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COOLING OF TURBINE ROTORS

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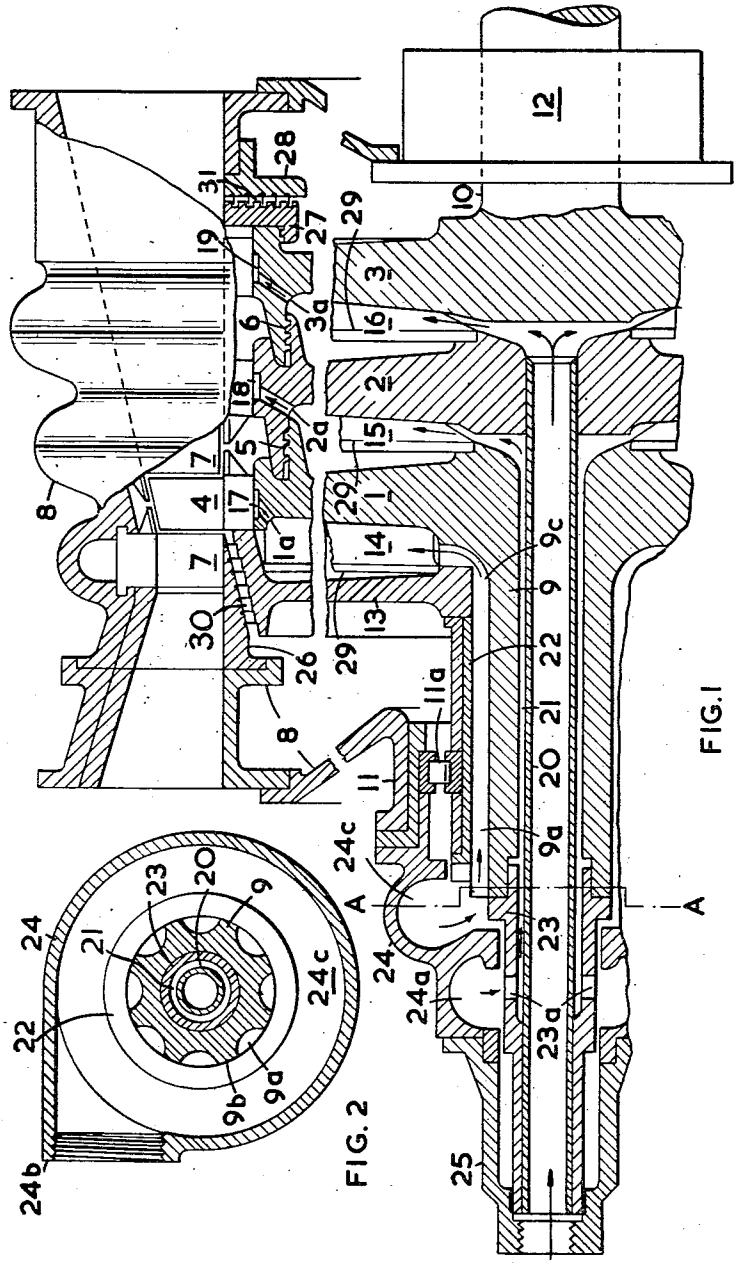



FIG. 1




FIG. 2

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# COOLING OF TURBINE ROTORS

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4 Claims. (Cl. 253—39.15)

This invention relates to the cooling of those parts—e. g. the blades—of the rotors of multi-stage axial flow turbines and in particular of gas turbines, which are heated by the hot working fluid. The invention is particularly applicable where the rotor is a hollow structure partitioned into an axially successive series of separate chambers each independently communicating with the blading of a different turbine stage, and separate supplies of coolant are provided to the interior of these separate chambers.

Broadly, according to the invention, separate streams of coolant admitted to the turbine interior and led separately to the different rings of blading, pass along the rotor by separate concentric paths having the rotor axis as their common axis. According to one form of the invention the rotor is mounted on shafting, including a tube within a hollow main shaft, so that independent paths are provided for supplies of coolant through the tube to one stage of the turbine and through one or more spaces between the tube and the wall of the bore of the main shaft to another stage of the turbine. Thus the bore of the main shaft may be of larger diameter than the outside of the inner shaft or the bore may be internally longitudinally grooved. As an addition to these concentric paths or as an alternative to one of them, the main shaft may also have external grooves forming another concentric path for coolant going to another stage of the turbine. If the rotor has three stages, the tube may supply the third stage, the annular internal space or internal grooves, the second stage, and the external grooves may supply the first stage.

The invention is intended to be applicable in particular, but not exclusively, to the turbine rotor cooling arrangement forming the subject matter of co-pending United States patent application Serial No. 271,601, filed February 14, 1952.

