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(54) Seal for a turbine system

(57) A seal for a turbine system includes a rotor 28, a bowl region 40 and a stator assembly 29 having a tip strip 46 disposed proximate the rotor 28. Also included is a packing head 48 disposed proximate the tip strip 46. Further included is a flex seal 60 having a first end portion 62 fixedly secured to at least one of the tip strip 46 and the packing head 48, with a second end portion 64 slidably engaged with at least one of the tip strip 46 and the packing head 48.

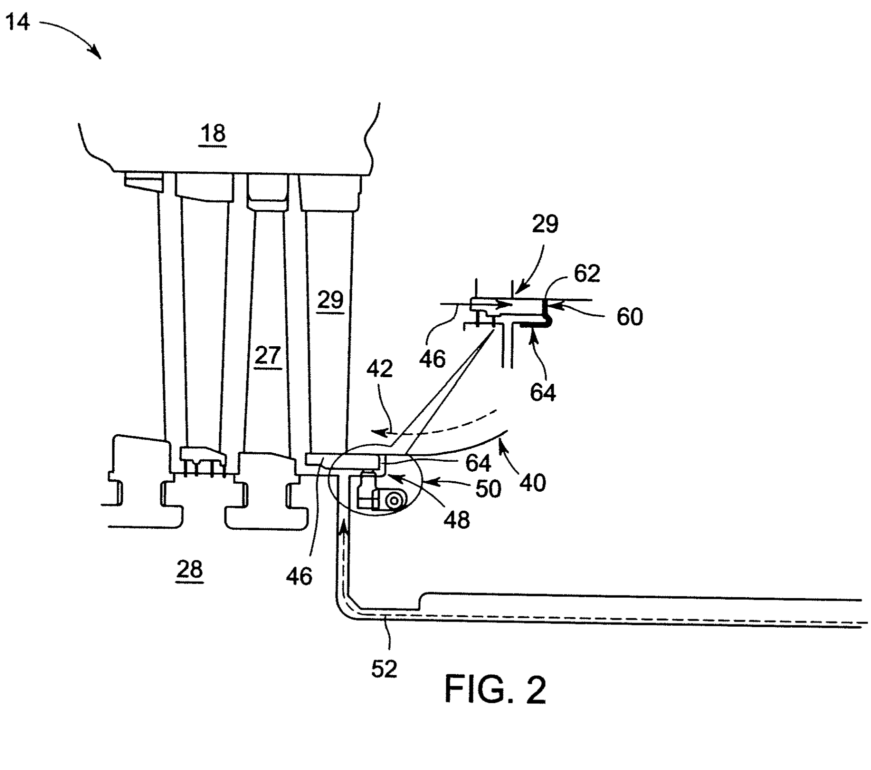

FIG. 2

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Description

[0001] The subject matter disclosed herein relates generally to turbine systems, and more particularly to a seal for such turbine systems.

[0002] Turbine systems, such as steam turbine systems, for example, often include different sections that operate at various pressures, including a high pressure (HP) section and an intermediate pressure (IP) section, each housing a portion of a rotor. During operation, it is common for a cooling source to be introduced to the area of the IP section proximate the rotor, in order to maintain the temperature of the rotor below the temperature of the general IP section. Failure to achieve maintenance of the rotor surface at a cooler temperature results in a need to reduce the rotor diameter design, but the reduced diameter negatively impacts overall steam turbine system performance.

[0003] Steam from the HP section often leaks across packing, such as N2 packing, toward the lower pressure environment of the IP section, and may provide the cooling source for the rotor. Preventing a separate steam source, namely the relatively hot IP section steam, from reaching the rotor surface requires sealing between stators proximate the rotor surface. Previous efforts to seal such locations from the hot IP section steam have encountered issues with radial and axial displacement of the stators during operation of the steam turbine system, with which the seals are often in contact.

