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(54) **Integrated nozzle and bucket wheel for a reaction steam turbine and method of manufacture**

(57) Integrated nozzle and bucket wheels (10, 44) for turbine stator and rotor components, respectively, include a three hundred sixty degree wheel formed from a single piece of stock material. The nozzle wheels (10) include radially inner portions formed to include a plurality of airfoils (16), while the bucket wheels are each formed to include a plurality of buckets (54). The nozzle and bucket wheels may be split into plural arcuate segments.

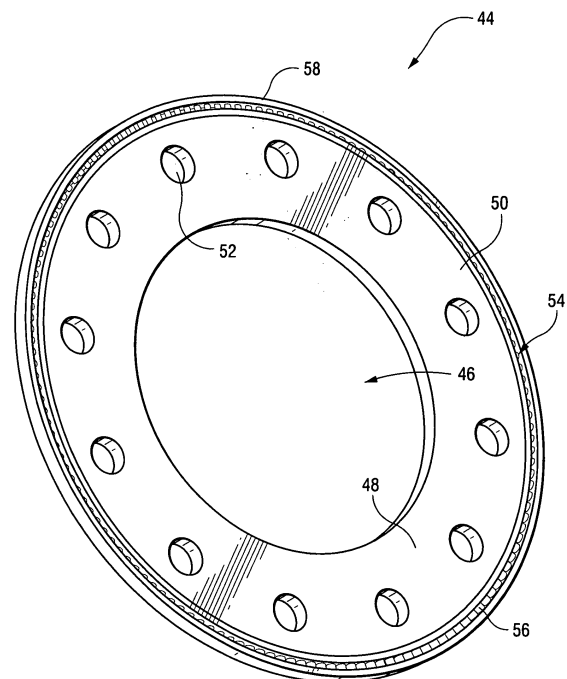


Fig. 5

Description

[0001] This invention relates generally to steam turbine construction and, more specifically, to integrated nozzle and bucket wheel constructions for a reaction steam turbine.

[0002] Current integral-cover reaction nozzle stages are made up of large quantities of individual reaction nozzles that are assembled into a machined stator casting or nozzle carrier. More specifically, individual nozzles are loaded into a dovetail groove and secured within the carrier using individual radial loading pins. Each nozzle tip is machined with a specified tip seal configuration for interaction with the turbine rotor so as to minimize leakage along the hot gas path.

[0003] Similarly, current integral-cover reaction bucket stages are also made up of large quantities of individual reaction buckets, assembled into a machined rotor forging using individual radial loading pins. After assembly, the buckets are secured with retention hardware, the bucket tips are machined to the specified tip seal configuration.

[0004] The time and cost associated with the manufacture of the stator casting, stator machining, nozzle stock material and nozzle machining, and stator assembly, as well as the rotor forging, rotor machining, bucket stock material, bucket machining and assembly add significant costs overall to the reaction steam path.

[0005] In accordance with an exemplary embodiment of this invention, the nozzle and bucket manufacturing/assembly processes are simplified, and the overall cost of the reaction steam path is reduced without impacting the integrity of the overall reaction steam turbine design.

[0006] In the exemplary embodiment, a full row of reaction nozzles is machined into a 360° piece of flat stock material. It will be understood that the stock material may be forged, rolled ring or plate stock. The 360° ring is placed into a machining center where the ID, OD, inlet blends, airfoils, airfoil radii, cover shroud sealing configuration, retention features and the balance of the standard nozzle features are machined. Thereafter, the integrated nozzle wheel may or may not be split into two or more arcuate segments in preparation for the final steam path assembly process.

[0007] Similarly, a single stage of reaction airfoils may be machined into a 360° piece of flat stock material that also may be forged, rolled ring or plate stock. The bucket seal tip geometry, mating axial face rabbet fits and retention features may also be machined into the integrated bucket wheel.

[0008] It is also possible to incorporate into the integrated nozzle and bucket wheels, adjacent stator and rotor surfaces, that are forward and/or aft of the nozzle and/or bucket airfoils, respectively, and utilized to facilitate axial stacking of plural nozzle wheels in an alternating arrangement with respective bucket wheels.

[0009] Accordingly, in one aspect, the present invention relates to an integrated bucket wheel for a turbine rotor component comprising a three hundred sixty degree wheel formed from a single piece of stock material, a radially outer portion of the wheel manufactured to include a plurality of buckets, each having an airfoil portion and a radially outer tip shroud portion; and a radially inner portion of the bucket wheel manufactured to include one or more assembly features.

