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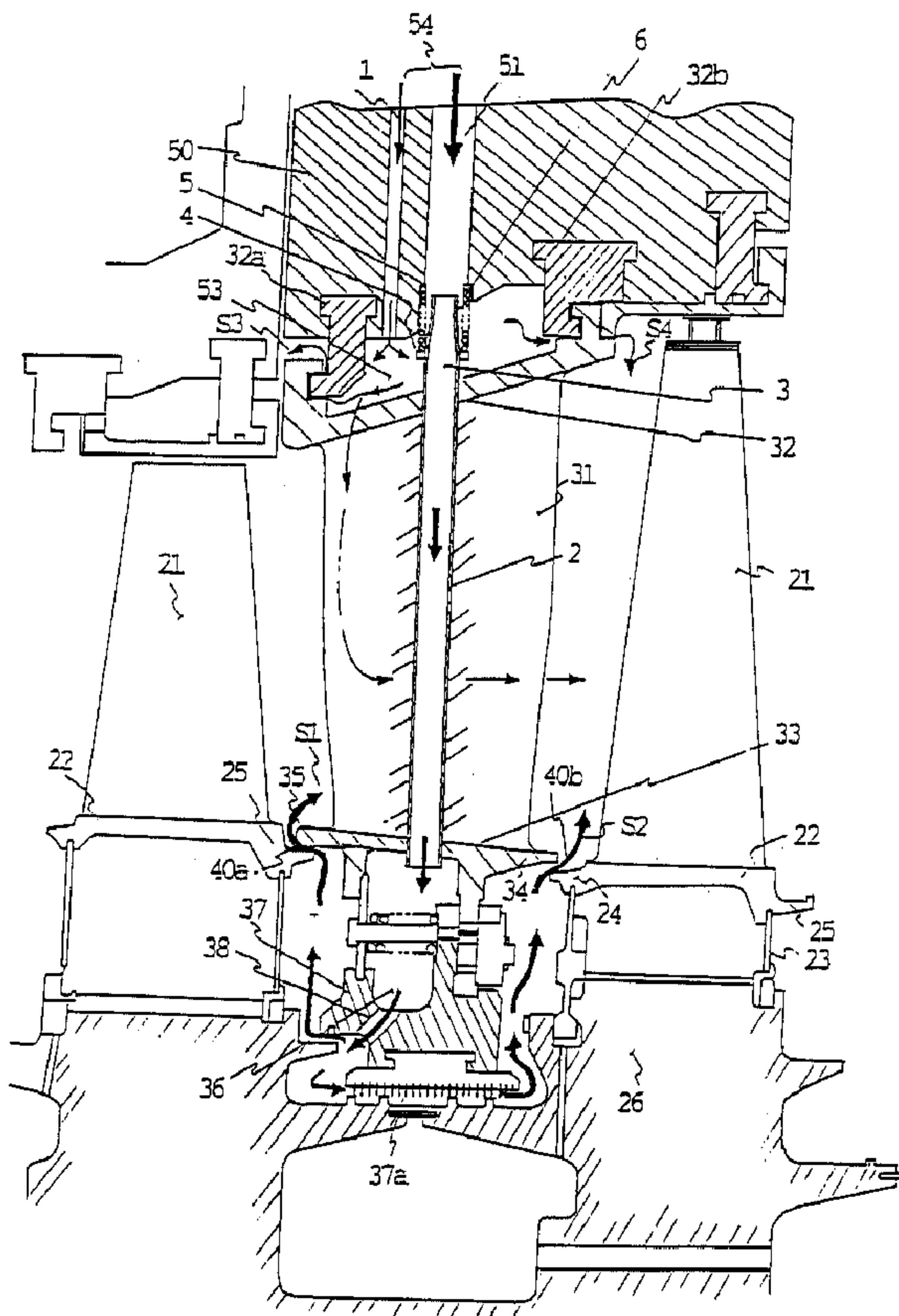
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(54) Titre : DISPOSITIF POUR SCELLER DES AUBES DE STATOR DE TURBINE A GAZ
(54) Title: SEALING DEVICE FOR GAS TURBINE STATOR BLADES



(57) Abrégé/Abstract:

A sealing device for a gas turbine stator blade, in which a sealing pressure of an inner shroud is raised to enhance a sealing effect. An outer shroud 32 is mounted through heat insulating rings 32a and 32b on a blade ring 50, and this blade ring 50 has



(57) Abrégé(suite)/Abstract(continued):

air holes 1 and 51, of which the air hole 1 communicates with a space 53 whereas the air hole 51 communicates with a seal tube 2. This seal tube 2 is inserted at its leading end portion 3 into the air hole 51, and a spring 6 is arranged between a projection 4 of the tube 2 and a retaining portion 5 of the air hole 51 to fix the seal tube 2 removably. Cooling air 54 flows on one side from the air hole 1 into the space 53 to cool the shrouds and the inside of a stator blade 31 until it is released from the trailing edge, and on the other hand into a cavity 36 so that the inside of the cavity 36 is kept at a high pressure without receiving a pressure loss because the tube 2 is independent of the space 53. The high pressure air from the cavity 36 flows out from seal portions 40a and 40b, as indicated by arrows S1 and S2, to prevent the inflow of the hot gas from a combustion gas passage.

ABSTRACT

A sealing device for a gas turbine stator blade, in which a sealing pressure of an inner shroud is raised to enhance a sealing effect. An outer shroud 32 is mounted through heat insulating rings 32a and 32b on a blade ring 50, and this blade ring 50 has air holes 1 and 51, of which the air hole 1 communicates with a space 53 whereas the air hole 51 communicates with a seal tube 2. This seal tube 2 is inserted at its leading end portion 3 into the air hole 51, and a spring 6 is arranged between a projection 4 of the tube 2 and a retaining portion 5 of the air hole 51 to fix the seal tube 2 removably. Cooling air 54 flows on one side from the air hole 1 into the space 53 to cool the shrouds and the inside of a stator blade 31 until it is released from the trailing edge, and on the other hand into a cavity 36 so that the inside of the cavity 36 is kept at a high pressure without receiving a pressure loss because the tube 2 is independent of the space 53. The high pressure air from the cavity 36 flows out from seal portions 40a and 40b, as indicated by arrows S1 and S2, to prevent the inflow of the hot gas from a combustion gas passage.