[0004] According to one aspect of the invention, a seal for a turbine system includes a rotor, a bowl region and a stator assembly having a tip strip disposed proximate the rotor. Also included is a packing head disposed proximate the tip strip. Further included is a flex seal having a first end portion fixedly secured to at least one of the tip strip and the packing head, with a second end portion slidably engaged with at least one of the tip strip and the packing head.

[0005] According to another aspect of the invention, a seal for a steam turbine system includes a rotor, a bowl region and a stator assembly including a stator tip strip, wherein the stator tip strip is disposed proximate the rotor. Also included is a first steam source injected into the bowl region at a first temperature. Further included is a packing head disposed proximate the stator tip strip. Yet further included is a rotor cooling steam source injected at a second temperature along a path in close proximity to the rotor, wherein the second temperature is lower than the first temperature. Also included is a flex seal having a fixed portion and a free portion, wherein the flex seal is fixedly coupled at the fixed portion to at least one of the stator assembly, the packing head and the stator tip strip, wherein the flex seal prevents the first steam source from entering the path in close proximity to the rotor.

[0006] According to yet another aspect of the invention, a seal for a steam turbine system includes an intermediate pressure section having a rotor, a bowl region, an outer casing and a stator assembly having a tip strip disposed proximate the rotor, wherein the intermediate pressure section comprises an axial direction corresponding to a longitudinal direction of the rotor and a radial direction extending relatively from the rotor to the outer casing. Also included is a packing head disposed proximate the tip strip. Further included is a flex seal having a first end portion fixedly secured to at least one of the tip strip and the packing head, with a second end portion slidably engaged with at least one of the tip strip and the packing head and configured to be displaced in the axial direction and the radial direction.

[0007] Various advantages and features will become more apparent from the following description taken in conjunction with the drawings.

[0008] 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. Various features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic illustration of a steam turbine system;

FIG. 2 is a cross-sectional view of an inlet region of an intermediate pressure section of the steam turbine system illustrating a flex seal according to one embodiment;

FIG. 3 is a cross-sectional view of the flex seal illustrated in FIG. 2;

FIG. 4 is a cross-sectional view of the flex seal according to a second embodiment;

FIG. 5 is a cross-sectional view of the flex seal according to a third embodiment; and

FIG. 6 is a cross-sectional view of the flex seal according to a fourth embodiment.

[0009] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

[0010] Referring to FIG. 1, a turbine system and more specifically an opposed-flow steam turbine system is generally illustrated with the reference numeral 10. The steam turbine system 10 includes a high pressure (HP) section 12 and an intermediate pressure (IP) section 14, with the HP section 12 being defined by an HP casing 16, and similarly the IP section 14 being defined by an IP casing 18. A central section 20 disposed between the HP section 12 and the IP section 14 includes a high pressure steam inlet 22 and an intermediate pressure steam inlet 24.

[0011] An annular section divider 26 extends radially inwardly from the central section 20 towards a rotor 28 that extends between the HP section 12 and the IP section 14. More specifically, the annular section divider 26 extends circumferentially around a portion of the rotor 28 between an HP section inlet nozzle 30 and an IP section inlet nozzle 32. The annular section divider 26 has a packing structure 50 annularly fitted close to the rotor 28.

[0012] In operation, the high pressure steam inlet 22 receives high pressure, high temperature steam from a steam source, such as a boiler (not illustrated), for example. Steam is routed through the HP section 12 from the first HP section inlet nozzle 30, from which work is extracted from the steam to mechanically rotate the rotor 28 via a plurality of turbine blades 27, or buckets (shown in FIG. 2) which are operably coupled to the rotor 28. Each set of buckets includes a corresponding stator 29 (shown in FIG. 2) that facilitates routing of steam to the associated buckets. The steam exits the HP section 12 and is returned to the boiler, where the steam is then reheated. The reheated steam is then routed to the intermediate pressure steam inlet 24 and returned to the IP section 14 via the IP section inlet nozzle 32 at a reduced pressure than steam entering the HP section 12, but at a temperature that is approximately equal to the temperature of the steam entering the HP section 12. Work is extracted from the steam in the IP section 14 in a similar manner as that employed for the HP section 12 via a system of rotating and stationary components. Accordingly, an operating pressure within the HP section 12 is higher than an operating pressure within the IP section 14, such that steam within the HP section 12 tends to flow towards the IP section 14 through leakage paths that may develop between the HP section 12 and the IP section 14.