[0010] In another aspect, the invention relates to an integrated bucket wheel for a rotor component of a reaction turbine comprising a unitary 360° piece of stock material having a radially outer portion machined to include a plurality of buckets, each having an airfoil portion and a radially outer tip shroud portion; and a radially inner portion machined to include a plurality of tie-rod or bolt holes circumferentially spaced about the radially inner portions.

[0011] In still another aspect, the invention relates to a method of making a turbine bucket wheel comprising forming flat stock material into an annular ring; machining a radially outer portion of the annular ring to include a plurality of buckets, each comprising an airfoil portion, and machining a radially inner portion of the annular ring to include assembly features.

[0012] The invention will now be described in detail in connection with the drawings identified below, in which:

FIGURE 1 is a perspective view of an integrated nozzle wheel in accordance with an exemplary embodiment of the invention;

FIGURE 2 is a perspective view of another integrated nozzle wheel in accordance with an embodiment of the invention;

FIGURE 3 is a perspective view of the nozzle wheel of Figure 1 assembled in a lower turbine casing component;

FIGURE 4 is a perspective view similar to Figure 3, but with an upper turbine casing component located over the upper nozzle wheel segment; and

FIGURE 5 is a perspective view of an integrated turbine rotor bucket wheel in accordance with another embodiment of the invention.

[0013] With initial reference to Figure 1, an integrated nozzle wheel 10 is shown, split into upper and lower 180° segments or halves 12, 14. It will be appreciated that splitting the wheel facilitates assembly in the upper and lower

turbine casing components or sections, with the nozzle wheel segments surrounding the rotor.

[0014] In the exemplary embodiment, the wheel 10 is manufactured from a single 360° piece of flat stock material that could be forged, rolled ring or plate stock. The annular ring is thereafter machined to include a plurality of airfoils 16, in a circumferential array at the radially inner portion of the wheel. The radially inner ends of the airfoils 16 are also machined to include an integral cover shroud sealing configuration 18 that determines the ID of the wheel. The remainder of the wheel, specifically the radially outer portion 20, is formed to include assembly bolt or tie-rod holes 22 and any other rim or rabbet configuration to facilitate axial stacking with similar wheels, or with discrete spacer rings therebetween that accommodate the rotating stages on the rotor.

[0015] Figure 2 illustrates another integrated nozzle wheel 24 where one side 26 of the wheel is machined to include a blended toroidal-shaped inlet 28 extending axially upstream of the integrated nozzles 30. Here again, bolt or tie-rod holes 32 are provided in the radially outer region 34 to facilitate axial stacking.

[0016] Figure 3 illustrates the nozzle wheel 10 of Figure 1 located in a lower turbine casing component 36 with a plurality of tie rods or bolts 38 extending through the holes 22 and secured by nuts 40 or the like to facilitate axial stacking of multiple nozzle wheels.

[0017] Figure 4 illustrates the arrangement in Figure 3 but with an upper casing component 42 assembled over the lower casing component 36. It will be appreciated that the upper and lower nozzle wheel segments 12, 14 and the upper and lower casing components 36, 42 will be secured, respectively, to each other, using conventional retention/securement hardware configurations (not shown). In the case of the nozzle wheel segments, the retention/securement features will be machined into the segments consistent with the invention described herein.

[0018] Turning to Figure 5, a reaction turbine rotor bucket wheel 44 is formed from a single, circular flat plate of stock material (forged, rolled ring or plate stock). The wheel 44 is formed with a center bore 46, a radially inner portion 48 and a radially outer portion 50. It will be appreciated that the bore 46 may be machined to the desired geometry, depending on the associated rotor size, configuration, etc.

[0019] The radially inner portion 48 is provided with fastening features which, in the example illustrated, includes a plurality of bolt or tie-rod holes 52 circumferentially spaced about the radially inner portion. The radially outer portion 50 is machined to include a plurality of buckets 54, each including an airfoil portion 56 and an integral shroud or tip cover 58 that extends 360°, over all of the radially outer tips of the airfoil portions 56.

[0020] As in the case of the turbine nozzle wheel shown in Figure 1, the bucket wheel 44 may be split into a pair of 180° arcuate segments to facilitate assembly, particularly for field replacement of a single wheel. In other instances, the bucket wheel 44 may remain, and be assembled as a unitary, integrated, 360° bucket wheel.