DESCRIPTION

TITLE OF THE INVENTION

Sealing Device for Gas Turbine Stator Blade

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TECHNICAL FIELD

The present invention relates to a stator blade for a gas turbine, which is enabled by improving the feed of sealing air to reduce leakage of the air thereby to feed the air to an inner shroud efficiently and by cooling the sealing air to reduce the clearance between a rotor side and a stationary side at a rated running time.

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BACKGROUND ART

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Fig. 14 is a general block diagram of a gas turbine, which is constructed to include a compressor 150, a turbine 151 and a combustor 152. A fuel is burned in the combustor 152 with the air coming from the compressor 150 so that a hot combustion gas is fed to the turbine 151. This combustion gas flows through a combustion gas passage, in which moving blades mounted on a rotor and stator blades are alternately arranged in multiple stages, to rotate the rotor thereby to drive a power generator connected directly to the rotor. Since the turbine 151 is exposed to the hot combustion gas, on the other hand, the air from the compressor 150 is partially bled and fed

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to the turbine 151 to cool the stator blades, the moving blades and the rotor.

Fig. 15 is a section showing a sealing air feed line to a representative stator blade of a gas turbine of the prior art, and shows the construction of the blades in the turbine 151 of Fig. 14.

In Fig. 15, reference numeral 21 designates a moving blade including a platform 22, a seal plate 23 under the platform 22, two end portions 24 and 25 of the platform 22, and a blade root 26. A plurality of moving blades 21 each composed of those members are arranged in the circumferential direction of the rotor.

Reference numeral 31 designates a stator blade which is arranged adjacent to the moving blade 21. Numeral 32 designates an outer shroud, and numeral 33 designates an inner shroud. Numerals 34 and 35 designate two end portions of the inner shroud 33, and numeral 36 designates a cavity under the inner shroud 33. Numeral 37 designates a seal ring retaining ring which has a labyrinth seal 37a at its end portion and which slides with respect to the rotating portion of the blade root 26 on the moving blade side. Numeral 38 designates an air hole which is formed through the seal ring retaining ring 37 to provide communication between the cavity 36 and a space at the blade root 26 of the adjoining moving blade 21. Numerals 40a and 40b designate seal portions between the platform 22 and the

inner shroud 33 adjoining each other and are constructed by fitting seal members between the end portions 24 and 34, and 25 and 35.

5 Numeral 50 designates a blade ring, on the inner side of which the outer shroud 32 of the stator blade 31 is fixed through heat insulating rings 32a and 32b. Numeral 51 designates an air hole which is formed in the blade ring 50. This air hole 51 communicates with a space 53, which is formed by the blade ring 50, the heat insulating rings 32a and 32b and 10 the outer shroud 32, and is connected at its leading end with an air source leading from the not-shown compressor. Numeral 52 designates a seal tube which is extended from the outer shroud 32 in the stator blade 31 through the inner shroud 33.

In the construction thus far described, cooling air 54 15 from the compressor is fed from the air hole 51 of the blade ring 50 and into a space 53. This cooling air 54 flows on one side through the seal tube 52 into the cavity 36 under the inner shroud 33. The cooling air from this cavity is blown from the air hole 38, as indicated by arrow S1, into the trailing 20 side space of the adjoining moving blade 21 at the upstream side and further through the labyrinth seal 37a into the leading side space of the moving blade 21 at the trailing stage, as indicated by arrow S2. These cooling air flows S1 and S2 emanate from the seal portions 40a and 40b, respectively, to 25 prevent the combustion gas from entering the inside of the

inner shroud 33.

On the other hand, the air having entered the space 53 cools the face of the outer shroud 32 and enters the cooling passage in the stator blade, as described with reference to Fig. 16, so that it is blown out of the holes of the trailing edge while cooling the blade inside, until it is released to the combustion gas passage.

In the sealing structure thus far described, the air hole 51 of the blade ring has a diameter of 2 to 50 mm, and the seal tube 52 is limited in its internal diameter by the thickness and the camber of the blades. As a result, the air to flow in is subjected to a pressure loss so that its pressure drops. In addition, the cooling air having entered the space 53 leaks from the clearances between the outer shroud 32 and the heat insulating rings 32a and 32b, as indicated by arrows S3 and S4.

Here will be described one example of the pressure situations resulting from the aforementioned leakage. The cooling air 54 to flow into the air hole 51 of the blade ring 50 has a pressure of about 6 Kg/cm². This pressure is lowered to about 5 Kg/cm² in the space 53 by the pressure loss and further to 3.5 Kg/cm² in the cavity 36 by the pressure loss. This pressure level is equal to the pressure of 3.5 Kg/cm² between the moving blade 21 and the stator blade 31 adjoining each other so that the sealing effect is deteriorated.

A first problem of the sealing structure for the gas turbine stator blade of the prior art thus far described is that the cooling air fed from the air hole 51 of the blade ring 50 leaks from the clearances between the outer shroud 32 and the heat insulating rings 32a and 32b, as described hereinbefore, although it flows into the space 53 between the blade ring 50 and the outer shroud 32 and into the cavity 36 under the inner shroud 33 from the seal tube 52. On the other hand, the cooling air is subjected to the pressure loss in the seal tube 52 so that its pressure drops when it flows into the cavity 36 of the inner shroud. As a result, the difference from the pressure of the combustion gas disappears to make it difficult for the cooling air to keep a sufficient pressure as the sealing air.

Fig. 16 is a section showing a stator blade of the gas turbine of the prior art and explains the cooling of the stator blade mainly although the stator blade has the same structure as that of Fig. 15. In the stator blade 31, as shown in Fig. 16, air passages 80A, 80B and 80C are sequentially formed to form a serpentine passage. Reference numeral 80D designates the trailing edge of the blade, which has a number of film cooling air holes 60. The seal tube 52 vertically extends through the stator blade 31. The inner shroud 33 has the cavity 36, into which the seal tube 52 is opened at its lower end. The seal ring retaining ring 37 retains the flange of the inner shroud 33

and the labyrinth seal 37a. The air hole 38 is formed in the retaining ring 37 to provide the communication of the cavity 36 with a space 72 between the former and the adjoining moving blade. The outer shroud 32 has a cooling air feeding hole 62. The numeral 21 designates the adjoining moving blade 21.