[0013] Although the steam turbine system 10 has been described as an opposed-flow high pressure and intermediate pressure steam turbine combination, it is to be appreciated that the steam turbine system 10 may be employed with any individual turbine including, but not limited to, low pressure turbines. Additionally, the steam turbine system 10 is not limited to being configured as an opposed-flow steam turbine, but may instead be configured as a single-flow or double-flow steam turbine system, for example. Moreover, it is contemplated that embodiments disclosed herein may be used in conjunction with gas turbine systems as well.

[0014] Referring to FIG. 2, a cross-sectional portion of the IP section 14 is shown in greater detail. The IP section 14 includes an IP bowl 40 proximate the IP section inlet nozzle 32, wherein a stream 42 of high temperature, intermediate pressure steam is injected into the IP bowl 40 for routing through the IP section 14, as described above. The stator 29 within the IP section 14 is operably connected at a radially outward position to the IP casing 18 and includes a tip strip 46 that is disposed proximate the rotor 28. Adjacent to, and in close proximity with, the tip strip 46 of the stator 29 is a packing head 48 of the packing structure 50 disposed between the HP section 12 and the IP section 14. In order to maintain the rotor 28 at a suitable application temperature, a cooling source may be introduced proximate the rotor 28. Such a cooling source may comprise a leaked flow 52 from the HP section 12 that has leaked across the N2 packing structure 50. The leaked flow 52 that comprises high pressure steam from the HP section 12 naturally tends to flow in the direction of the lower pressure IP section 14. As the leaked flow 52 travels from the HP section 12 to the IP section 14, the temperature of the leaked flow 52 decreases, thereby providing a cooler flow to the rotor 28 than would otherwise be felt by the rotor 28 as a result of heat transfer stemming from the stream 42 generally flowing through the IP section 14. It is to be appreciated that the cooling source has been described as the leaked flow 52 from the HP section 12 across the N2 packing structure 50, however, various alternative cooling sources may be employed to maintain the temperature of the rotor 28 below that of the general IP section 14.

[0015] As illustrated, a gap 54 between the packing head 48 and the tip strip 46 of the stator 29 is present. Unsealed, the gap 54 may result in a direct path of the stream 42, which may have a varying temperature of about 1,100°F, toward the rotor 28. Additionally, mixing of the stream 42 with a cooling source, such as the leaked flow 52, hinders the efficiency of the rotor cooling effort. In order to prevent passage of the stream 42 through the gap 54, a flex seal 60 is disposed within the gap 54. The flex seal 60 includes a first end portion 62 and a second end portion 64, with one of the first end portion 62 or the second end portion 64 being operably coupled to the tip strip 46, or more generally the stator 29, or the packing head 48. The end not operably coupled to an object, that being either the first end portion 62 or the second end portion 64 is fittingly engaged with either the tip strip 46 or the packing head 48 and relatively free to displace. In other words, irrespective of whether the first end portion 62 or the second end portion 64 is operably coupled to the tip strip 46 or the packing head 48, the other end is fittingly engaged with the other object, specifically the tip strip 46 or the packing head 48.

[0016] The ability of the first end portion 62 or the second end portion 64 to displace is based on the tendency of stator components, such as the tip strip 46 and the packing head 48 to displace in an axial and/or a radial direction during operation of the steam turbine system 10. Therefore, tight seals having a pressure fit at both the first end portion 62 and the second end portion 64 or an operable connection at the first end portion 62 and the second end portion 64 are not adequately held within the gap 54. The allowance of the flex seal 60 to displace proximate at least one end in correspondence with an associated structure, such as the tip strip 46 or the packing head 48, maintains a robust seal of the gap 54, while accommodating the axial and/or radial displacement of the tip strip 46 or the packing head 48.

