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DeFeo

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[54] **DIAPHRAGM AND LABYRINTH SEAL ASSEMBLY FOR GAS TURBINES**

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[52] **U.S. Cl.** **415/136,** 415/172, 415/117

[51] **Int. Cl.** **F01d 25/24,** F01d 25/26, F02d 7/20

[58] **Field of Search** 415/136, 134, 138, 139, 415/172, 173, 117; 60/39.32

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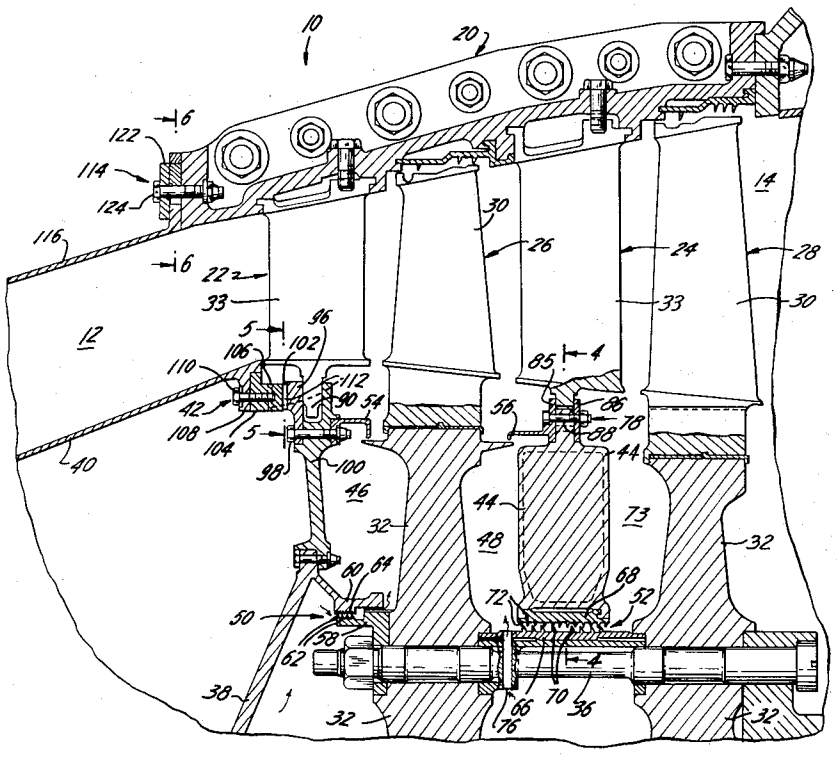
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Attorney, Agent, or Firm—Arthur L. Frederick

[57] **ABSTRACT**

The diaphragm member and labyrinth seal assembly for a gas turbine machine comprises an annular diaphragm or wall member disposed adjacent at least one of the rotor discs of a rotor blade assembly to define with the rotor disc a cooling fluid chamber. The chamber is in communication with a source of cooling fluid such as air, to receive cooling fluid from the latter. A labyrinth seal is disposed between the rotor blade assembly and the diaphragm member to provide a relatively fluid-tight joint between the stationary diaphragm member and the rotating rotor blade assembly. A slipjoint connecting means is disposed to connect together the diaphragm member to the turbine housing, which connecting means maintains concentricity of the diaphragm member and turbine housing and permits thermal differential movement of the diaphragm member and turbine housing without affecting the efficiency of the labyrinth seal.