The invention makes it possible in certain cases to supply all the separate streams of coolant from one end of the turbine—viz. the opposite end from that from which the drive is taken to the load.

One particular construction according to the invention is shown in the accompanying drawings of which Figure 1 is a longitudinal section through the upper part of a three-stage gas turbine and Figure 2 is a cross section on the line A—A of Figure 1. In this construction the three-stage rotor is built up of three disc-like members or wheels **1**, **2** and **3**, each having a central hub and peripheral flange carrying conventional blades **4**, the flanges of adjacent wheels being secured together in some well-known manner as for example by screwed joints **5** and **6**. To one side of each ring of the rotor blades **4** is a ring of stator guide vanes **7** carried by the stator casing **8**. The rotor is supported by a main shaft which comprises stub shaft **9** formed on wheel **1** and by another stub shaft **10** formed on wheel **3** and mounted in bearings **11** and **12** at opposite ends of the rotor; these bearings are supported by the stator casing **8**.

Wheel **1** and its stub shaft **9** have an axial bore. The



wheel flanges where secured together at **5** and **6** are sealed together to close up each of the spaces between the webs of the wheels. Secured to a face of wheel **1** and rotating therewith, between the wheel and the bearing, is an annular enclosure member **13** also formed as a disc wheel with a rim abutting, at one edge, against the rim of the turbine wheel **1**. The spaces between wheel **1** and enclosure member **13**, between wheels **1** and **2** and between wheels **2** and **3** constitute separate air chambers **14**, **15** and **16**. Thus the wheels together constitute a rotor partitioned into an axially successive series of separate air chambers **14**, **15** and **16**. Holes **1***a*, **2***a* and **3***a* through the flanges of wheels **1**, **2** and **3** put chambers **14**, **15** and **16** into communication with cavities **17**, **18** and **19** under the roots of blades **4** which are hollow for flow of coolant in a well-known manner.

Separate paths for cooling gas (hereinafter called air) are provided longitudinally along the rotor from the end supported by bearing **11** into the chambers **14**, **15** and **16**. For this purpose a tube **20** has its inner end fitting into the bore of wheel **2** to form the passage for coolant to chamber **16** to cool the third stage, this tube **20** passing through the axial bore in the stub shaft **9** with such a considerable clearance space over a part of its length as to provide an annular passage **21** to admit coolant to chamber **15** for cooling the second stage of the turbine.

Fitting on and firmly secured to the outside of stub shaft **9** is a sleeve **22** which forms a journal seating for roller bearing **11***a* supported in the bearing housing forming part of stator casing **8**. Extending along the outside of stub shaft **9** and equally spaced therearound are several grooves **9***a* which alternate with splines **9***b* fitting in the sleeve **22**, these grooves forming passages for a third stream of coolant to chamber **14** for cooling the first stage. Hollow stub shaft **9** extends through the bearing **11**. The main shaft further comprises a hollow shaft extension piece **23** spigotted to stub shaft **9** which extends some distance further beyond the bearing; the cooling tube **20** passes right through the extension **23** and fits in and is secured thereto at its outer end. The grooves **9***a* in the external surface of the stub shaft **9** extend up to and are continued in the face of the hub of the wheel **1** wherein at **9***c* they curve smoothly from the axial to the radial direction.

The bearing end cap **24** on the end of the bearing housing is formed with an annular cavity **24***a* surrounding the shaft extension **23**. The tubular wall of the main shaft is apertured by holes **23***a* in the shaft extension **23** and these holes put cavity **24***a* into communication with the annular passage **21** around tube **20**. The end cap **24** has also a second annular cavity **24***c* surrounding the junction of stub shaft **9** and shaft extension **23**; cavity **24***c* thus communicates with all the grooves **9***a*.

The sectional view Figure 2 on line A—A through the internal cavity **24***c* in end cap **24** shows the tube **20**, the annular passage **21**, the stub shaft **9** with grooves **9***a* and the sleeve **22**. The view also shows that the end cap **24**, where it includes the cavity **24***c*, is provided with a boss **24***b* tapped to receive the coolant supply pipe and forming a tangential inlet for leading cooling fluid into the cavity **24***c* tangentially in a sense to give the incoming fluid a swirl in the direction of rotation of the stub shaft **9**. The end cap **24** is also similarly formed around the internal cavity **24***a*.

The stub shaft **10** passes through the bearing **12** and extends outside as the driving shaft from which power can be taken. Thus it will be seen that all three streams of coolant can be admitted at the end of the turbine opposite from the end supported by bearing **12** and from which the power is taken. The bearing **12**, which is shown only in external view, contains the usual journal and thrust bearings, all of which are of well-known form.