[0017] Referring to FIGS. 3-6, enlarged views of various embodiments of the flex seal 60 are illustrated. It is to be appreciated that the geometries of the flex seal 60 shown are merely illustrative, and are not limiting, as numerous geometric variations of the flex seal 60 are contemplated. Irrespective of the specific geometry employed for the flex seal 60, included is the first end portion 62 and the second end portion 64, with each being disposed in contact with the tip strip 46 and the packing head 48, respectively. As previously described, only one end of the flex seal 60 is operably coupled to one of the tip strip 46 and the packing head 48. By way of example, the first end portion 62 may be operably coupled to the tip strip 46 via mechanical fastening, such as bolting, riveting, or welding. These manners of mechanically fastening the first end portion 62 to the tip strip 46 are merely examples, and any suitable fastener may be employed to ensure retention of the first end portion 62 to the tip strip 46. Continuing with the example, the second end portion 64 is in fitting engagement with the packing head 48, yet not operably coupled in a fixed manner, such that displacement may be achieved during axial and/or radial displacement of the tip strip 46 and/or the packing head 48. Adequate sealing and engagement of the second end portion 64 with the packing head 48 is achieved by pre-pressurizing the flex seal 60 to maintain sealing during even relatively large displacements.

[0018] The various embodiments of the flex seal 60 are illustrated and may be characterized as "Y-shaped" (FIG. 3), "S-shaped" (FIG. 4), or variations thereof (FIGS. 5 and 6). While described as having the first end portion 62 and the second end portion 64 that are either operably coupled or in fitting engagement with the associated structural components, it is to be appreciated that the end is not necessarily the portion that requires such a connection. As seen in FIG. 6, for example, the second end portion 64 is not disposed in contact with the packing head 48, and as such it may be another portion of the flex seal 60 that provides the operable connection or the fitting engagement. As described above, the illustrated embodiments of the flex seal 60 are merely examples of the numerous contemplated configurations that may be employed to prevent the high temperature steam, in the form of the stream 42, from intruding the rotor area through the gap 54.

[0019] Advantageously, the flex seal 60 prevents the high temperature steam routing through the IP section 14 from being imposed on the surface of the rotor 28, while maintaining adequate structural integrity at seal contact points.

[0020] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

[0021] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A seal for a turbine system comprising:

   rotor, a bowl region and a stator assembly having a tip strip disposed proximate the rotor;

   a packing head disposed proximate the tip strip; and

   a flex seal having a first end portion fixedly secured to at least one of the tip strip and the packing head, with a second end portion slidably engaged with at least one of the tip strip and the packing head.

2. The seal of clause 1, wherein the flex seal is disposed in an intermediate pressure section of the turbine system.

3. The seal of any preceding clause, wherein the first end portion is bolted to the tip strip.

4. The seal of any preceding clause, wherein the first end portion is riveted to the tip strip.

5. The seal of any preceding clause, wherein the first end portion is welded to the packing head.

6. The seal of any preceding clause, wherein the stator assembly is operably coupled to an outer casing of the intermediate pressure section.

7. The seal of any preceding clause, further comprising an axial direction and a radial direction, wherein the axial direction relatively corresponds to a longitudinal direction of the rotor and the radial direction relatively extends from the rotor to the outer casing.

8. The seal of any preceding clause, wherein the second end portion of the flex seal is configured to be displaced in the axial direction and the radial direction.