3 Claims, 6 Drawing Figures



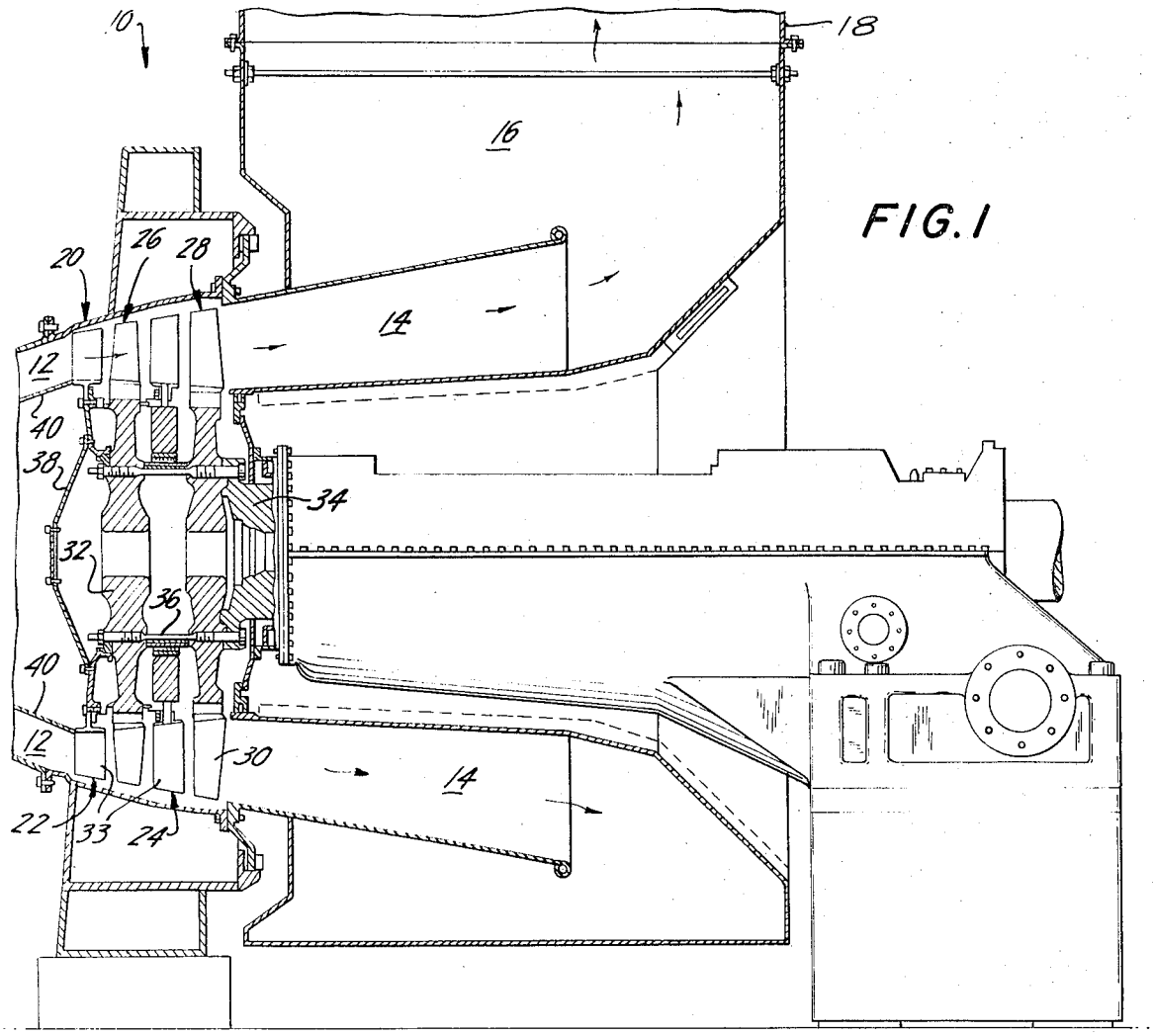

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FIG. 1

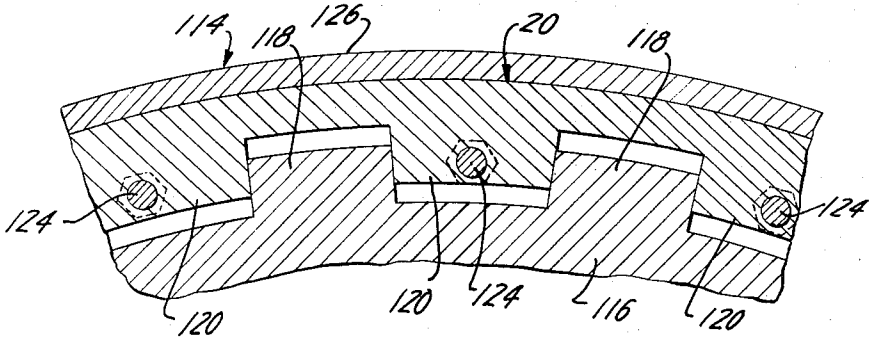
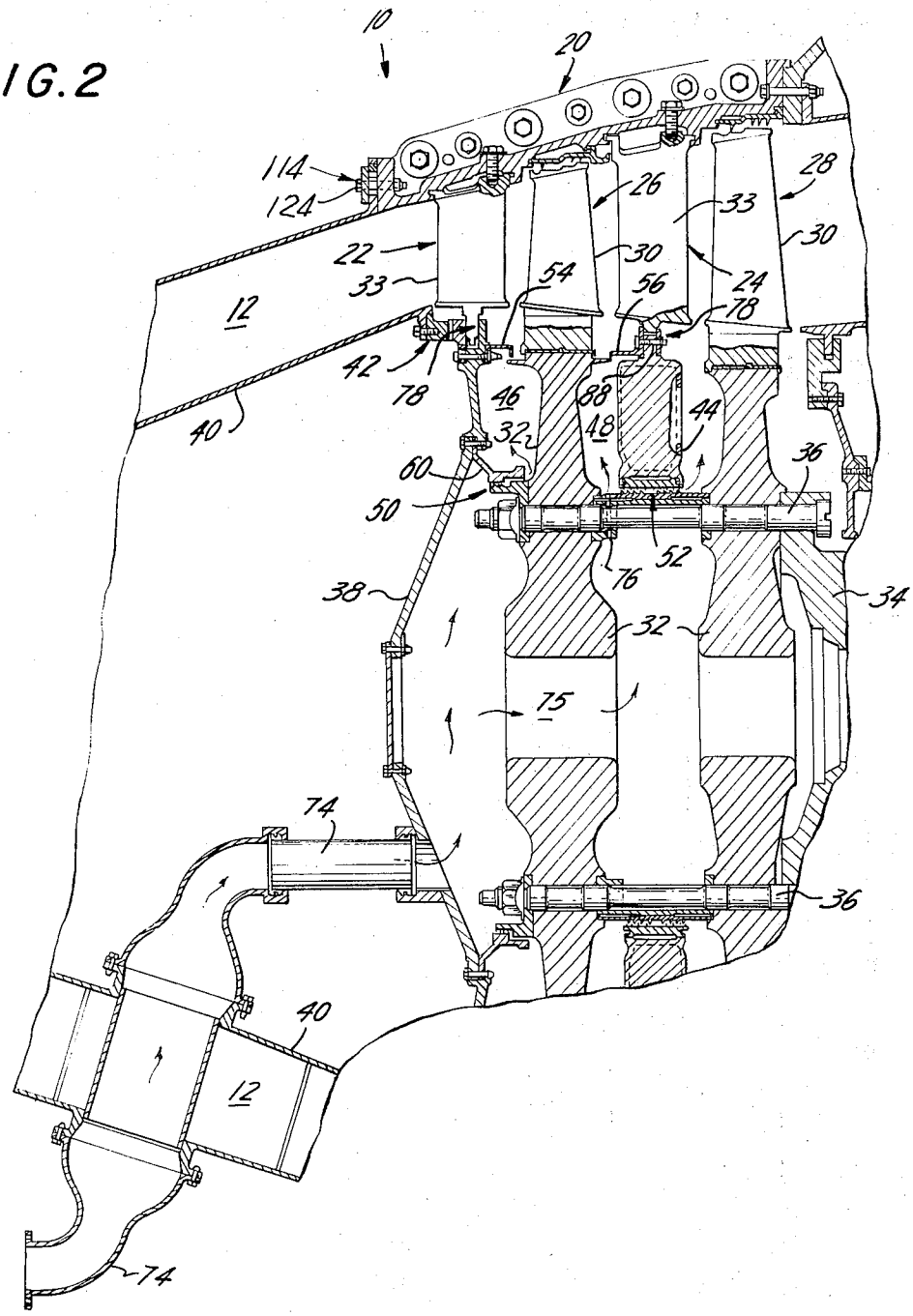

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FIG. 6

FIG. 2


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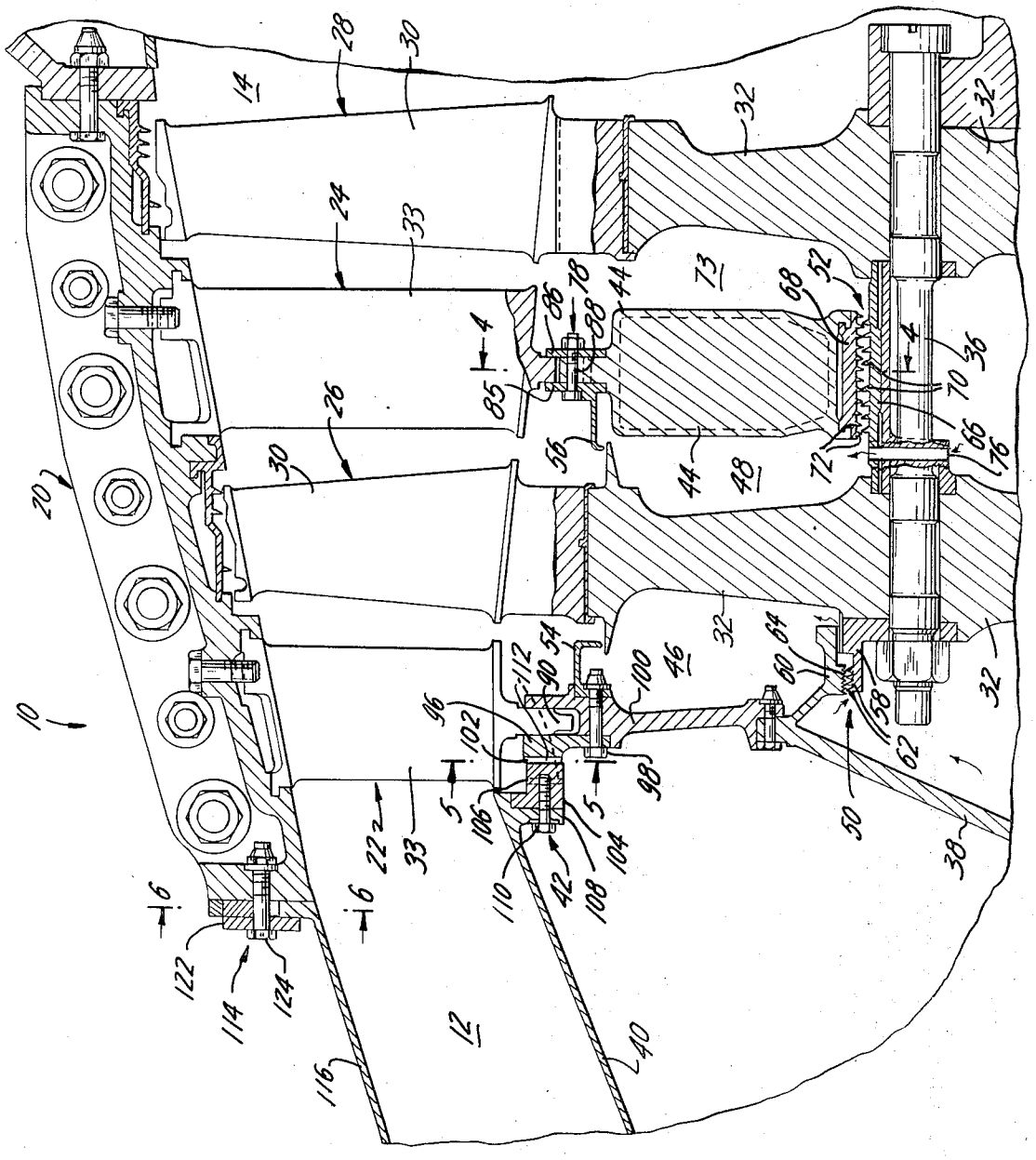
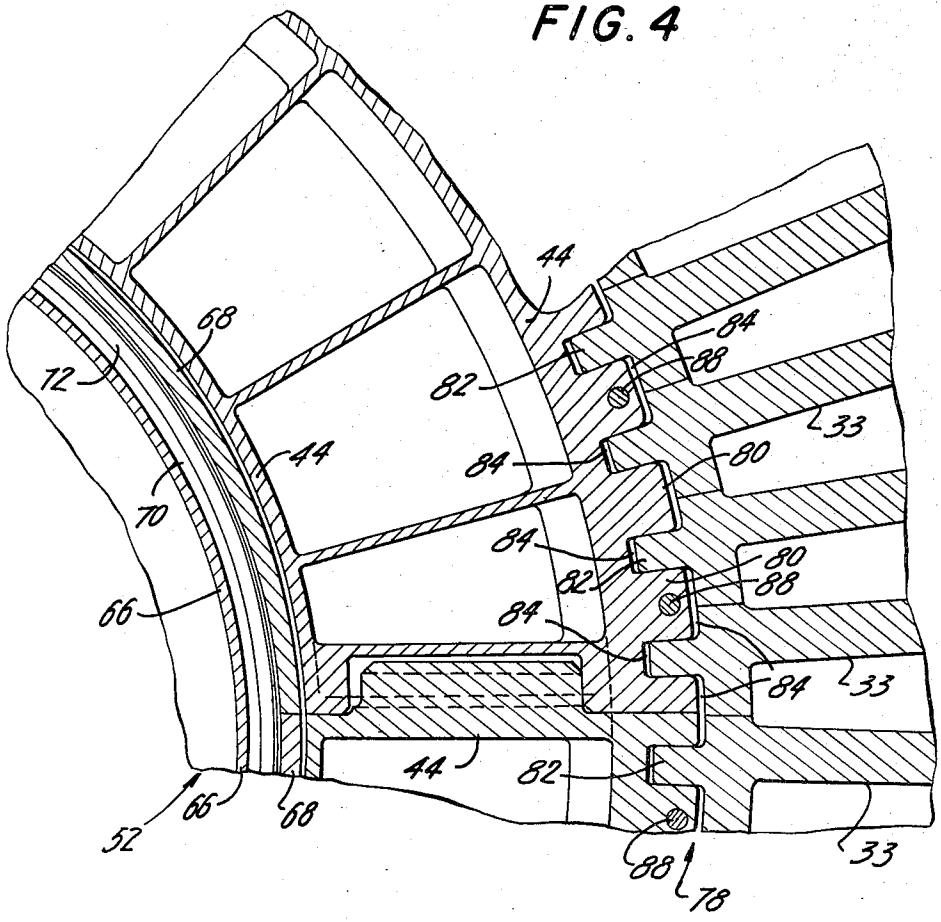

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FIG. 3

FIG. 4


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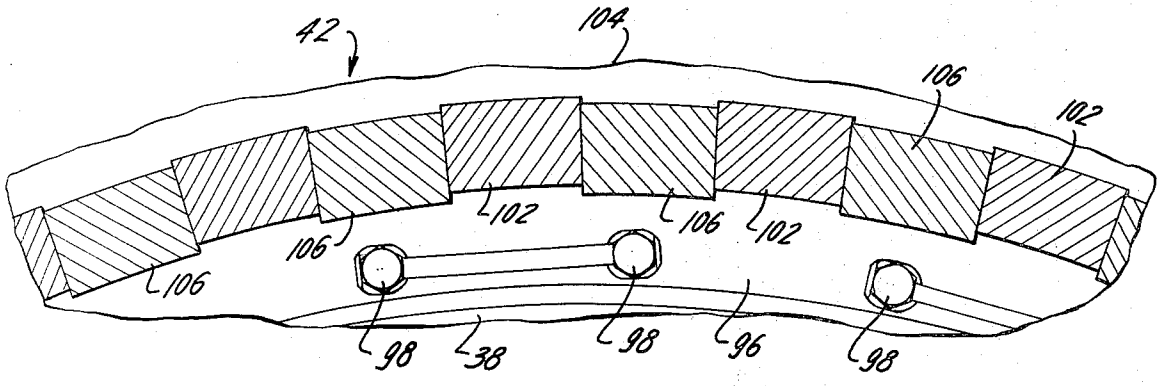

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FIG. 5

DIAPHRAGM AND LABYRINTH SEAL ASSEMBLY FOR GAS TURBINES

DISCLOSURE OF INVENTION

This invention relates to fluid elastic machines, such as gas turbines, and more particularly to the diaphragm means and labyrinth seal assembly disposed adjacent to the rotor discs of gas turbine machines.

BACKGROUND OF THE INVENTION

In gas turbines having a plurality of rotors it is essential for relatively long, trouble-free operative life to provide means for cooling the rotor discs or hubs of the turbine. Conventionally, this rotor disc cooling has been achieved by providing wall means, partition means or diaphragm means cooperating with the housing means, including stator vane assemblies, to form chambers adjacent the rotor discs into which chambers cooling fluid such as air, is introduced. To render the chambers reasonably fluid-tight, a labyrinth seal is conventionally provided between the diaphragm means and rotor discs, one part of each of the labyrinth seals being carried by a diaphragm means while the other part is carried by a rotor disc. It has been found that in such installations the integrity or efficiency of the labyrinth seals cannot be maintained because of the differential, radially directed, expansion and contraction between the turbine housing and the stator vanes which, in turn, through the diaphragm means causes one part of the labyrinth seal to move relative to the other part.

Accordingly, it is an object of the present invention to provide in a gas turbine a diaphragm means and labyrinth seal assembly wherein integrity of the labyrinth seal is unaffected by differential thermal expansion and contraction of the turbine components.

Another object of this invention is to provide in a gas turbine a diaphragm means and labyrinth seal assembly wherein efficiency of the labyrinth seal is independent of the relative expansion and contraction of the stator vanes and turbine housing.

A further object of the present invention is to provide in a gas turbine a diaphragm means and labyrinth seal assembly wherein concentricity of the labyrinth seal component parts is maintained during all phases of turbine operation.

A still further object of this invention is to provide in a gas turbine a diaphragm and labyrinth seal assembly which permits the selection of the material for the inlet housing and the diaphragm without regard to their respective thermal coefficients.

A feature of this invention is the expansion joint interconnection between a diaphragm means and housing means, including stator vane assembly, which permits relative radial movement between the associated diaphragm means and housing means upon differential expansion and contraction of those components. This allowance for relative movement between the diaphragm means and housing means prevents relative radial movement of the component parts of the associated labyrinth seal, thus permitting the component parts of each of the labyrinth seals to maintain desired predetermined clearances.

SUMMARY OF THE INVENTION

Accordingly, the present invention contemplates, in

a gas turbine machine having at least one stator vane assembly and one rotor blade assembly disposed within a housing means, a diaphragm means and labyrinth seal assembly comprising a stationary annular partition means or diaphragm means disposed adjacent the rotor disc of the rotor blade assembly to define with the latter a cooling fluid chamber which is in communication with a suitable source of cooling fluid, such as air. A labyrinth seal is disposed between the rotor blade assembly and the diaphragm means to provide a substantially fluid-tight joint between stationary diaphragm means and the rotating rotor blade assembly. The labyrinth seal is constructed and arranged to provide for a controlled amount of fluid leakage for the passage of cooling fluid therethrough. The diaphragm means is connected to the housing means via a slipjoint connecting means which permits radially directed differential thermal expansion and contraction between the diaphragm means and the housing means. This slipjoint connecting means provides in the assembly of the turbine the flexibility which may be necessary to obtain the desired labyrinth seal clearances without introducing thermal stresses into the assembly. The slipjoint connecting means also permits the maintenance of the desired clearances between the component parts of the labyrinth seal even under the effects of differential thermal expansion and contraction of the housing means relative to the diaphragm means.

In a more specific aspect of this invention the slipjoint connecting means comprises meshing radially extending splines constructed and arranged to allow relative movement in a radial direction but preventing relative rotative movement.

In a further specific aspect of this invention the slipjoint connecting means constitutes meshing radially extending splines between the inner inlet shell and the first stage stator vane assembly and between the outer inlet shell and the first stage stator vane assembly so that the annular inlet assembly is permitted to move relative to the first stage stator vane assembly and the diaphragm means.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following description when considered in connection with the accompanying drawings in which:

FIG. **1** is a schematic view in longitudinal cross-section of a gas turbine having a diaphragm and labyrinth seal assembly according to this invention;

FIG. **2** is a fragmentary view in longitudinal crss-section of the gas turbine shown in FIG. **1**;

FIG. **3** is an enlarged fragmentary view in longitudinal cross-section, similar to FIG. **2** but on a much larger scale; and

FIGS. **4, 5** and **6** are each fragmentary cross-sectional views taken substantially along lines **4—4, 5—5** and **6—6** of FIG. **3.**

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Now referring to the drawings, and more particularly to FIG. **1,** the reference number **10** designates a gas turbine which may form part of a power generating apparatus wherein a combustion gas generator, such as a turbojet engine (not shown), is connected, through an inlet passageway **12,** to gas turbine **10** to deliver combustion gases to the latter. The combustion gases flow-

ing into gas turbine **10** are conventionally at an elevated temperature, as for example in the range of about 1,200° F to about 1,450° F. The combustion gases after expansion in gas turbine **10** discharge into an annular outlet passageway **14** and thence into an outlet volute section **16.** From the outlet volute section **16,** the exhaust gases pass to atmosphere via a stack **18.**

As best shown in FIGS. **2** and **3,** gas turbine **10** comprises an annular housing structure **20** to which is connected in any suitable manner well known in the art, a first-stage stator vane assembly **22** and a second-stage stator vane assembly **24.** Disposed adjacent stator vane assemblies **22** and **24** are a first-stage rotor blade assembly **26** and second-stage rotor blade assembly **28.** Each of the rotor blade assemblies **26** and **28** comprises a plurality of circumferentially arranged blades **30** supported in a hub or disc **32.** Each of the stator vane assemblies **22** and **24** comprises a plurality of circumferentially spaced vanes **33.** The hub or discs **32** of each of the rotor blade assemblies **26** and **28** are connected together and to a driveshaft **34** for conjoined rotation by a plurality of circumferentially spaced tie-bolts **36.** The driveshaft **34** is connected to drive another device (not shown), such as an electrical generator. A partition, wall or diaphragm **38** is disposed adjacent to and spaced from the first-stage rotor blade assembly **26.** The periphery of diaphragm **38** is connected to the inner wall **40** of inlet passageway **12,** by a slipjoint connection **42,** hereinafter more fully explained. Another partition wall or interstage diaphragm **44** is disposed between the first and second-stage rotor blade assemblies **26** and **28.** To provide relatively fluid-tight annular chambers **46** and **48** on opposite sides of disc **32** of first-stage rotor blade assembly **26,** labyrinth seal assemblies **50** and **52** are provided between diaphragms **38** and **44** and rotor discs **32** while, at the outer peripheral portion of rotor disc **32** of rotor blade assembly **26,** running seals **54** and **56** are provided.

As best shown in FIG. **3,** labyrinth seal assembly **50** of conventional construction comprises an annular ring **58** which is mounted on disc **32** of first-stage rotor blade assembly **26** and a shroud **60** secured to and forming part of diaphragm **38.** The ring **58** is provided with a plurality of spaced annular ribs **62** which are in a predetermined juxtapositional relationship with spaced annular ribs **64** mounted on shroud **60** to provide for a predetermined fluid leakage into chamber **46.** This fluid leakage flow path provides the means, as hereinafter more fully described, for introducing cooling fluid into chamber **46.**

The labyrinth seal assembly **52** which also may be of well known construction, comprises a first annular ring **66** mounted between and secured to discs **32** of the first and second-stage rotor blade assemblies **26** and **28** and a second annular ring **68** secured to diaphragm **44** in concentric relationship to ring **66.** Each of the rings **66** and **68** have a plurality of annular, spaced ribs, **70** and **72,** respectively, which are in a predetermined juxtapositional relationship to each other to provide for a predetermined amount of fluid leakage into the annular space **73** between diaphragm **44** and disc **32** of second-stage rotor blade assembly **28.**

As illustrated only in FIG. **2,** to effect cooling of discs **32,** cooling fluid, such as air at a temperature in the range of about 400° to 680° F, is supplied to cooling chambers **46** and **48** and annular space **73** by a supply duct **74** which is connected, at one end, to a suitable source of cooling fluid (not shown) and, at the opposite end, to diaphragm **38.** As best shown in FIG. **3,** one portion of the cooling fluid flows past shroud **60,** through labyrinth assembly **50,** into chamber **46,** while another portion of the cooling fluid passes through central bore **75** in disc **32** and thereafter, through a plurality of radially extending openings or ports **76** in ring **66,** into chamber **48.** Also part of the cooling fluid entering chamber **48** passes into annular space **73,** through labyrinth seal assembly **52,** to effect cooling of the forward face of disc **32** of rotor blade assembly **28.**

In accordance with this invention and as best shown in FIGS. **3** and **4,** the integrity of labyrinth seal assembly **52** is preserved against the differential thermal expansion and contraction of housing structure **20,** including stator vane assembly **24,** and the interstage diaphragm **44** by a slipjoint connection **78** between the roots **82** of the stator vanes and diaphragm **44.** As best illustrated in FIG. **4,** diaphragm **44** is provided with a plurality of radially extending splines **80** which mesh with radially extending, circumferentially spaced roots **82** which cooperate to form splines. The radial clearances at **84** between the splines **80** and root splines **82** permits relative radial movement between stator vane assembly **24** and diaphragm **44,** thus preventing relative movement between rings **66** and **68** of labyrinth seal assembly **52.** Since the predetermined clearances between ribs **70** and **72** of rings **66** and **68** are maintained despite the differential thermal expansion and contraction of the turbine housing structure **20,** including stator vane assembly **24,** and diaphragm **44,** the sealing efficiency of the labyrinth seal assembly **52** is preserved. Also, the meshing splines **80** and root splines **82** of slipjoint connection **78** coact to maintain the angular relative position of the stator vane assembly **24** and interstage diaphragm **44** about the longitudinal axis of turbine **10** to further insure the maintenance of the sealing efficiency of labyrinth seal assembly **52.**

To prevent relative linear movement of stator vane assembly **24** and interstage diaphragm **44** which movement, if it occurred, would adversely effect the integrity of labyrinth seal assembly **52,** meshing splines **80** and **82** are held in axial alignment between an annular flange **85** of seal **56** and a washer or ring **86** (see FIG. **3**). A plurality of circumferentially spaced bolts **88** clamp flange **85** and ring **86** against the opposite sides of splines **80** and **82** sufficiently tight to prevent longitudinal linear movement, but not sufficient to prevent, under differential thermal expansion and contraction, relative radial movement of the splines.

Similar to slipjoint **78,** the vanes **33** of stator vane assembly **22** and diaphragm **38** are interconnected so that relative radial movement is permitted between the roots **90** of the stator vanes and diaphragm **38.** This is accomplished by a ring **96** which is secured by a plurality of circumferential bolts **98** to a reversed "L" shaped end portion **100** of diaphragm **38** (see FIG. **3**), these elements defining receptacles for roots **90** of the stator vanes. As shown in FIGS. **3** and **5,** ring **96** also forms part of slipjoint **42** by which relative radial movement between inner wall **40** of inlet passageway **12** and diaphragm **38** can occur and concentricity can be simultaneously maintained. In addition to ring **96** which has, as best shown in FIGS. **3** and **5,** axially extending splines **102,** slipjoint **42,** comprises a washer or ring **104** which has splines **106** constructed and arranged to mesh with splines **102.** The ring **104** is secured to a

flanged end portion **108** of wall **40** by a plurality of bolts **110.** Furthermore, the longitudinal clearances at **112** between meshing splines **102** and **106** permits relative longitudinal thermal expansion and contraction between wall **40,** as well as radial movement of the stator vane assembly **22** relative to diaphragm **38,** and thereby prevents movement of diaphragm **38,** which movement would adversely affect labyrinth seal assembly **50.**

As best shown in FIGS. **3** and **6,** another slipjoint **114,** similar to slipjoint **42,** is provided to connect the outer wall **116** of inlet passageway **12** to housing structure **20.** This slipjoint **114** comprises radially extending meshing splines **118** and **120** which, while permitting relative radial movement between the wall **116** and housing structure **20,** prevents relative rotative movement between the parts. As shown, relative longitudinal movement between wall **116** and housing structure **20** is prevented by a ring **122** which is secured by a plurality of bolts **124** against the splines. The ring **122** is press-fitted within the annular flange **126** of the housing structure **20.**

It is believed now readily apparent that the present invention provides a diaphragm and labyrinth seal assembly for a gas turbine in which the effectiveness of the labyrinth seal is unaffected by the radial expansion and contraction of the housing structure, including the stator vane assemblies connected thereto, relative to diaphragms which define with the discs of the rotor blade assemblies cooling fluid chambers for cooling the discs. It is a diaphragm and labyrinth seal assembly which maintains its angular position relative to the turbine housing structure about the longitudinal axis of the gas turbine. This isolation of the labyrinth seal from the effects of radial relative movement due to differential expansion and contraction of the diaphragm and housing structure and the assurance of continued concentricity enables the predetermined clearance between the ribs of the labyrinth seal to be maintained and hence the sealing efficiency and cooling fluid distribution preserved.

Although but one embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the arrangement of parts without departing from the spirit and scope of the invention, as the same will now be understood by those skilled in the art.

What is claimed is:

1. In a gas turbine machine having at least one stator vane assembly and one rotor blade assembly, including a rotor disc, disposed within a housing and an inner wall spaced inwardly from the housing to define with the latter an inlet passageway for conducting combustion gases to said stator vane assembly, an improved diaphragm and labyrinth seal assembly comprising:

a. a diaphragm means disposed adjacent to the rotor disc of said rotor blade assembly to define with the rotor disc a cooling fluid chamber;

b. each vane of stator vane assembly having a root portion;

c. a first slipjoint connecting means for connecting said root portions of said stator vanes to the diaphragm means so that relative radial movement is permitted between the stator vanes and diaphragm means due to thermal differential expansion and contraction;

d. a source of cooling fluid in communication with the fluid chamber to provide the latter with cooling fluid;

e. a labyrinth seal disposed between the diaphragm means and the rotor blade assembly;

f. one part of said labyrinth seal being carried by diaphragm means while another part is carried by the rotor blade assembly; and

g. a second slipjoint connecting means for connecting the diaphragm means to the inner wall of the inlet passageway so that thermal differential expansion and contraction in a radial direction is permitted between the inner wall and said diaphragm means;

h. said first and second slipjoint connecting means coacting to permit relative radial movement between the diaphragm means and said inner wall and stator vanes without affecting the cooperative relationship of said labyrinth seal parts.

2. The apparatus of claim **1** wherein said slipjoint connecting means comprises interlocking means connected to the diaphragm means and the inner wall to prevent relative rotative movement between the diaphragm and said inner wall and simultaneously allowing relative radial movement therebetween.

3. The apparatus of claim **1** wherein said diaphragm means includes an annular shroud connected along its one periphery and supporting at its distal periphery said one part of the labyrinth seal.

* * * * *