[0021] In addition to the airfoil portion 56 and shroud or tip cover 58, the machining operation may also include finish machining of the wheel OD, ID, inlet blends, airfoil radii and any other standard bucket features.

[0022] Adjacent rotor surfaces that are forward and aft of the bucket airfoil portions, may also be integrated into the bucket wheel. For example, a single adjacent rotor surface (forward or aft) may be incorporated into the bucket wheel, and may be integral or added on after the airfoils have been machined. Alternatively, double adjacent rotor surfaces (forward and aft) may be incorporated into the bucket wheel and may be integral or added on after the airfoils have been machined. Some applications may not require any added adjacent rotor surfaces.

[0023] By machining the airfoils in the fashion disclosed hereinabove, the following obstacles associated with current reaction bucket design may be reduced and/or eliminated:

Cover shroud interference;

Untwist of cover shrouds during operation;

Axial clearance issues related to the untwist for assembling multiple individual bucket/pins for each stage.

The need to perform in process assembly checks such as twist, shingling and throat area measurements;

The need for standing assembled modal test and the associated costs of each test; and

[0024] Ergonomic concerns related to assembling individual loading pins for individual buckets.

[0025] In addition to eliminating the items above, the integrated bucket wheel may also accomplish the following:

Increase the ability to service/repair rows of buckets;

Create a known/repeatable boundary condition;

Reduce the number of parts per stage;

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Reduce the amount of variation within an assembled stage;

Reduce the amount of unused (wasted) material from the bucket and rotor manufacturing processes;

Reduce the size, weight and cost of the rotor forging;

Prevent assembly in the wrong location and/or direction;

Reduce the number of resources needed to support manufacturing-fewer manufacturing processes, fixtures, operators, inspections, program and attendant opportunities for errors; and

Significantly reduce the amount of material required versus individual parts.

[0026] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

PART LIST

[0027]

Ref. Nos.	Description
10	Nozzle wheel
16	Airfoils
18	Cover shroud sealing configuration
22	Holes
24	Integrated nozzle wheel
26	One side
12, 14	Upper and lower nozzle wheel segments
32	Bolt or tie-rod holes
34	Outer region
36	Lower turbine casing component
40	Nuts
42	Upper casing component
44	Bucket wheel
46	Center bore
48	Radially inner portion
50	Radially outer portion
52	Bolt or tie-rod holes
54	Buckets
56	Airfoil portion
58	Shroud or tip cover

Claims

1. An integrated bucket wheel (44) for a turbine rotor component comprising a three hundred sixty degree wheel formed from a single piece of stock material, a radially outer portion (50) of said wheel manufactured to include a plurality of buckets (54), each having an airfoil portion (56) and a radially outer tip shroud portion (58); and a radially inner portion (48) of said bucket wheel manufactured to include one or more assembly features (52).
2. The integrated bucket wheel of claim 1 wherein said assembly features include a plurality of tie-rod or bolt holes (52) radially inward of said airfoil portions.
3. The integrated bucket wheel of claim 2 wherein said tie-rod or bolt holes (52) are circumferentially spaced about said radially inner portion (48).
4. The integrated bucket wheel of any preceding claim wherein said bucket wheel (44) is split into two or more arcuate segments.
5. The integrated bucket wheel of any preceding claim wherein said stock material comprises a forged stock.
6. The integrated bucket wheel of any one of claims 1 to 4 wherein said stock material comprises rolled ring stock.
7. The integrated bucket wheel of any one of claims 1 to 4 wherein said stock material comprises generally flat plate stock.
8. The integrated bucket wheel of any preceding claim including a center opening (46) adapted to receive a turbine rotor.
9. An integrated bucket wheel (44) for a rotor component of a reaction turbine comprising a unitary 360° piece of stock material having a radially outer portion (50) machined to include a plurality of buckets (54), each having an airfoil portion (56) and a radially outer tip shroud portion (58); and a radially inner portion (48) machined to include a plurality of tie-rod or bolt holes (52) circumferentially spaced about said radially inner portions.
10. A method of making a turbine bucket wheel (44) comprising forming flat stock material into an annular ring; machining a radially outer portion of said annular ring to include a plurality of buckets (54), each comprising an airfoil portion (56), and machining a radially inner portion (48) of said annular ring to include assembly features (52).