In the stator blade thus constructed, cooling air 70 is fed from the hole 62 of the outer shroud 32 to the air passage 80A on the leading edge side of the stator blade 31 and flows at the inner side into the next air passage 80B and then at the outer side into the adjoining air passage 80C. The cooling air 70 then flows at the inner side to cool the stator blades 31 sequentially and further flows from the air holes 60 of the trailing edge 80D along the outer surfaces of the trailing edge to effect the film cooling.

From the open end of the seal tube 52 of the outer shroud 32, on the other hand, cooling air 71 for the cooling operation flows from the lower end of the seal tube 52 into the cavity 36, as shown in Fig. 15, so that its portion flows from the air hole 38 formed in the cavity 36 into the space 72 between the former and the adjoining moving blade and further through the labyrinth seal 37a into a forward space 73. Thus, the cooling air flows from the seal tube 52 into the cavity 36 to keep the inside of the cavity 36 at a higher level than that in the outside combustion gas passage thereby to prevent the hot combustion gas from entering the inside. Although not

shown, on the other hand, the air from the compressor passes the disc cavity and flows from the radial hole formed in the blade root 26 to the inside of the platform 22 so that it is guided to cool the moving blade 21.

5 The gas turbine stator blade of the prior art is provided therein with the air passage for cooling, as has been described hereinbefore. This air passage is ordinarily formed into the serpentine passage, and the cooling air is fed from the outer shroud into the air passage to cool the inside of the
10 stator blade until it is released from the trailing edge to the outside. Separately of the cooling purpose, on the other hand, the seal tube is extended through the stator blade to feed a portion of the cooling air as the sealing air from the outer
15 shroud into the cavity of the inner shroud, which is kept at a higher pressure than that in the external combustion gas passage to prevent the hot combustion gas from entering the inside.

 In the stator blade cooling system thus far described, the much cooling air is fed for the cooling purpose and for the
20 sealing purpose. The cooling air cools the stator blade and is then released from the trailing edge to the combustion gas passage. On the other hand, a portion of the cooling air is bled as the sealing air and is fed through the seal tube to the cavity so that it is released from the cavity into the spaces
25 between the former and the adjoining front and rear moving

blades. In addition to the pressure loss of the foregoing first embodiment, therefore, a second problem of the sealing device for the gas turbine stator blade is raised from the fact that much air is consumed for the cooling and sealing purposes so that the capacity of the compressor increases to burden a serious power on the performance of the gas turbine.

Fig. 17 is a section showing a general blade cascade of the gas turbine and shows the entire cascade of the stator blades shown in Fig. 15 or 16. Reference numerals 81C, 82C, 83C and 84C in Fig. 17 designate the stator blades which are individually arranged in plurality radially around the rotor and on the stationary side. Numerals 81S, 82S, 83S and 84S designate the moving blades which are mounted around the rotor through their respective roots and which are axially arranged alternately of the stator blades so that they may rotate together with the rotor. Numerals 111C, 112C, 113C and 114C designate the individual inner shrouds of the stator blades 81C to 84C, and numerals 111S, 112S, 113S and 114S designate the individual plat forms of the moving blades 81S to 84S.

Numerals 37-1, 37-2 and 37-3 designate the seal ring retaining rings which are respectively fixed on the flanges of the inner shrouds 111C to 114C of the stator blades 81C to 84C and arranged in an annular shape around the rotor. These seal ring retaining rings 37-1 to 37-3 retain on their insides the labyrinth seals (or seal rings) adjacent to the rotor. Thus in

the example shown in Fig. 17, the gas turbine is constructed of the stator blades and the moving blades of four stages. With this construction, the rotor is rotated to drive a generator by the combustion gas coming from the combustor.

5 In the gas turbine, as described with reference to Figs. 15 and 16, the stator blades, the moving blades and the rotor are exposed to the hot gas which is at 800 to 1,000 °C at the entrance or up to 1,500 °C, as developed in the recent years, so that they are cooled with the cooling air by bleeding it from
10 the compressor. A constant clearance is necessary between the rotor side and the stationary side of the rotary members. In Fig. 17, a clearance CR' is retained between the lower end of the labyrinth seal 37a supported by the seal ring retaining ring 37 and the opposed face on the rotor side. Between the
15 individual turbine stages, the clearance CR' is given the minimum from the start to the rated rotating speed by the time difference of the thermal elongation between the rotor side and the stationary side and increases from the minimum when the rated rotating number is reached as the clearance is heated by
20 the combustion gas. This clearance CR' is preferably the smaller for the higher sealing performance. Since the clearance is given the minimum after the start by the aforementioned characteristics, however, the design value cannot be made so small while estimating not only that minimum but
25 also the vibration during the run and the manufacture error.

Therefore, a third problem is that a large clearance is caused to deteriorate the sealing performance when the rotation reaches the rated value after the run. Thus, it has been desired to optimize the clearance for causing improvement in the drop of the sealing pressure due to the pressure loss of the
5 aforementioned first problem and the consumption of the high flow rate of the second embodiment and to reduce the clearance during the run.

10 DISCLOSURE OF THE INVENTION

 In order to solve the first problem, therefore, it is an object of the invention to provide a sealing device for a gas turbine stator blade, which is enabled to enhance the sealing effect by devising the feed line of sealing air to be fed from
15 the blade ring into the stator blade, thereby to reduce the air flow to leak from the outer shroud and to feed the sealing air under a sufficient pressure to the inner shroud.

 Another object of the invention is to provide a sealing device for a gas turbine stator blade, which has the enhanced
20 sealing effect and which can be easily assembled and disassembled for its assembly and maintenance by adopting a removable structure for the sealing air feeding seal tube and can achieve the sealing effect with a simple structure.