9. The seal of claim 1, wherein the flex seal is of a relatively Y-shaped geometric configuration.

10. A seal for a steam turbine system comprising:

   a rotor, a bowl region and a stator assembly including a stator tip strip, wherein the stator tip strip is disposed proximate the rotor;

   a first steam source injected into the bowl region at a first temperature;

a packing head disposed proximate the stator tip strip;

a rotor cooling steam source injected at a second temperature along a path in close proximity to the rotor, wherein the second temperature is lower than the first temperature; and

a flex seal having a fixed portion and a free portion, wherein the flex seal is fixedly coupled at the fixed portion to at least one of the stator assembly, the packing head and the stator tip strip, wherein the flex seal prevents the first steam source from entering the path in close proximity to the rotor.

11. The seal of any preceding clause, wherein the flex seal is disposed in an intermediate pressure section of the steam turbine system.

12. The seal of any preceding clause, wherein the fixed portion is bolted to the tip strip.

13. The seal of any preceding clause, wherein the fixed portion is riveted to the tip strip.

14. The seal of any preceding clause, wherein the fixed portion is welded to the packing head.

15. The seal of any preceding clause, further comprising an axial direction and a radial direction, wherein the axial direction relatively corresponds to a longitudinal direction of the rotor and the radial direction relatively extends from the rotor to an outer casing.

16. The seal of any preceding clause, wherein the free portion of the flex seal is configured to be displaced in the axial direction and the radial direction.

17. The seal of any preceding clause, wherein the flex seal is of a relatively Y-shaped geometric configuration.

18. A seal for a steam turbine system comprising:

an intermediate pressure section having a rotor, a bowl region, an outer casing and a stator assembly having a tip strip disposed proximate the rotor, wherein the intermediate pressure section comprises an axial direction corresponding to a longitudinal direction of the rotor and a radial direction extending relatively from the rotor to the outer casing;

a packing head disposed proximate the tip strip; and

a flex seal having a first end portion fixedly secured to at least one of the tip strip and the packing head, with a second end portion slidably engaged with at least one of the tip strip and the packing head and configured to be displaced in the axial direction and the radial direction.

19. The seal of any preceding clause, further comprising:

a first steam source injected into the bowl region at a first temperature;

a rotor cooling steam source injected at a second temperature along a path in close proximity to the rotor, wherein the second temperature is lower than the first temperature, wherein the flex seal prevents the first steam source from entering the path in close proximity to the rotor.

20. The seal of any preceding clause, wherein the flex seal is of a relatively Y-shaped geometric configuration.

Claims

1. A seal for a turbine system comprising:

a rotor (28), a bowl region (40) and a stator assembly (29) having a tip strip (46) disposed proximate the rotor (28);
a packing head (48) disposed proximate the tip strip (46); and
a flex seal (60) having a first end portion (62) fixedly secured to at least one of the tip strip (46) and the packing head (48), with a second end portion (64) slidably engaged with at least one of the tip strip (46) and the packing head (48).

2. The seal of claim 1, wherein the flex seal (60) is disposed in an intermediate pressure section (14) of the turbine system.

3. The seal of any preceding claim, wherein the first end portion (62) is bolted to the tip strip (48).

4. The seal of any preceding claim, wherein the first end portion (62) is riveted to the tip strip (48).

5. The seal of any preceding claim, wherein the first end portion (62) is welded to the packing head (48).

6. The seal of any preceding claim, wherein the stator assembly (29) is operably coupled to an outer casing (18) of the intermediate pressure section (14).

7. The seal of any preceding claim, further comprising an axial direction and a radial direction, wherein the axial direction relatively corresponds to a longitudinal direction of the rotor (28) and the radial direction relatively extends from the rotor (28) to the outer casing.

8. The seal of any preceding claim, wherein the second end portion (64) of the flex seal (60) is configured to be displaced in the axial direction and the radial direction.

9. The seal of any preceding claim, wherein the flex seal (60) is of a relatively Y-shaped geometric configuration.

10. A seal for a steam turbine system comprising:

a rotor (28), a bowl region (40) and a stator assembly (29) including a stator tip strip (46), wherein the stator tip strip is disposed proximate the rotor;
a first steam source injected into the bowl region (40) at a first temperature;
a packing head (48) disposed proximate the stator tip strip;
a rotor cooling steam source injected at a second temperature along a path in close proximity to the rotor (28), wherein the second temperature is lower than the first temperature; and
a flex seal (60) having a fixed portion and a free portion, wherein the flex seal is fixedly coupled at the fixed portion to at least one of the stator assembly, the packing head and the stator tip strip, wherein the flex seal prevents the first steam source from entering the path in close proximity to the rotor (28).

11. The seal of claim 10, wherein the flex seal (60) is disposed in an intermediate pressure section (14) of the steam turbine system.

12. The seal of claim 10 or claim 11, wherein the fixed portion is welded to the packing head.

13. The seal of any of claims 10 to 12, further comprising an axial direction and a radial direction, wherein the axial direction relatively corresponds to a longitudinal direction of the rotor (28) and the radial direction relatively extends from the rotor (28) to an outer casing (18).

14. The seal of a claim 13, wherein the free portion of the flex seal (60) is configured to be displaced in the axial direction and the radial direction.

15. A seal for a steam turbine system comprising:

an intermediate pressure section (14) having a rotor (28), a bowl region (40), an outer casing (18) and a stator assembly (29) having a tip strip (46) disposed proximate the rotor, wherein the intermediate pressure section (14) comprises an axial direction corresponding to a longitudinal direction of the rotor and a radial direction extending relatively from the rotor to the outer casing (18);
a packing head (48) disposed proximate the tip strip (46); and
a flex seal (60) having a first end portion fixedly secured to at least one of the tip strip and the packing head, with a second end portion slidably engaged with at least one of the tip strip (46) and the packing head (48) and configured to be displaced in the axial direction and the radial direction.

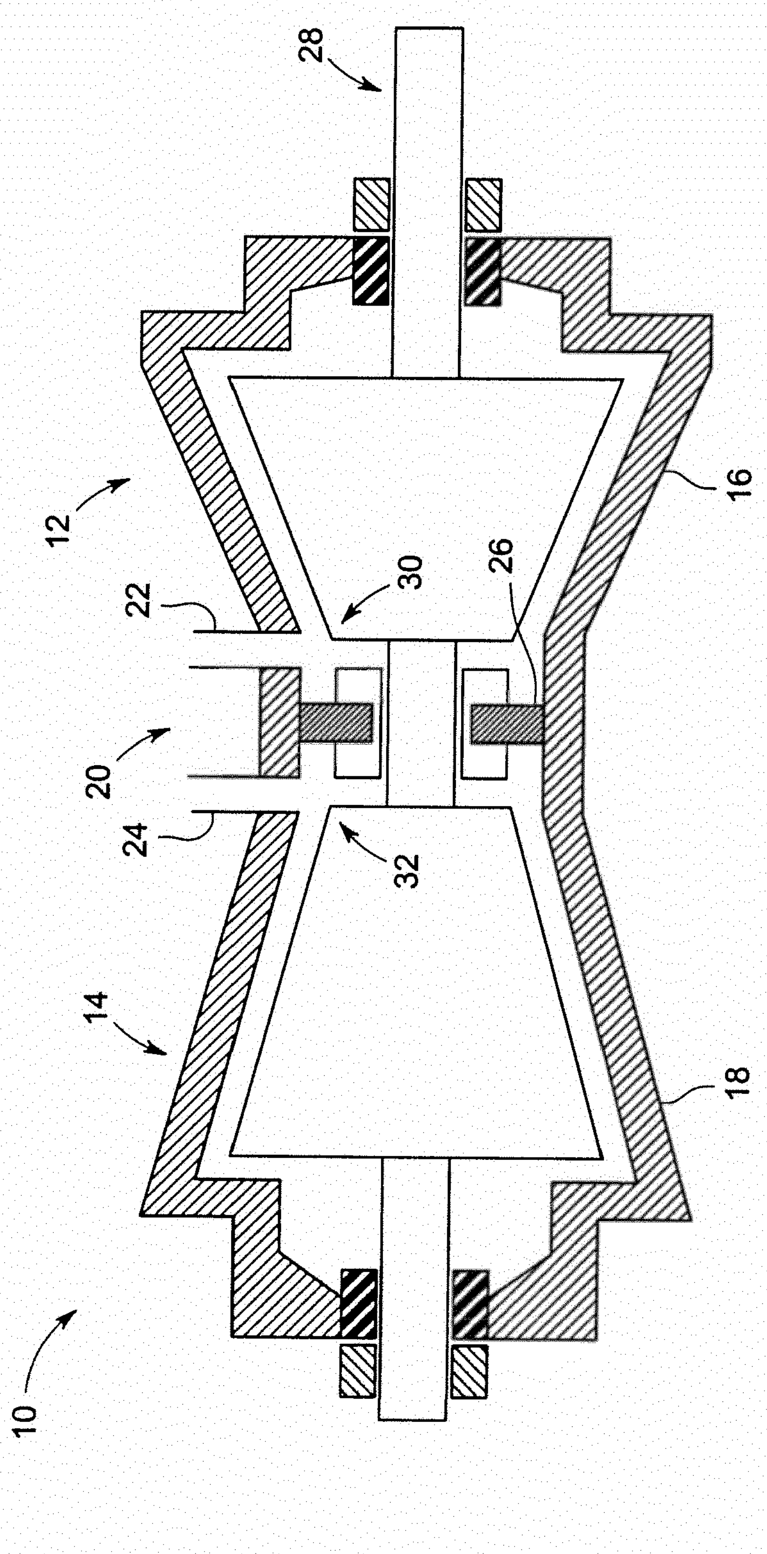

FIG. 1

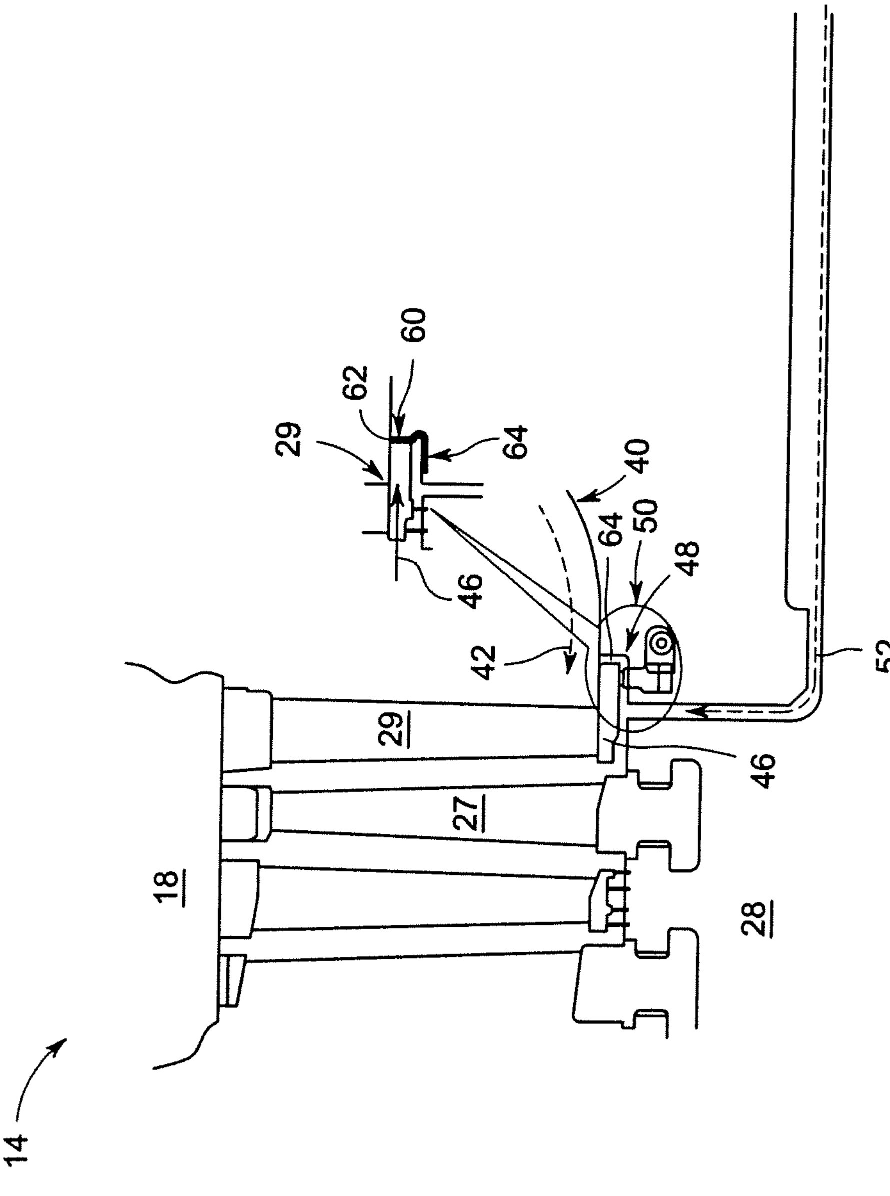

FIG. 2

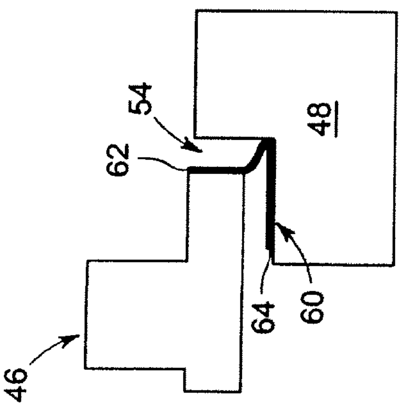

FIG. 3

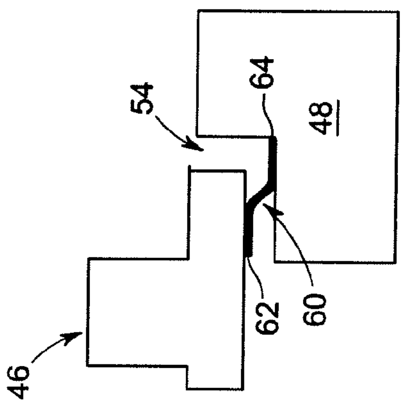

FIG. 4

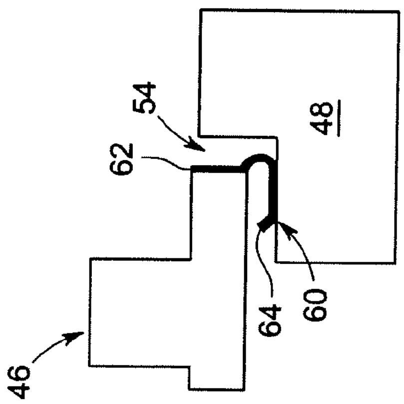

FIG. 5

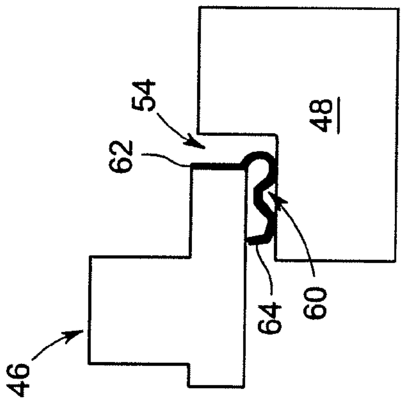

FIG. 6