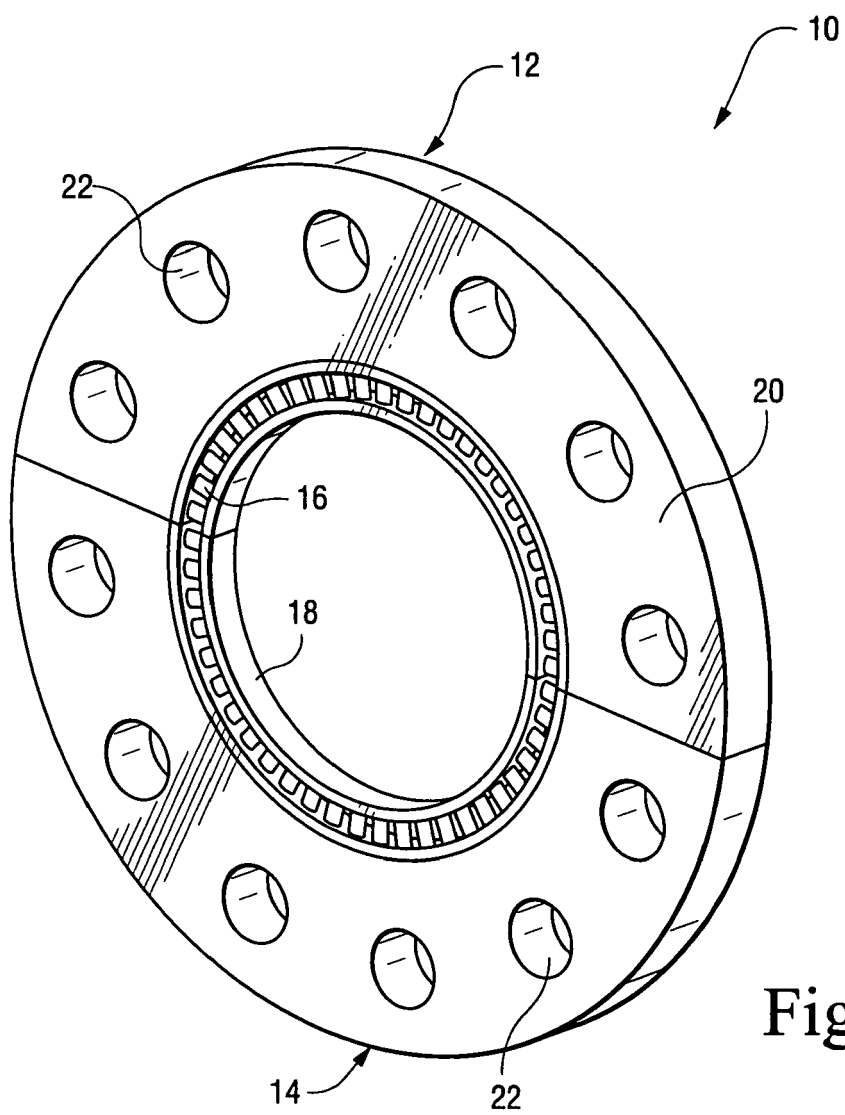


Fig. 1

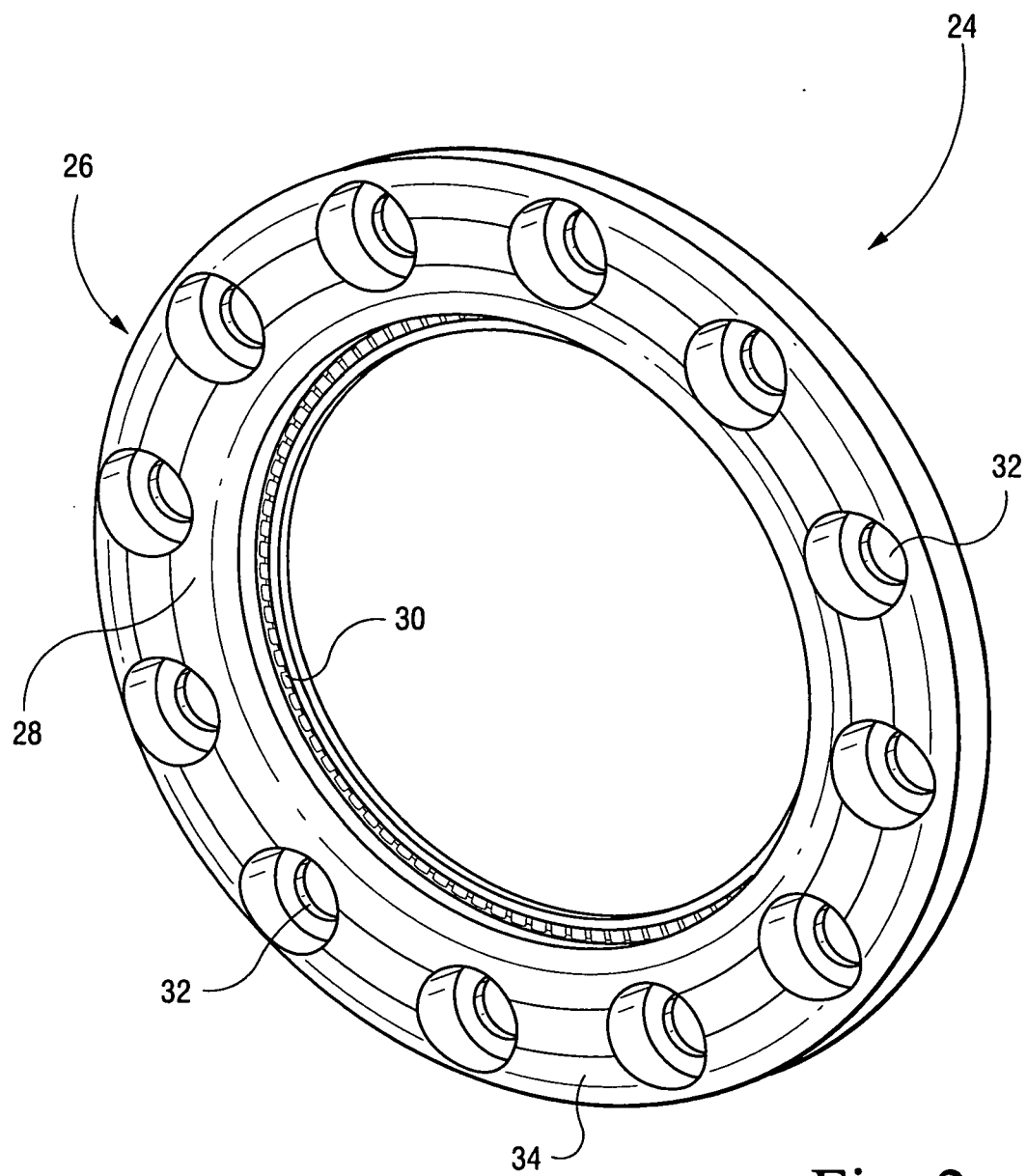


Fig. 2

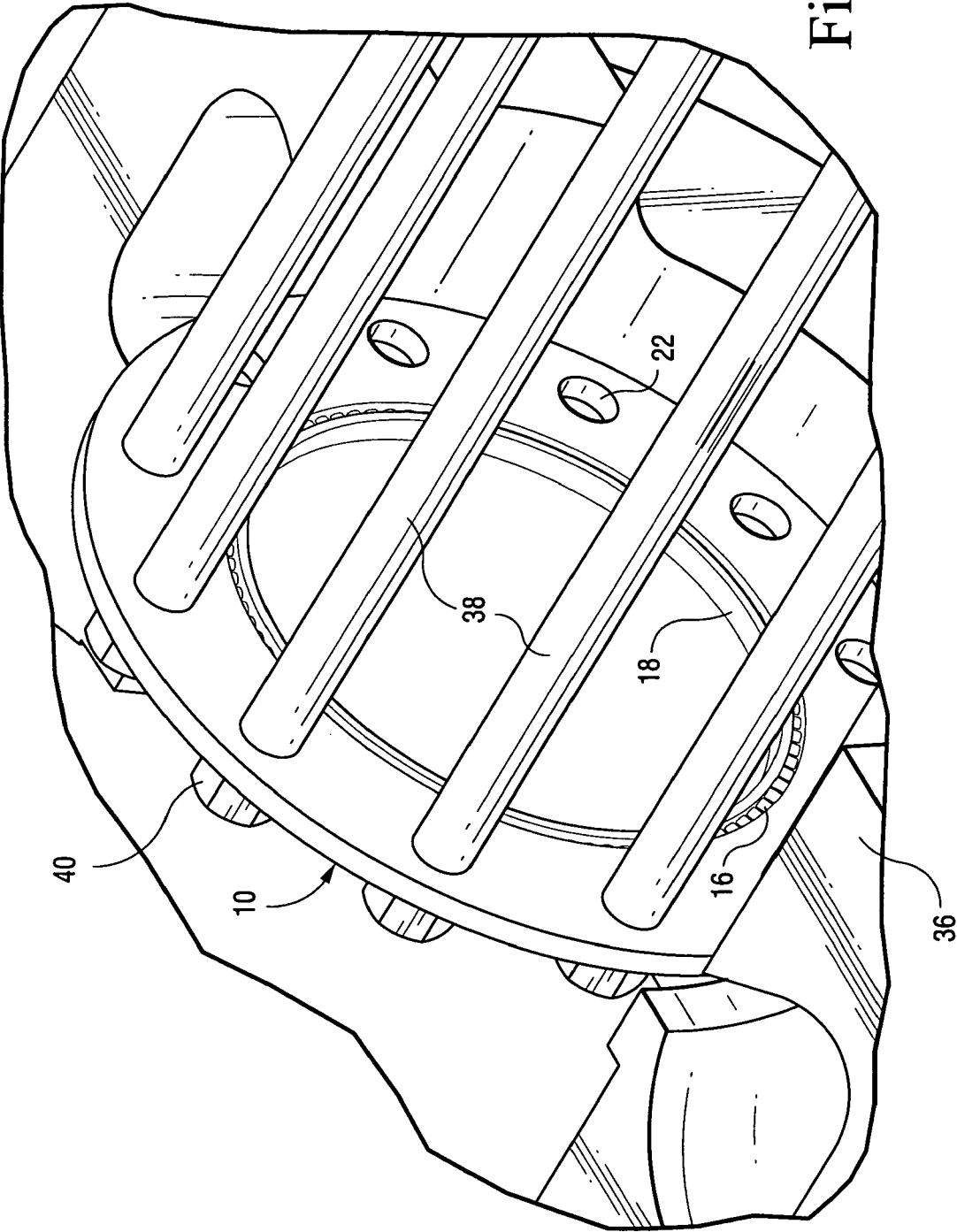


Fig. 3

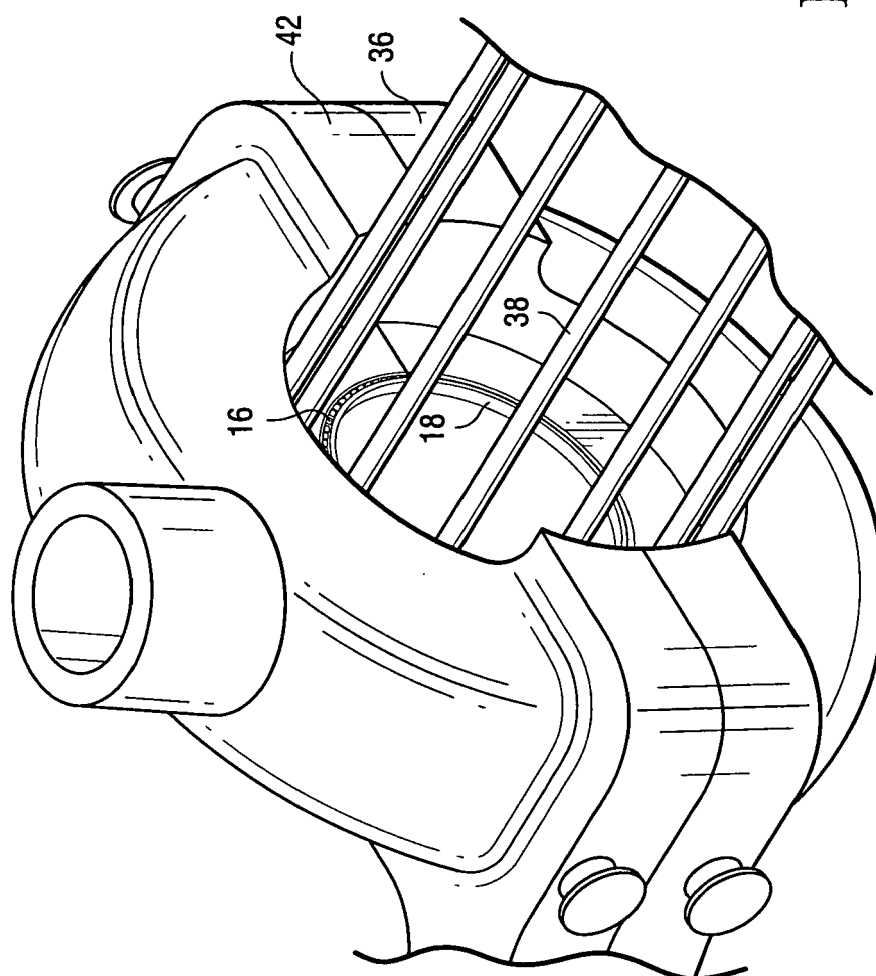