 In order to solve the second problem, on the other hand,
25 it is still another object of the invention to reduce the

cooling air flow and to contribute to an improvement in the performance of a gas turbine by improving the system for feeding the cooling air and the sealing air for the stator blade of the gas turbine to use the cooling air and the sealing air commonly.

In order to solve the third problem, moreover, a further object of the invention is to improve the sealing performance by cooling the seal ring retaining ring with the sealing air in a manner to make the clearance between the rotor side and the stationary side smaller than that of the prior art, even if the clearance is thermally elongated during the run between the individual stages of the gas turbine, thereby to improve the sealing performance.

In order to achieve these individual objects, according to the invention, there are provided the following means (1) to (4).

(1) A sealing device for a gas turbine stator blade, in which air is guided from an air hole formed in a blade ring through a space formed by said blade ring, a heat insulating ring and an outer shroud and further from said space through a seal tube in the stator blade into an inner shroud, so that the pressure in a cavity of said inner shroud may be held at a higher pressure than that in a combustion gas passage to seal the inside of said inner shroud, characterized in that said air hole includes an air hole communicating with said seal tube and

an air hole communicating with said space.

(2) A sealing device for a gas turbine stator blade as set forth in (1), characterized in that said seal tube is removably connected to the blade ring air hole communicating with said seal tube.

(3) A sealing device for a gas turbine stator blade characterized in that an air passage is formed in a blade and fed with cooling air from an outer shroud to cool said blade, so that the cooling air is then fed as sealing air from said air passage via an air hole formed in an inner shroud to an inner cavity.

(4) A sealing device for a gas turbine stator blade, in which a portion of air is bled from a compressor and guided via a space formed by an outer shroud into a stator blade and further through said stator blade into a cavity formed by an inner shroud and a seal ring retaining ring, to make the pressure in said inner shroud higher than that in a combustion gas passage thereby to seal the inside of said inner shroud, characterized in that the air bled from said compressor is cooled by a cooler and is then guided into said stator blade to cool said seal ring retaining ring with the air cooled by said cooler.

In the means (1) of the invention, the space, which is formed by the wind ring, the heat insulating ring and the outer shroud, is fed with the air from the air hole communicating

with the space, and this air is guided to the cooling passage in the stator blade while cooling the face of the outer shroud and is released from the holes of the blade trailing edge while cooling the blade inside.

5 On the other hand, the seal tube is fed with the air from the air hole communicating therewith and is independent of the space so that the air can be fed to the inner shroud without being influenced by the air flow to leak from the space through the clearance between the outer shroud and the heat
10 insulating ring joint and with receiving little pressure loss. As a result, the cavity in the inner shroud can be kept at a higher pressure than that of the combustion gas passage to enhance the sealing effect.

 In the means (2) of the invention, the leading end of
15 the seal tube is removably connected to the air hole so that it can be easily inserted and fixed in and removed from the stator blade at the assembly or maintenance of the stator blade.

 In the means (3) of the invention, the air having passed the air passage in the stator blade and cooled the blade is
20 guided as the sealing air for the stator blade so that the seal tube can be dispensed with unlike the prior art. In the prior art, a portion of the cooling air is guided as the sealing air from the outer shroud and directly into the cavity through the seal tube and is uselessly released after having cooled the
25 blade from the trailing edge to the combustion gas passage. In

the means (3) of the invention, cooling air passes the air passage in the stator blade to cool the blade and then flows as the sealing air from the air hole of the inner shroud into the cavity so that the pressure in the cavity is kept higher than that of the outside to prevent the hot gas from entering the inside. As a result, the seal tube can be dispensed with to contribute to cut the cost, and the cooling air is effectively used to reduce its flow rate thereby to improve the performance of the gas turbine.

10 In the means (4) of the invention, in addition to the improvement in the sealing effect by the constructions of the aforementioned means (1) and (2), the clearance between the stationary side and the rotor side at the rated running time. Specifically, the seal ring retaining ring of the gas turbine
15 is mounted on the flange of the inner shroud of the stator blade and is made annular to retain the seal ring on its inner side. The rotor is rotating while keeping a predetermined clearance between the seal ring or the stationary side and the rotor side so that the sealing effect becomes the better for the smaller clearance. When the rated run is reached by the
20 thermal elongation during the run, however, the clearance grows rather larger than the initial set value so that the sealing performance lowers. Specifically, the clearance is determined by the difference of the thermally elongated size between the
25 stator side and the rotor side, and the thermally elongating

characteristics are so different between the stationary side and the rotor side that the thermal elongation is larger on the stationary side than on the rotor side. At the running time at the rated rotating speed, the difference exceeds the initial clearance.

In the means (4) of the invention, therefore, the sealing air is cooled by the cooler and used to cool the seal ring retaining ring. At the seal ring retaining ring, i.e., on the stationary side, therefore, the temperature difference between the starting (or cold) time and the running (or hot) time is smaller than that of the prior art in which the seal ring retaining ring is not cooled. As a result, the thermal elongation on the stationary side at the rated running time is smaller than that of the prior art, and the clearance when the rated rotating speed is reached, that is, the difference of the thermal elongation between the stationary side and the rotor side is also smaller than that of the prior art so that the sealing air is accordingly reduced to improve the sealing performance.

In the invention, moreover, the seal ring retaining ring is cooled so that the thermal elongation at the seal ring retaining ring, i.e., on the stationary side is made gentler from the start than that of the prior art. As a result, the initially clearance can be set at a larger value than that of the prior art with the resultant advantages in the design and

manufacture.

According to one aspect of the invention, there is provided a sealing device for a gas turbine stator blade, in which air is guided from air holes formed in a blade ring through a space formed by said blade ring, a heat
5 insulating ring and an outer shroud, the air being further guided from said space through a seal tube in the stator blade into an inner shroud, such that a pressure in a cavity of said inner shroud may be maintained at a higher pressure than that in a combustion gas passage to seal the interior of said inner shroud; wherein said air holes include a first air hole communicating
10 with said space, and a second air hole communicating with said seal tube.

According to another aspect of the invention, there is provided a stator blade sealing arrangement for a gas turbine, said sealing arrangement comprising a stator blade having an outer shroud and an inner shroud; a blade ring connected to said outer shroud, said blade ring including a first
15 air hole and a second air hole; heat insulating rings connecting said blade ring with said outer shroud; a radial space defined by said heat insulating rings, said outer shroud, and said blade ring, wherein said first air hole communicates with said radial space; a seal tube extending from said second air hole, through said radial space and said stator blade and into
20 said inner shroud, said seal tube having a first end communicating with said second air hole; wherein air bled from a compressor can be guided into said radial space, via said first air hole, and into an interior of said inner shroud through said seal tube, via said second air hole, so that pressure in a cavity of said inner shroud can be maintained at a higher pressure than a
25 pressure in a combustion gas passage.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Fig. 1 is a diagram showing the entire construction of a gas turbine plant to which a gas turbine stator blade of the invention is applied;

Fig. 2 is a section showing the entirety of a sealing device for a gas turbine stator blade according to the first embodiment of the invention;

10 Fig. 3 is a perspective view showing an assembled state of the sealing device for a gas turbine stator blade according to the first embodiment of the invention;

15 Fig. 4 is a section showing a seal tube leading end portion of the sealing device for a gas turbine stator blade according to the first embodiment of the invention;

Fig. 5 is a section showing another example of the seal tube leading end portion of the sealing device for a gas turbine stator blade according to the first embodiment of the invention;

20 Fig. 6 is a section showing a seal tube leading end portion of a sealing device for a gas turbine stator blade according to a second embodiment of the invention;

25 Fig. 7 is a section showing another example of the seal tube leading end portion of the sealing device for a gas turbine stator blade according to the second embodiment of the

invention;

Fig. 8 is a section showing an application example of Fig. 6 of the sealing device for a gas turbine stator blade according to the second embodiment of the invention;

5 Fig. 9 is a section showing an application example of Fig. 7 of the sealing device for a gas turbine stator blade according to the second embodiment of the invention;

10 Fig. 10 is a section showing the neighborhood of a seal ring retaining ring of the gas turbine stator blade according to the first and second embodiments of the invention;

15 Fig. 11 is a characteristic diagram illustrating comparisons with the prior art in thermal elongations on a rotor side and a stator side by cooling a gas turbine seal ring retaining ring according to the first and second embodiments of the invention;

Fig. 12 is a section showing a sealing device for a gas turbine stator blade according to a third embodiment of the invention;

20 Fig. 13 is a section taken in the direction of arrows A - A of Fig. 12;

Fig. 14 is a diagram showing a general construction of the gas turbine of the prior art;

Fig. 15 is a section showing a sealing structure of the gas turbine stator blade of the prior art;

25 Fig. 16 is a section of the gas turbine stator blade of

the prior art and shows flows of sealing air and cooling air;
and

Fig. 17 is a diagram showing a blade array and a seal
ring retaining ring of the gas turbine of the prior art.

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BEST MODE FOR CARRYING OUT THE INVENTION

The invention will be described in detail in connection
with its embodiments with reference to the accompanying drawings.
Fig. 1 is a diagram showing a construction of the entirety of
a gas turbine. As shown, the gas turbine is constructed to
include a compressor 150, a turbine 151 and a combustor 152. In
the combustor 152, the fuel is burned with the air coming from
the compressor so that a hot combustion gas is generated and fed
to the turbine 151. On the other hand, the construction, in
which the air from the compressor 150 is bled via a bleeder line
153 and fed through the turbine 151 into a rotor, moving blades
and stator blades until it cools down, is identical to that of
the prior art, as shown in Fig. 14. In the embodiments of the
invention, on the other hand, a cooler 154 is disposed, if
necessary, midway of the bleeder line 153 so that it can cool
the cooling air coming from the compressor 150. This cooler
154 is used, if necessary, for cooling especially a seal ring
retaining ring, as shown in Figs. 10 and 11, in the invention.
Fig. 2 is a section showing a sealing device for a stator blade
in the turbine 151 of the gas turbine, as described

hereinbefore, and shows a first embodiment of the invention.

5 In Fig. 2, the structure of the moving blade, as designated by the reference numerals 21 to 26, the structure of the stator blade, as designated by the numerals 31 to 38, and the entire structure of the stator blade and the moving blade, as designated by the numerals 40, 50, 51 and 53, are given the same functions as those of the prior art shown in Fig. 15. Therefore, they are quoted as they are although their descriptions are omitted. The portions featuring the invention are located at the reference numerals 1 to 6, as will be described in detail.

10 Reference numeral 1 appearing in Fig. 2 designates an air hole which is so formed separately of the air hole 51 in the blade ring 50 as to communicate with the space 53. Numeral 2 designates a seal tube which is extended from an outer shroud 32 through the inside of a stator blade 31 and further through an inner shroud 33 and is inserted into a cavity 36. A seal tube leading end portion 3 is extended into the space 53 and is inserted into the air hole 51.

20 Numeral 4 designates a projection fixed around the leading end portion 3 of the seal tube 2, and numeral 5 designates a retaining portion formed at the blade ring 50 on the exit side of the air hole 51 and having an enlarged radius. Numeral 6 designates a coil spring which is arranged around the seal tube leading end portion 3. When this coil spring is

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given an elastic force, its one end goes into the air hole 51 and is retained on the step of the retaining portion 5, and its other end is held by the projection 4 to push the projection with the elastic force thereby to fix the seal tube leading end portion 3.

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Fig. 3 is a perspective view showing the assembled state of the stator blade. When the stator blade 31 is to be assembled, as shown, in order to insert the seal tube 2 into the air hole 51 of the blade ring 50, the outer shroud 32 bearing the seal tube 2 and the spring 6 is covered with the blade ring 50 while inserting the seal tube 2 into the air hole 51. Next, heat insulating rings 32a and 32b are carried one by one in a circumferential direction (or in a direction R) to attach the outer shroud 32. The detachment is performed in the reversed order. In this assembly, the spring 6 is elongated by its elastic force between the projection 4 of the seal tube leading portion 3 and the enlarged retaining portion 5 of the air hole 51 so that the seal tube 2 can be fixed in the blade ring 50.

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Fig. 4 is a section showing the state in which the seal tube leading end portion 3 is mounted in the air hole 51. As shown, the seal tube leading end portion 3 is slightly fitted in the air hole 51 and is surrounded by the spring 6. This spring 6 is fitted with the elastic force between the projection 4 formed on the seal tube 2 and the radially enlarged retaining

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portion 5 in the air hole 51 of the blade ring 50 so that its elastic force fixes the seal tube 2 in the air hole of the blade ring 50.

Fig. 5 is a section showing another example of the first embodiment of the state in which the seal tube leading end portion is fitted in the air hole. On the leading end of the seal tube 2, there is fitted a removable adapter 7, the leading end of which is inserted into the air hole 51 of the blade ring 50. The adapter 7 is provided with a projection 8, and the spring 6 is fitted with the elastic force between the projection and the enlarged retaining portion 5 formed in the air hole 51, to fix the seal tube with its elastic force. Thus in the example shown in Fig. 5, the seal tube 2 is fixed through the adapter 7.

In the sealing device for the gas turbine stator blade thus far described according to the first embodiment, a portion of the cooling air, as bled from the compressor, flows from the air hole 1 into the space 53 which is formed by the blade ring 50, the outer shroud 32 and the heat insulating rings 32a and 32b. The air thus having flown into the space 53 cools the face of the outer shroud 32 as in the prior art, then go into the cooling passage inside the stator blade 31 that is not shown, and blows out from the trailing edge while cooling the blade inside, as has been described in connection with the example of the prior art of Fig. 16, until it is released to the

combustion gas passage.

A portion of the air having entered the space 53 leaks, as indicated by arrows S3 and S4, from the clearances between the outer shroud 32 and the heat insulating rings 32a and 32b into the combustion gas passage, but exerts no influence on the pressure of the sealing air because it is independent of the lines of the sealing air hole 51 and the seal tube 2.

On the other hand, the cooling air 54 flows from the air hole 51 into the seal tube 2 and goes into the cavity 36 in the lower portion. The cooling air further flows from the cavity 36 via an air hole 38, which is formed in a seal ring retaining ring 37, into the space, as indicated by arrow S1, between the adjoining moving blade 21 and stator blade 31, until it flows out to the combustion gas passage through a seal portion 40a.

On the other hand, the air in the cavity 36 flows via the air hole 38 and through a labyrinth seal 37a into the space between the labyrinth seal 37a and the adjoining downstream moving blade 21 until it flows through a seal portion 40b, as indicated by arrow S2, into the combustion gas passage. Thus, the hot combustion gas is prevented, by the outflow of the sealing air from the seal portions 40a and 40b, from entering the inside of the stator blade from the combustion gas passage.

Here will be described one example of the pressure state in the air passages thus far described. The cooling air 54 is at about 6 Kg/cm². When the cooling air 54 flows into the air

holes 1 and 51, it is subjected in the space 53 to a pressure loss by the inflow from the air hole 1 so that it takes about 5 Kg/cm² as in the prior art. However, the air to flow from the air hole 51 is independent of the space 53 so that it flows without any substantial pressure loss from the seal tube 2 into the cavity 36 to keep the pressure in the cavity 36 at about 5 Kg/cm².

In the prior art, the pressure in the cavity 36 is lowered to about 3.5 Kg/cm² because the air flowing from a seal tube 52 receives the pressure loss. In the first embodiment of the invention, however, the pressure in the cavity can be kept as high as 5 Kg/cm². By this high pressure in the cavity 36, the air is expelled, as indicated by the arrows S1 and S2, from the seal portions 40a and 40b into the combustion gas passage, which is at about 3.5 Kg/cm² so that the sealing pressure is so high as to provide a sufficient sealing effect.

For the assembly or disassembly of the stator blade, on the other hand, the leading end of the seal tube 2 can be easily fixed in the air hole 51 of the blade ring 50 by compressing the spring 6, by inserting the seal tube leading end slightly into the air hole 51 and by elongating the spring 6. If the structure shown in Fig. 5 is adopted, on the other hand, the attachment and detachment are facilitated by handling the adapter 7 and the spring 6. According to this fixing method using the spring 6, moreover, the thermal elongation, if any,

of the seal tube 2 can be admitted by the air hole 51 against the elastic force of the spring 6 so that it can be absorbed.

Figs. 6 to 9 show a sealing device for a gas turbine stator blade according to a second embodiment of the invention, which is different from the first embodiment in that a bellows 9 is used to seal the inserted portion of the blade ring 50 of the seal tube leading end portion 3 into the air hole 51. The remaining construction is identical to that of the first embodiment so that its description will be omitted.

10 In Fig. 6, the construction of Fig. 4 is provided with the bellows 9 to seal the seal tube leading end portion 3. This bellows 9 is fixed at its upper end around the air hole 51 of the blade ring 50 by a soldering method or the like and at its lower end around the seal tube 2 likewise by the soldering method or the like. In Fig. 7, the construction of Fig. 5 is 15 provided with the bellows 9, which is fixed at its lower end around the adopter 7. The remaining construction is identical to that of Fig. 6. In Fig. 8, on the other hand, the spring 6 and the projection 4 are eliminated from the construction of Fig. 6, but only the bellows 9 is likewise attached to the construction so that its elongation and contraction may take the action of the spring force. In Fig. 9, the spring force is 20 likewise given to the construction of Fig. 7 exclusively by the bellows 9.

25 In the second embodiment shown in Figs. 6 to 9, the

sealing air to be fed to the seal tube 2 is more completely sealed than the first embodiment so that the sealing effect can be more enhanced.

Here in this second embodiment, the description has been made on the example in which the lower end of the bellows 9 is fixed by the soldering method or the like, but the bellows 9 may be fixed by binding or elastically fastening it.

Fig. 10 is an enlarged section showing the neighborhood of the seal ring retaining ring in the first and second embodiments of the invention, and shows a portion of the stator blade at the second stage. The air, as bled from the compressor 150, is cooled by the cooler 154 shown in Fig. 1. The cooling air thus cooled by the cooler 154 is introduced from the seal tube 2 of the stator blade 31 into the cavity 36 to keep the cavity at a high pressure as in the prior art while cooling the seal ring retaining ring 37.

Reference letters $\triangle A1$ and $\triangle A2$ designate the thermal elongations in the radial direction of the front and rear stages, as confronting the seal ring mounted on the seal ring retaining ring 37, on the rotor side, and letters $\triangle B$ designate the thermal elongation of the seal ring end face, as held by the seal ring retaining ring 22, on the stationary side. Of these, the thermal elongations $\triangle A1$ and $\triangle A2$ are substantially equal to each other, but the thermal elongation $\triangle B$ exhibits characteristics different from those of the

elongations $\triangle A1$ and $\triangle A2$.

Fig. 11 plots the thermal elongations in the radial direction on the stationary side and the rotor side in a manner to compare the prior art, in which the seal ring retaining ring 37 is not cooled, and the invention in which the same is cooled. In Fig. 11, letters $\triangle B'$ designate a thermal elongation of the end face of the labyrinth seal 37a (or the seal ring) supported by the seal ring retaining ring 37 and plot the characteristics of the prior art, in which the seal ring retaining ring 37 is not cooled. According to these characteristics, the thermal elongation occurs after the run gradually from the initial clearance S1 and is saturated to a constant level for 4 mm or more at the rated rotation time.

Letters $\triangle A1$ and $\triangle A2$ designate the thermal elongations of the face confronting the seal ring on the rotor side. According to these characteristics, the thermal elongation more abruptly occurs than the elongation $\triangle B$ for ten minutes after the run and then increases little by little until it is saturated at a lower level than the elongation $\triangle B$ at the rated rotation time. The elongations $\triangle A1$ and $\triangle A2$ exhibit the substantially equal values, and the elongation $\triangle A1$ is located on the front stage side and is slightly larger. However, the elongations $\triangle A1$ and $\triangle A2$ exhibit the substantially identical characteristics.

Letters $\triangle B$ designate a thermal elongation of the seal

ring end face of the invention of the case the air is cooled by the cooler 154 to cool the seal ring retaining ring 37. The thermal elongation ΔB has an initial value S2 rather larger than the value S1 of the prior art. The characteristics of this thermal elongation ΔB are gentler than those of the elongation $\Delta B'$, and the thermal elongation is saturated at a lower value at the rated rotation time.

The thermal elongation ΔL of a body is generally expressed by $\Delta L = \alpha \cdot L \cdot \Delta T$, wherein: α indicates a coefficient of linear expansion; L indicates the length of the body; and ΔT indicates a temperature difference. Since the thermal elongation ΔL can be reduced according to the formula by reducing the temperature difference ΔT , this difference between the temperature at an assembly (or cold) time and the temperature at a running (hot) time is reduced by cooling the air by the cooler 154 to cool the seal ring holding ring 37 with the air so that the thermal elongation of the seal ring holding ring 37 can be reduced to make the ΔB smaller than the $\Delta B'$.

Reverting to Fig. 11, the thermal elongations $\Delta A1$ and $\Delta A2$ really fluctuate depending upon a vibration at the start or upon an error at the manufacture or assembly. If this error is designated by TL, the thermal elongation $\Delta B'$ of the prior art, for which the run has been started with the initial clearance S1, reaches the minimum clearance MCR' before ten minutes and

then gradually increases up to thirty minutes, until it is saturated at 4 mm or more when the rated rotating speed is reached. On the other hand, the thermal elongations $\Delta A1$ and $\Delta A2$ on the rotor side increases more steeply at the start but are saturated at lower levels. At the rated rotating time, the difference from the $\Delta B'$, i.e., the clearance at the hot time takes a large value, as indicated by CR'.

On the other hand, the thermal elongation ΔB of the invention has the initial clearance S2 which is set larger than the S1 of the prior art. Since the air is cooled by the cooler 154 to cool the seal ring retaining ring 37 thereby to make the temperature difference smaller than that of the prior art between the at the starting (or cold) time and at the running (or hot) time, as described hereinbefore, the thermal elongation ΔB is gentler than the $\Delta B'$ so that the minimum clearance MCR occurs after about ten minutes later than the prior art. At the rated rotating time, on the other hand, the thermal elongation is saturated at a lower level than that of the prior art so that the difference between the $\Delta A1$ and $\Delta A2$ at the rated rotating time, i.e., the clearance can take the value CR smaller than CR' of the prior art.

In the first and second embodiments of the invention, as described hereinbefore, in addition to the aforementioned improvement in the sealing effect, the sealing air to the stator blades at the individual stages is cooled by the cooler 154 and

fed to the cavity 36 to cool the seal ring retaining ring 37 so that the temperature difference between the starting time and the running time can be made lower than that of the prior art, in which the sealing air is not cooled, to reduce the clearance between the seal portions on the rotor side and the stationary side at the rated rotating time.

In the aforementioned case, moreover, the clearance at the rated running time can be made smaller than that of the prior art even if the initial clearance is enlarged from the S1 to the S2, so that advantages in the design and manufacture can be achieved to improve the sealing performance.

Fig. 12 is a section showing a gas turbine stator blade according to a third embodiment of the invention, and Fig. 13 is a section A - A of Fig. 12. In the stator blade 31, as shown in Figs. 12 and 13, there are formed air passages 80A, 80B and 80C which sequentially communicate with one another to form a serpentine passage. Reference numeral 80D designates a trailing edge having a number of film cooling air vents 60. Numeral 64 designates a turbulence generator which is exemplified by a projecting fins formed on the individual inner walls of the air passages 80A, 80B and 80C to enhance the heat transfer efficiency by making the inflow of the cooling air turbulent.

The cavity 36 is formed in the inner shroud 33. The seal ring retaining ring 37 retains the flange of the inner shroud 33 and the labyrinth seal 37a. The air hole 38, as

formed in the seal ring retaining ring 37, has communication with a space 72 between the cavity 36 and the adjoining moving blade.

5 An air hole 63 is formed in the inner shroud 33 to use the cooling air, as having flown in the air passage 80C to cool the stator blade 31, as the sealing air by guiding the cooling air into the cavity 36. In the outer shroud 32, there is formed a hole 62 for feeding the cooling air. This hole 62 has communication with the air passage 80A on the leading edge side
10 of the stator blade 31. Numerals 72 and 73 designate spaces between the adjoining moving blades 21.

