for the curves, the spray apparatus was applied to the solid turbine blades of a turbojet engine having a rated speed of 11,500 revolutions per minute, an inlet-gas temperature of about 1568° F., a coolant-to-gas ratio of 0.0235 and small and large orifice diameters of 0.078 inch and 0.135 inch, respectively.

Fig. 4, in curve 30, indicates a maximum temperature reduction of about 1000° F. at the developing midspan points on the midchord suction surface of the blade and a reduction of over 600° F. at the blade tip. Curve 31 indicates uncooled temperatures corresponding to the test points of curve 30.

Fig. 5, in curve 33, indicates chordwise temperature distribution of the blade as applied to both suction and pressure surfaces at the midspan, and chordwise temperatures at the blade root are indicated by curve 34. Curve 35 indicates corresponding uncooled temperatures for the chord test locations. Broken line 36 shows the effect of increasing the coolant-to-gas flow ratio to 0.0278 (7600
lb./hr.) with the larger orifice diameter increased from 0.135 inch to 0.150 inch. With these increased values the midspan chordwise temperature difference between the leading and trailing edges was reduced to about 100° F. and an average midspan temperature of about 450° F., 760° F. and 470° F. for a coolant-to-gas ratio of 0.0235 with a larger orifice diameter of 0.135.

In general, the curves of Figs. 4 and 5 clearly show a substantial reduction in temperature both spanwise and chordwise of the turbine blade through use of spray jets located at the downstream edge of the inner diaphragm ring between the stator blades. By using differently sized orifices, spanwise cooling is effectively accomplished. These results are made possible without complex modifications of the turbine structure and without addition of complicated equipment, the limited apparatus being readily installed and maintained with small danger of breakdown in use. Utilizing the described equipment, when applied to turbojet operation at sea level a 40 percent increase above rated thrust may be realized with a representative centrifugal-flow engine by operation at 2000° F. inlet-gas temperature and 10 percent overspeed.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A turbine blade spray apparatus comprising a stator blade diaphragm having an innerblade ring with a plurality of openings therein and adapted for positioning a turbine rotor, coolant ducts having terminal orifices fluidly attached to said openings, said openings spaced circumferentially around said ring; and means for supplying coolant under pressure to said coolant ducts, with the terminal orifices of some of said ducts having a cross-sectional area lesser than that of the terminal orifices of other ducts.

2. The turbine blade spray apparatus as defined in claim 1, the area of said terminal orifices alternately increasing and decreasing moving in sequence around said ring.

3. The turbine blade spray apparatus, as defined in claim 2, with the areas of adjacent terminal orifices being in the ratio of about 0.078 to 0.150.

4. The turbine blade spray apparatus, as defined in claim 2, with said openings being at least 4 in number and spaced equal distances in sequence, one from another around said blade ring.

5. A turbine blade spray apparatus comprising a stator blade diaphragm having an innerblade ring with a plurality of openings therein; coolant ducts having terminal orifices fluidly attached to said openings, said openings spaced circumferentially around said ring; a manifold, said ducts being fluidly connected to said manifold; and means for supplying coolant under pressure to said manifold, with adjoining openings being equally spaced one from another and at least one of said terminal orifices having a lesser cross-sectional area than another of said terminal orifices.

References Cited in the file of this patent

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CERTIFICATION OF CORRECTION

Patent No. 2,956,772

October 18, 1960

John C. Freche

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, lines 2 and 3, for "assignor to the United States of America as represented by the Secretary of the Navy," read -- assignor to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration," lines 12 and 13, for "United States of America as represented by the Secretary of the Navy" read -- United States of America as represented by the Administrator of the National Aeronautics and Space Administration --; in the heading to the printed specification, lines, 3, 4, and 5, for "assignor to the United States of America as represented by the Secretary of the Navy" read -- assignor to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration --.

Signed and sealed this 18th day of April 1961.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents