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Wilson et al.(10) **Pub. No.: US 2009/0053042 A1**(43) **Pub. Date: Feb. 26, 2009**(54) **METHOD AND APPARATUS FOR
CLEARANCE CONTROL OF TURBINE
BLADE TIP**(73) Assignee: **GENERAL ELECTRIC
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F01D 25/24 (2006.01)(52) **U.S. Cl.** **415/134; 415/173.6**(57) **ABSTRACT**

A gas turbine including a casing and a shroud ring, the gas turbine including an attachment device rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

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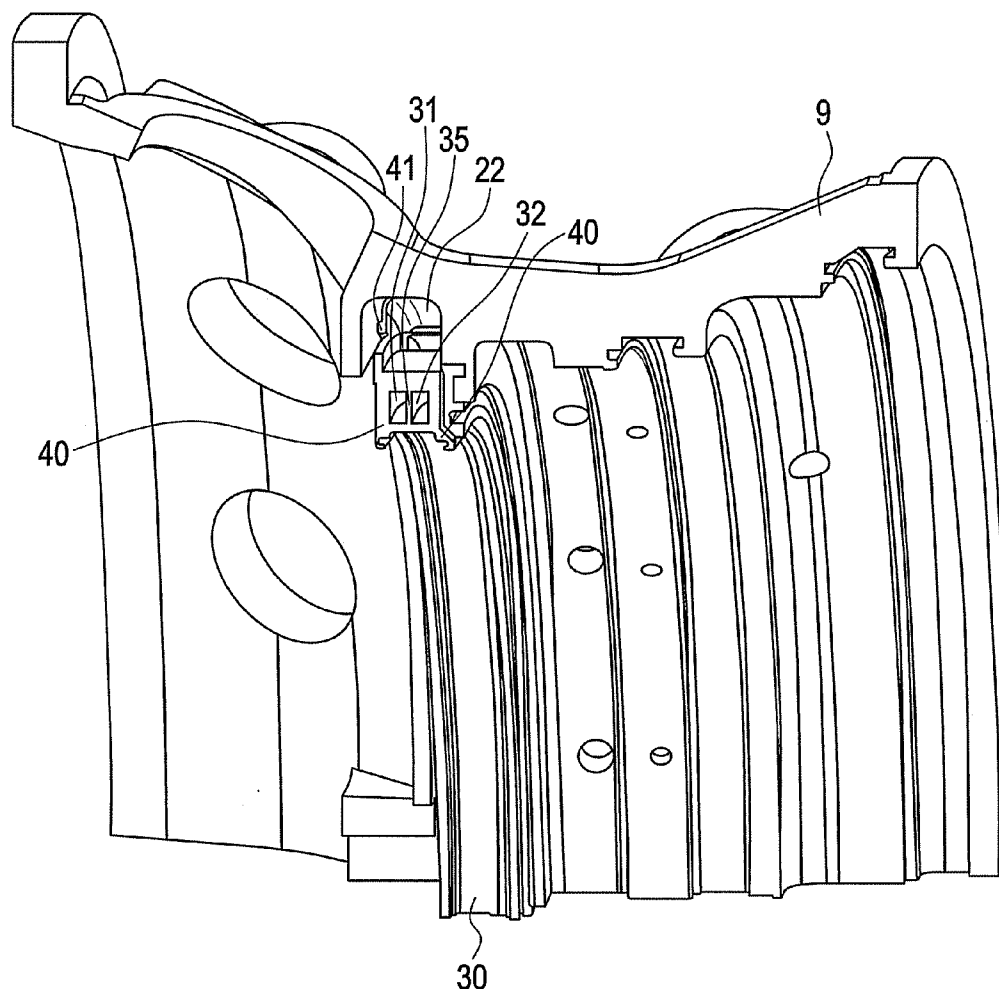


FIG. 2

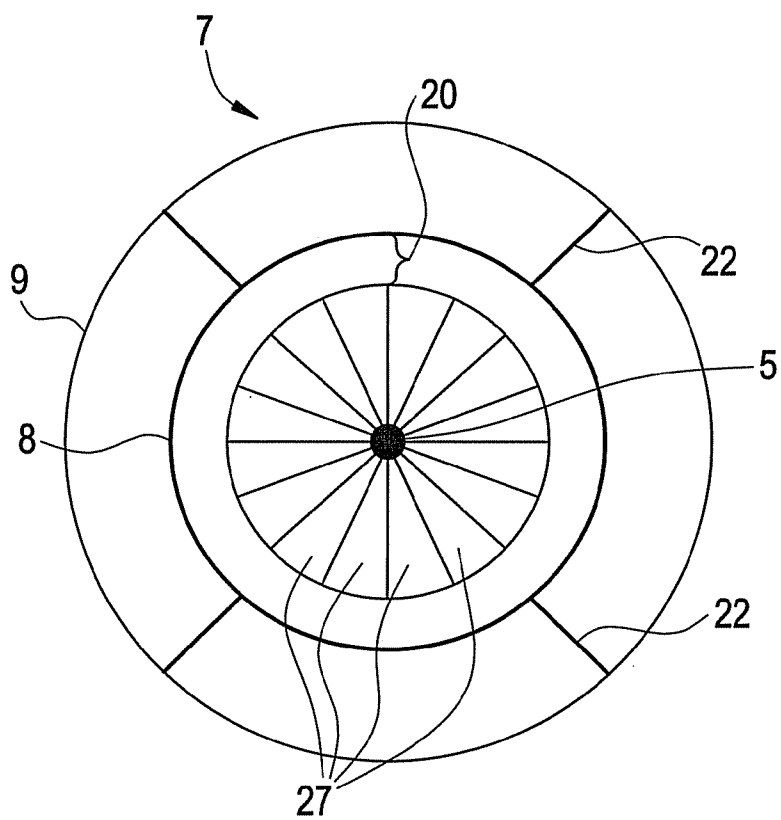


FIG. 3A

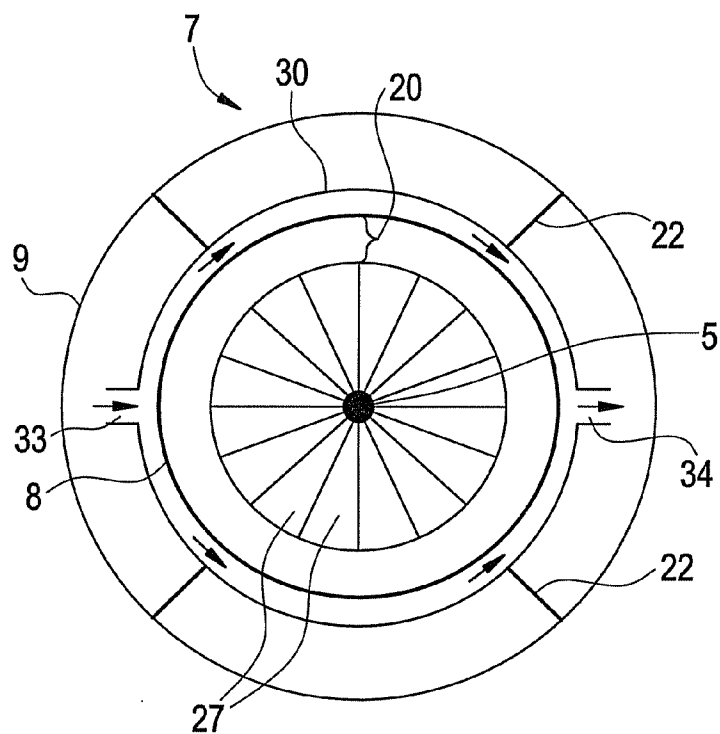


FIG. 3B

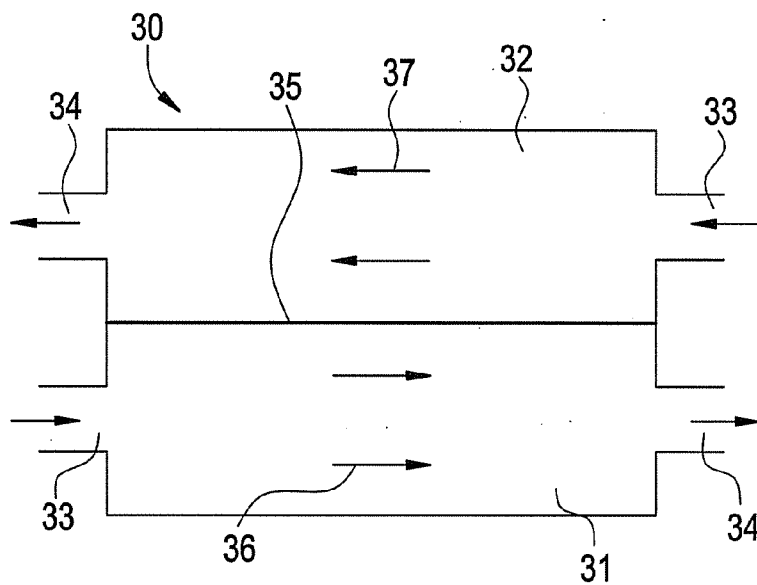


FIG. 4A

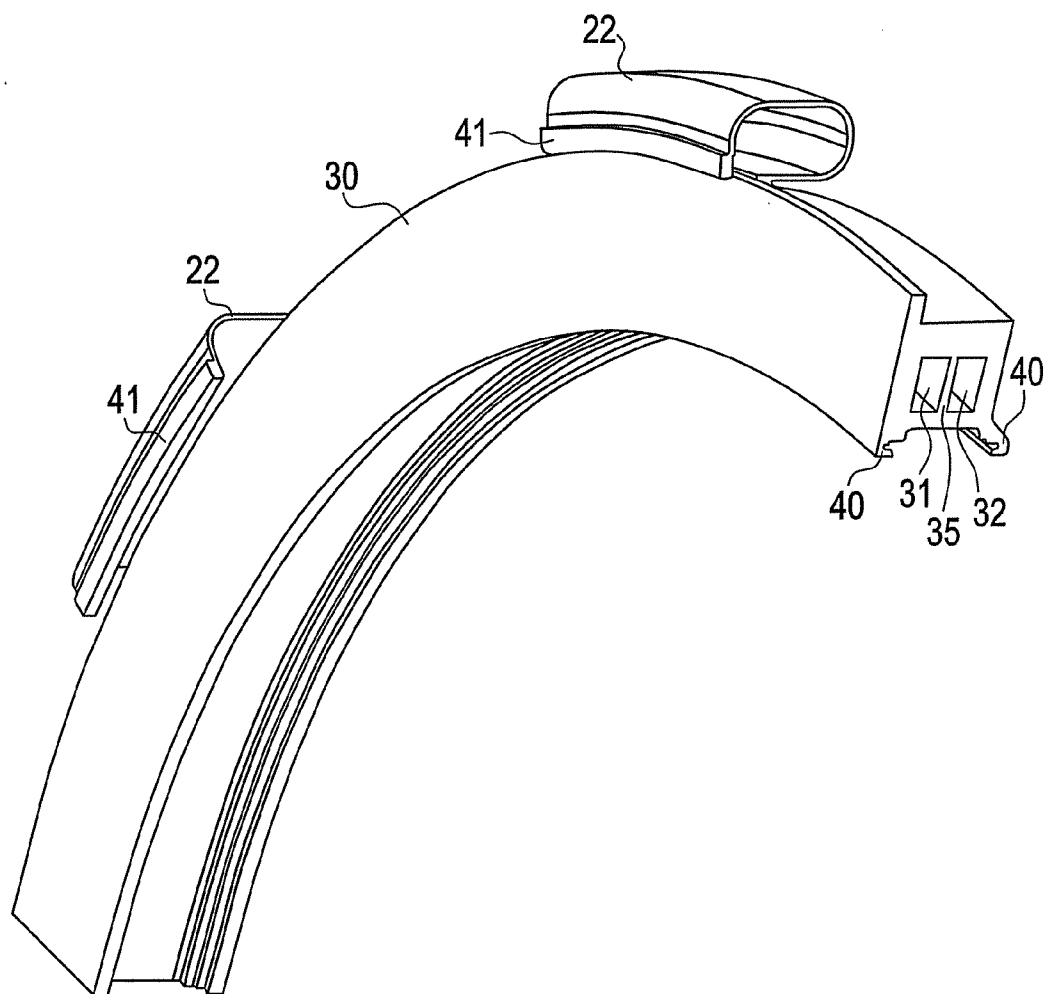


FIG. 4B

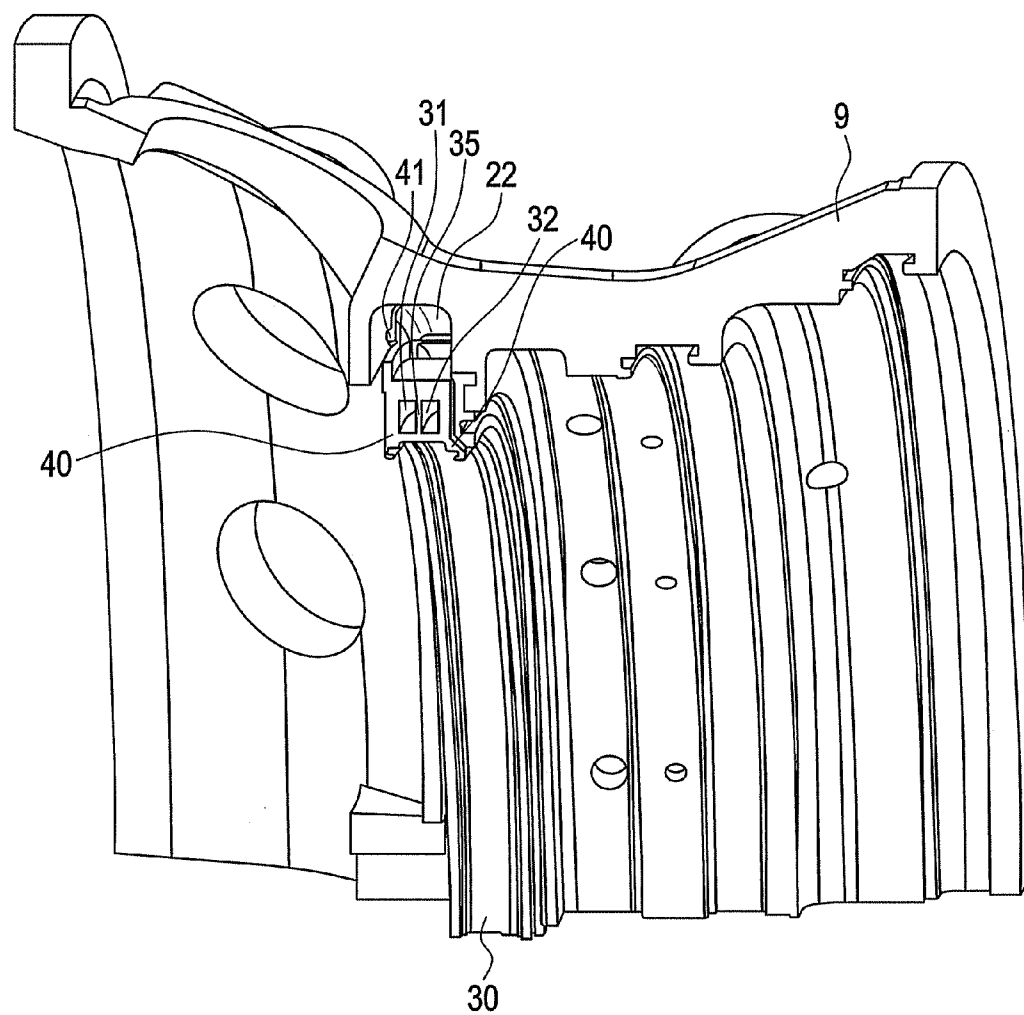
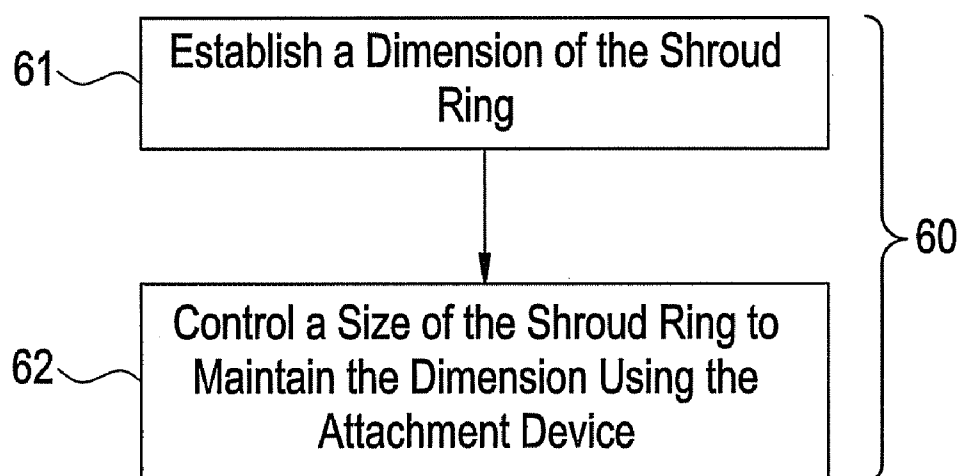


FIG. 6

METHOD AND APPARATUS FOR CLEARANCE CONTROL OF TURBINE BLADE TIP

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention disclosed herein relates to the field of gas turbines. In particular, the invention is used to provide control of turbine blade tip clearance.

[0003] 2. Description of the Related Art

[0004] A gas turbine includes many parts, each of which may expand or contract as operational conditions change. A turbine interacts with hot gases emitted from a combustion chamber to turn a shaft. The shaft is generally coupled to a compressor and, in some embodiments, a device for receiving energy such as an electric generator. The turbine is generally adjacent to the combustion chamber. The turbine uses blades, sometimes referred to as “buckets,” for using energy of the hot gases to turn the shaft.

[0005] The buckets rotate within a shroud ring. As the hot gases impinge on the buckets, the shaft is turned. The shroud ring is used to prevent the hot gases from escaping around the buckets and, therefore, not turning the shaft.

[0006] The distance between the end of one bucket and the shroud ring is referred to as “clearance.” As the clearance increases, efficiency of the turbine decreases as hot gases escape through the clearance. Therefore, an amount of clearance can affect the overall efficiency of the gas turbine.

[0007] If the amount of clearance is too small, then thermal properties of the buckets, the shroud ring, and other components can cause the buckets to rub the shroud ring. When the buckets rub the shroud ring, damage to the buckets, the shroud ring and the turbine may occur. It is important, therefore, to maintain a minimal clearance during a variety of operational conditions.

[0008] Therefore, what are needed are techniques to reduce clearance between buckets and a shroud ring in a gas turbine. The techniques should be useful for a variety of operational conditions.

BRIEF DESCRIPTION OF THE INVENTION

[0009] Disclosed is one embodiment of a gas turbine including a casing and a shroud ring, the gas turbine including an attachment device rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

[0010] Also disclosed is one embodiment of a gas turbine including a casing and a shroud ring, the gas turbine including a plurality of springs shaped generally as a “C” rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

[0011] Further disclosed is one example of a method for controlling a dimension of a shroud ring in a gas turbine including a casing, the method including establishing the dimension for the shroud ring; and controlling a size of the shroud ring to maintain the dimension using an attachment device rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the

device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0013] FIG. 1 illustrates an exemplary embodiment of a gas turbine;

[0014] FIG. 2 is an end view of an exemplary embodiment of a turbine stage;

[0015] FIG. 3A and FIG. 3B, collectively referred to as FIG. 3, illustrate an exemplary embodiment of a duct system coupled to a shroud ring;

[0016] FIG. 4A and FIG. 4B, collectively referred to as FIG. 4, illustrate another exemplary embodiment of the duct system;

[0017] FIG. 5 illustrates an exemplary embodiment of a control system; and

[0018] FIG. 6 presents an exemplary method for controlling a dimension of the shroud ring.

DETAILED DESCRIPTION OF THE INVENTION

[0019] The teachings provide embodiments of apparatus and methods for controlling a clearance between a plurality of buckets and a shroud ring in a gas turbine. The teachings provide for controlling a temperature of the shroud ring to maintain a proper amount of clearance. In general, the shroud ring may be made from a metal. The metal may expand and contract in accordance with its thermal coefficient of expansion. An attachment device is provided to allow the shroud ring to expand and contract with respect to a casing of the gas turbine. Before the embodiments are discussed in detail, certain definitions are provided.

[0020] The term “gas turbine” relates to a continuous combustion engine. The gas turbine generally includes a compressor, a combustion chamber and a turbine. The combustion chamber emits hot gases that are directed to the turbine. The term “bucket” relates to a blade included in the turbine. Each bucket generally has an airfoil shape to provide for converting the hot gases impinging on the bucket into rotational work. The term “turbine stage” relates to a plurality of buckets circumferentially disposed about a section of a turbine shaft. The buckets of the turbine stage are arranged in a circular pattern about the shaft. The term “shroud ring” relates to a structure for preventing the hot gases from escaping, unimpeded, around the buckets of the turbine stage. The structure may be at least one of cylindrical and conical. In general, there is one shroud ring for each turbine stage. The term “clearance” relates to an amount of distance between a tip of the bucket and the shroud ring. The term “casing” relates to a structure for supporting the shroud ring. The term “attachment device” relates to a device used to support the shroud ring from the casing. The term “rigidly attached” relates to a type of connection to the attachment device. The attachment device that is rigidly attached to a structure will not move or slide at the point of attachment to the structure. The term “net axial growth” relates to displacement of the shroud ring along the longitudinal axis of the gas turbine. The term “rubbing”

relates to at least one bucket making contact with the shroud ring. Rubbing generally causes damage to the gas turbine. The term “bleed-heat” relates to air extracted from the compressor before the air is sent to the combustion chamber.

[0021] FIG. 1 illustrates an exemplary embodiment of a gas turbine 1. The gas turbine 1 includes a compressor 2, a combustion chamber 3, and a turbine 4. The compressor 2 is coupled to the turbine 4 by a turbine shaft 5. In the embodiment of FIG. 1, the turbine shaft 5 is also coupled to an electric generator 6. The turbine 4 includes turbine stages 7, respective shroud rings 8, and a casing 9. The turbine 4 is described in more detail next. Also depicted in FIG. 1 is an axial direction 11 parallel to the shaft 5 and a radial direction 12 representative of radial directions normal to the shaft 5.

[0022] FIG. 2 illustrates an end view of an exemplary embodiment of one turbine stage 7 of the turbine 4. Referring to FIG. 2, a clearance 20 is illustrated. The shroud ring 8 shown in FIG. 2 encloses a plurality of buckets 27 by about 360 degrees. In some embodiments, the shroud ring 8 is built from a plurality of shroud ring segments that include a plurality of arc segments, each segment less than 360 degrees. By controlling the temperature of the shroud ring 8, the clearance 20 can be minimized without an increase in a risk of rubbing. The shroud ring 8 is supported by a plurality of attachment devices.

[0023] Referring to FIG. 2, the shroud ring 8 is shown supported from the casing 9 by a plurality of devices 22. One end of each attachment device 22 is rigidly attached to the shroud ring 8. The other end of the attachment device 22 is rigidly attached to the casing 9. The attachment devices 22 provide for supporting the shroud ring 8 and allowing the shroud ring 8 to thermally expand and contract while maintaining roundness independent of the casing 9. The plurality of attachment devices 22 is generally disposed circumferentially about the shroud ring 8. One exemplary embodiment of the attachment device 22 is a spring. A duct system may be used to provide air for at least one of cooling and heating the shroud ring 8 to control the clearance 20.

[0024] FIG. 3 illustrates an exemplary embodiment of the shroud ring 8 coupled to a duct system 30. In the embodiment of FIG. 3, the duct system 30 is supported from the casing 9 by a plurality of attachment devices 22. Referring to FIG. 3A, the duct system 30 includes an inlet 33 for providing air into the duct system 30. Similarly, the duct system 30 includes an outlet 34 for removing the air. The duct system 30 can conduct one of heated air for heating and cooled air for cooling. Because of heat transfer between the air in the duct system 30 and the shroud ring 8, the temperature of the air at the inlet 33 may be different from the temperature of the air at the outlet 34. Different temperatures of air at the inlet 33 and the outlet 34 may lead to warping of the shroud ring 8.

[0025] Warping of the shroud ring 8 can lead to out-of-roundness. When the shroud ring 8 is out-of-round, the clearance 20 can vary about a circumference of the shroud ring 8. As warping increases, a point will be reached when rubbing will occur. To limit warping, two flow paths are provided in the duct system 30.

[0026] A first flow path 31 and a second flow path 32 are illustrated in FIG. 3B. To minimize temperature variations about the shroud ring 8, the air in the second flow path 32 flows in a direction 37 opposite to the direction 36 of the air flowing in the first flow path 31. Also, a conduction plate 35 as shown in FIG. 3B is used to transfer heat between the first flow path 31 and the second flow path 32. The use of counter-

flow and the conduction plate 35 acts to minimize any temperature variations about the shroud ring 8. While the embodiment of FIG. 3B illustrates two flow paths, more flow paths can be used. The first flow path 31 and the second flow path 32 are generally normal to the shaft 5. The duct system 30 of FIG. 3 is referred to as a “dual cross-conduction counter-flow duct system.”

[0027] FIG. 4 illustrates another exemplary embodiment of the duct system 30. Referring to FIG. 4A and FIG. 4B, the duct system 30 includes notches 40 for coupling to the segments used to build the shroud ring 8. In the embodiment of FIG. 4, the attachment devices 22 are springs. Referring to FIG. 4A, each attachment device 22 includes an attachment rail 41 for rigidly attaching each attachment device 22 to the casing 9. Each attachment device 22 is also rigidly attached to the duct system 30. A closed loop control system is generally used to control a dimension of the shroud ring 8. For the embodiments of FIGS. 3 and 4, airflow to each of the first flow path 31 and the second flow path 32 is controlled by an associated closed loop flow control system.

[0028] FIG. 5 illustrates an exemplary embodiment of a flow control system 50. The discussion of the flow control system 50 is with respect to the first flow path 31. However, the discussion also applies to the second flow path 32 and any other flow paths. The flow control system 50 includes a control valve 51 for controlling the airflow to the first flow path 31. The flow control system 50 also includes a flow controller 52 and at least one sensor 53. The sensor 53 may be at least one of a flow sensor, a temperature sensor, a pressure sensor, a distance sensor, and other types of sensors. For example, the sensor 53 may measure the temperature of the shroud ring 8. Using the temperature of the shroud ring 8, the flow controller 52 can regulate airflow through the control valve 51 to control the temperature of the shroud ring 8. A source 54 of air to the control valve 51 may be at least one of bleed-heat for heated air, ventilation air for cooled air, and other sources. Air from the source 54 is generally at a pressure greater than atmospheric pressure to provide for flow through the first flow path 31. If the pressure is not great enough to provide the required flow, a fan may be used to provide the required flow. While not depicted in FIG. 5, the source 54 may be selected by the flow controller 52 in order to provide air at a temperature necessary for controlling the clearance 20. The flow control system 50 also includes the attachment devices 22 to allow the duct system 30 to expand and contract independent of the casing 9.

[0029] In general, detailed analyses and tests are performed to determine a set point. For example, in situations where the source 54 of air has an approximately constant temperature, the detailed analyses and tests can determine at least one airflow rate for each of start-up, shut-down, steady-state operation at full power, and operation at less than full power. For another example, a sensor may be used to measure the clearance 20 while the airflow rate and the temperature of the source 54 are adjusted to maintain a set point for the clearance 20.

[0030] FIG. 6 presents an exemplary method 60 for controlling the clearance 20. The clearance 20 may be controlled by controlling a dimension, such as a diameter, of the shroud ring 8. The method 60 calls for establishing 61 a dimension of the shroud ring 8. Further, the method 60 calls for controlling 62 a size of the shroud ring 8 to maintain the dimension. The method 60 is implemented using the attachment device 22.

[0031] The method 60 may be implemented by a computer program product included in the control system 50. The com-

puter program product is generally stored on machine-readable media and includes machine executable instructions for controlling a dimension of the shroud ring **8** in the gas turbine **1**.

[0032] The technical effect of the computer program product is to increase the efficiency of the gas turbine **1** by controlling the clearance **20**.

[0033] The discussion above is with respect to flowing air through the duct system **30** to transfer heat. It is recognized that other forms of media such as liquids and gases may also be used to transfer heat in the duct system **30**. Exemplary embodiments of other media are water and steam. It is also recognized that additives such as corrosion inhibitors may be added to the media.

[0034] The attachment devices **22** may include various embodiments. The embodiments allow the shroud ring **8** to expand and contract in the radial direction **12** independent of the casing **9**. The attachment devices **22** also retain the shroud ring **8** in place in the axial direction **11**. The attachment devices **22** provide for net axial growth that is at least one of limited and about zero.

[0035] As discussed above, one embodiment of the attachment device **22** is the spring. The spring may include various shapes. One shape includes a general "C" shape. Another shape may include a general "W" shape. Another embodiment of the attachment device **22** is a mechanical linkage. Movement of the mechanical linkage may be restrained by a spring.

[0036] The teachings provide that the attachment devices **22** may include various arc segments, which may be measured by a number of degrees. For example, the gas turbine **1** may include one attachment device **22** having an arc segment of 360°. As another example, the gas turbine **1** may include a plurality of attachment devices **22**. Generally, when a plurality of attachment devices **22** is used, each attachment device **22** has an arc segment less than about 180°.

[0037] Various components may be included and called upon for providing for aspects of the teachings herein. For example, the flow controller **52** may include at least one of an analog system and a digital system. The digital system may include at least one of a processor, memory, storage, input/output interface, input/output devices, and a communication interface. In general, the computer program product stored on machine-readable media can be input to the digital system. The computer program product includes instructions that can be executed by the processor for controlling the clearance **20**. The various components may be included in support of the various aspects discussed herein or in support of other functions beyond this disclosure.

[0038] It will be recognized that the various components or technologies may provide certain necessary or beneficial functionality or features. Accordingly, these functions and features as may be needed in support of the appended claims and variations thereof, are recognized as being inherently included as a part of the teachings herein and a part of the invention disclosed.

[0039] While the invention has been described with reference to exemplary embodiments, it will be understood that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications will be

appreciated by those skilled in the art to adapt a particular instrument, situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A gas turbine comprising a casing and a shroud ring, the gas turbine comprising:

an attachment device rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

2. The gas turbine as in claim 1, wherein the net axial growth is about zero.

3. The gas turbine as in claim 1, wherein the device comprises a spring.

4. The gas turbine as in claim 3, wherein the spring comprises a general "C" shape.

5. The gas turbine as in claim 3, wherein the spring comprises a general "W" shape.

6. The gas turbine as in claim 3, wherein the spring comprises a rail for coupling to the casing.

7. The gas turbine as in claim 1, wherein the device comprises a 360° segment.

8. A gas turbine comprising a casing and a shroud ring, the gas turbine comprising:

a plurality of springs shaped generally as a "C" rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

9. A method for controlling a dimension of a shroud ring in a gas turbine comprising a casing, the method comprising:

establishing the dimension for the shroud ring; and controlling a size of the shroud ring to maintain the dimension using an attachment device rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

10. The method as in claim 9, wherein the method is implemented by a computer program product stored on machine-readable media and comprising machine executable instructions for controlling a dimension of a shroud ring in a gas turbine comprising a casing, the product comprising instructions for:

establishing the dimension for the shroud ring; and controlling a size of the shroud ring to maintain the dimension using an attachment device rigidly attached to the casing and at least one of the shroud ring and a duct attached to the shroud ring, wherein the device allows the shroud ring to expand and contract independent of the casing and provides limited net axial growth of the shroud ring.

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