Fig. 4

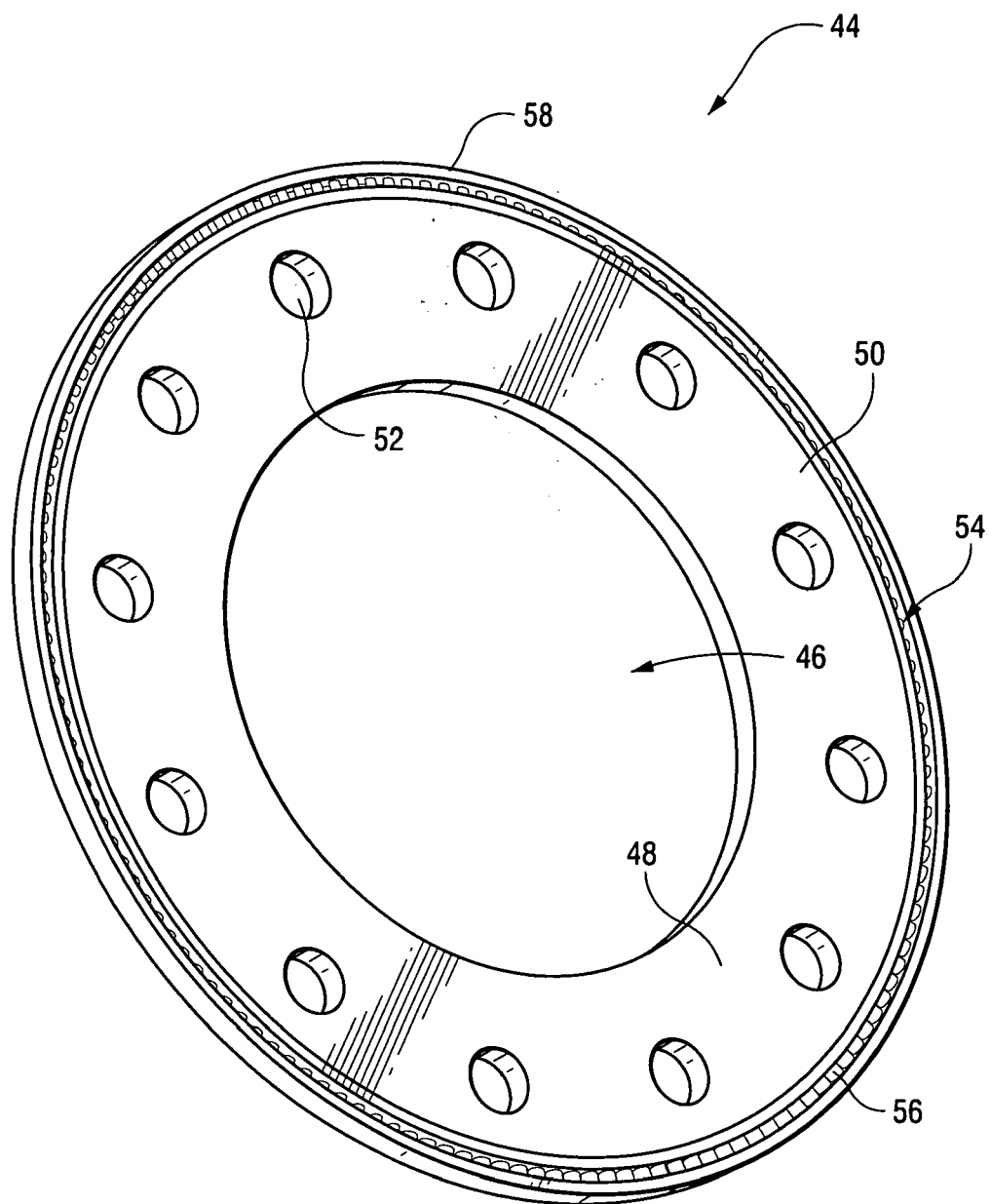


Fig. 5