In the moving blade of the third embodiment thus far described, the cooling air 70 is fed from the hole 62 of the outer shroud 32 to the air passage 80A on the leading edge side
15 of the stator blade 31 and flows inward into the next air passage 80B and outward into the adjoining next air passage 80C. In the inward flowing route, the cooling air 70 flows out from the trailing edge air hole 60 to cool the trailing edge in a film shape, and the remaining cooling air flows into the cavity
20 36 from the air hole 63 formed in the inner shroud 33.

Like the cooling air fed from the seal tube 52 in the prior art, the cooling air having flown into the cavity 36 partially flows from the air hole 63 formed in the seal ring retaining ring 37, to the space 72 between the labyrinth seal
25 37a and the adjoining moving blade and further to the front

space 73 via the labyrinth seal 37a.

5 A portion of the cooling air 70 thus having flown via the air passages 80A, 80B and 80C in the stator blade 31 to cool this blade 31 further flows from the air passage 80C via the air hole 63 of the inner shroud 33 into the cavity 36 to keep the inside of the cavity at a higher pressure than that in the combustion gas passage so that the hot combustion gas of the outside may be prevented from entering the inside.

10 The sealing air to flow into the cavity 36 is fed by bleeding a portion of the cooling air from the outer shroud 32 such that the seal tube 52 is formed in the prior art through the stator blade 31, as shown in Figs. 15 and 16, whereas the seal tube 2 is formed in the embodiments 1 and 2 through the stator blade 31, as shown in Fig. 2. According to this third
15 embodiment of the invention, on the contrary, the cooling air having cooled the stator blade 31 is fed from the air hole 63 of the inner shroud 33 into the cavity 36. Therefore, the seal tube 52 of the prior art and the seal tube 2 of the embodiments 1 and 2 are dispensed with, and the air having cooled the
20 stator blade 31 is used as the sealing air, so that the cooling air can be effectively exploited while reducing its flow rate thereby to make a contribution to an improvement in the performance of the gas turbine.

25 INDUSTRIAL APPLICABILITY

According to the invention, the air can be fed without any cavity pressure loss in the inner shroud, so that the pressure in the cavity can be kept at a higher level than that in the combustion gas passage to enhance the sealing effect. On the other hand, the seal tube is characterized by connecting it removably to the air hole in the blade ring communicating with the seal tube. With this construction, at the assembly or maintenance time of the stator blade, the leading end of the seal tube can be easily inserted into and fixed in the air hole of the blade ring and can be easily removed.

According to the invention, on the other hand, the seal tube of the prior art is dispensed with to cut the cost, and the air having cooled the stator blade is used for the sealing purpose so that the cooling air can be effectively exploited while reducing its flow rate to improve the performance of the gas turbine.

According to the invention, moreover, the sealing ring retaining ring is cooled to make the thermal elongation smaller on the stationary side than that of the prior art. As a result, the clearance between the stationary side and the rotor side at a rated rotation time can be made smaller than that of the prior art without the cooling, thereby to improve the sealing performance.

What is claimed is:

1. A sealing device for a gas turbine stator blade, in which air is guided from air holes formed in a blade ring through a space formed by said blade ring, a heat insulating ring and an outer shroud, the air being further guided from said space through a seal tube in the stator blade into an inner shroud, such that a pressure in a cavity of said inner shroud may be maintained at a higher pressure than that in a combustion gas passage to seal the interior of said inner shroud;

wherein said air holes include a first air hole communicating with said space, and a second air hole communicating with said seal tube.

2. A sealing device as claimed in claim 1, wherein said seal tube is removably connected to said second air hole.

3. A sealing device as claimed in claim 1, wherein a portion of the air is bled from a compressor into said air holes, said cavity is formed by an inner shroud and a seal ring retaining ring, and the air bled from said compressor is cooled by a cooler prior to being guided into said stator blade to cool said seal ring retaining ring.

4. A sealing device as claimed in claim 1, further comprising a coil spring interposed between a retaining portion of said second air hole and a projection formed on said seal tube.

5. A sealing device as claimed in claim 4, further comprising a coil spring, wherein said seal tube includes a removable adapter partially inserted in said second air hole, said removable adapter having a projection, and said coil spring is interposed between a retaining portion of said second air hole and said projection formed on said removable adapter.

6. A sealing device as claimed in claim 1, further comprising a bellows member connected between said blade ring and said seal tube.

7. A sealing device as claimed in claim 6, further comprising a coil spring disposed between a retaining portion of said second air hole and a radial projection of said seal tube.

8. A stator blade sealing arrangement for a gas turbine, said sealing arrangement comprising:

a stator blade having an outer shroud and an inner shroud;

a blade ring connected to said outer shroud, said blade ring including a first air hole and a second air hole;

heat insulating rings connecting said blade ring with said outer shroud;

a radial space defined by said heat insulating rings, said outer shroud, and said blade ring, wherein said first air hole communicates with said radial space;

a seal tube extending from said second air hole, through said radial space and said stator blade and into said inner shroud, said seal tube having a first end communicating with said second air hole;

wherein air bled from a compressor can be guided into said radial space, via said first air hole, and into an interior of said inner shroud through said seal tube, via said second air hole, so that pressure in a cavity of said inner shroud can be maintained at a higher pressure than a pressure in a combustion gas passage.

9. A sealing arrangement as claimed in claim 8, wherein the air bled from the compressor passes through a cooler prior to entering said first and second air holes.

10. A sealing arrangement as claimed in claim 8, further comprising a coil spring interposed between a retaining portion of said second air hole and a projection formed on said seal tube.

11. A sealing arrangement as claimed in claim 8, further comprising a coil spring, wherein said seal tube includes a removable adapter partially inserted in said second air hole, said removable adapter having a projection, and said coil spring is interposed between a retaining portion of said second air hole and said projection formed on said removable adapter.

12. A sealing arrangement as claimed in claim 8, further comprising a bellows member connected between said blade ring and said seal tube.

13. A sealing arrangement as claimed in claim 12, further comprising a coil spring disposed between a retaining portion of said second air hole and a radial projection of said seal tube.