A disc like member **29** with a number of radial ribs is fastened to the left hand face of the turbine wheel **1** by being clamped between that wheel and the member **13**. A similar member **29** is clamped between wheels **1** and **2** and another between wheels **2** and **3**. These members **29** form enclosures and radial passages within the chambers **14**, **15** and **16** which radial passages are lined with polished sheet metal spaced from the walls of the chambers to form heat insulating air gaps.

The rim of enclosure member **13** co-operates with an annular stationary shroud **26** around the inside of the first ring of stator nozzle blades to form a labyrinth seal **30** to prevent leakage of the hot working gases from the gas path. This seal, being at the opposite end of the rotor from the thrust bearing, is formed to extend in a general direction nearly parallel to the turbine shaft axis, so that it will allow of the considerable possible relative movement due to differences of expansion of the rotor and stator as the turbine warms up to its working temperature. At the other end of the turbine, near to the thrust bearing, relative movement will be so small that a seal **31** can be formed between the faces of rotary member **27** and stationary member **28** with its general direction substantially radial. Axial adjustment of the rotor to adjust the spacing of this radial seal will be readily accommodated by relative movement of the axial seal members **13** and **26**.

For cooling the turbine, in operation, one stream of air is led into the end of the extension **25** and so into the open end of tube **20**, whence it flows into air chamber **16**, through the radial passages, and so to the blading of the third stage. A second stream of air is supplied into cavity **24***a* and thence through the annular passage **21** to the air chamber **15** and so to the blading of the second stage. A third stream of air is supplied to cavity **24***c* whence it flows through the grooves **9***a* and **9***c* to the air chamber **14** and so to the blading of the first stage.

What I claim is:

1. In a gas turbine having a stator, a chambered bladed rotor, a hollow shaft on said rotor communicating with the interior of said rotor, holes being provided through the wall of said hollow shaft into its interior, and a member formed firstly with a cavity which encircles, in the shape of an annulus, the portion of the hollow shaft having said holes and secondly with a coolant inlet to said cavity whose direction is generally tangential to the annulus, the annulus and said coolant inlet together defining a fluid swirl path in the direction of rotation of the hollow shaft.

2. In a gas turbine having a stator, a chambered bladed rotor, a shaft on said rotor, a sleeve fitting concentrically around said shaft, there being axially extending passages between said sleeve and said shaft formed by grooves in one of these said sleeve and shaft elements and communicating with the interior of the rotor, and a stationary member formed with a cavity which encircles, in the shape of an annulus, the shaft at the inlet end of said grooves, the member also having a coolant fluid inlet to said cavity whose direction is generally tangential to the annulus, the annulus and said coolant fluid inlet together defining a fluid swirl path in the direction of rotation of the hollow shaft.



3. A three-stage axial-flow gas turbine consisting of a stator, a chambered rotor having blading thereon, said rotor being internally partitioned into an axially successive series of separate chambers each communicating with the blading of a separate stage through apertures in the peripheral surface of said rotor, a driving shaft extending from one end of the rotor, a first bearing supporting said driving shaft, a hollow shaft on the other end of said rotor, with its interior communicating with at least one of said chambers in the middle of the series, a tube extending axially through said hollow shaft with some clearance space therearound, one end of said tube communicating with at least the one of said chambers nearest to said first bearing, an apertured wall terminating said clearance space towards the other end of said tube and defining a coolant fluid inlet to said clearance space, a bearing sleeve fitting concentrically around said hollow shaft, a second bearing supporting said sleeve, there being a plurality of axially extending passages formed between said hollow shaft and said sleeve by grooves in one of these said sleeves and shaft elements and communicating with at least the one of said chambers nearest to said second bearing and means defining a separate inlet for coolant to said grooves.

4. A gas turbine according to claim 10, including a member attached to said second bearing and having therein a first cavity extending around said hollow shaft in the form of an annulus at the inlet end of said grooves to constitute the said coolant fluid inlet thereto, a tangential inlet to said first cavity, and also having therein a second cavity extending in the form of an annulus around the said apertured wall defining the said fluid coolant inlet to said clearance space, and a tangential inlet to said second cavity, each of said tangential inlets together with its associated annulus defining a fluid swirl path in the direction of rotation of the hollow shaft.


**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,820,725 | Bailey | Aug. 25, 1931 |
| 1,880,747 | Bowen | Oct. 4, 1932 |
| 1,938,688 | Brooke | Dec. 12, 1933 |
| 2,339,779 | Holzwarth | Jan. 25, 1944 |
| 2,575,682 | Price | Nov. 20, 1951 |
| 2,611,532 | Ljungstrom | Sept. 23, 1952 |
| 2,657,901 | McLeod | Nov. 3, 1953 |