



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.05.2014 Bulletin 2014/19

(51) Int Cl.:
F01D 25/14 (2006.01) F01D 25/26 (2006.01)

(21) Application number: **13189620.1**

(22) Date of filing: **22.10.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(30) Priority: **31.10.2012 US 201261720822 P**
08.05.2013 US 201313889822

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(54) **Steam turbine cowling system with insulation and flow guide devices**

(57) A steam turbine cowling system (200) is disclosed. The steam turbine cowling system including: a lower portion (120) configured to be disposed proximate an inner casing (190) of a steam turbine, and an upper portion (110) connected to at least one of the lower portion (120) and the inner casing (190), the upper portion (110) shaped to be disposed proximate the inner casing (190) of the steam turbine (10), the upper portion (110) substantially defining a flowpath (192) about the inner casing (190). The cowling system is configured as a thermal and flow guide device.

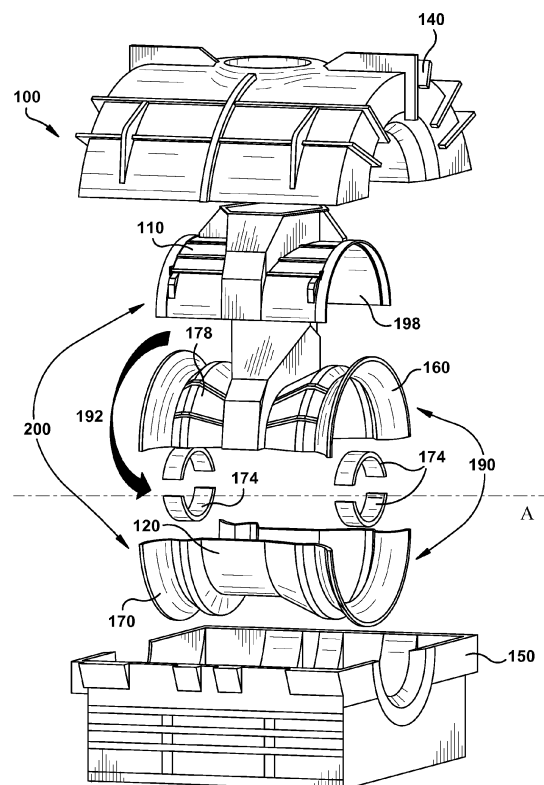


FIG. 2

Description

[0001] The subject matter disclosed herein relates to a shell for steam turbine systems. More specifically, the subject matter disclosed herein relates to a cowling system (e.g., a fabricated sheet metal shell) for a low pressure inner casing of a steam turbine system, the cowling system is configured as a thermal (e.g., heat lagging, insulation, etc.) and flow guide device.

BACKGROUND OF THE INVENTION

[0002] Steam turbine shells are components that encompass, for example, the high pressure (HP), intermediate pressure (IP), and/or low pressure (LP) sections of the steam turbine. Conventional steam turbine shells/cowlings include a plurality of components which may be permanently attached to an inner casing of the turbine. In practice, this plurality of components aids in insulating the steam turbine and steam turbine components. As a result of the permanent connection to the steam turbine and/or the inner casing and the configuration, orientation, and relation of each of the components relative to one another; manufacture and assembly of the cowling about the steam turbine may be a labor intensive process which must be performed during steam turbine manufacture in order to provide adequate heat lagging and proper assembly. However, the assembly of this plurality of components and their permanent attachment to the steam turbine inner casing may complicate future maintenance operations and procedures, and lengthen and complicate steam turbine build and assembly times. Additionally, these multiple components disposed about the inner casing may interfere and/or obstruct with portions of a steam flow path about the inner casing to a condenser of the steam turbine system.

BRIEF DESCRIPTION OF THE INVENTION

[0003] A first aspect of the invention includes a steam turbine cowling system including: a lower portion configured to be disposed proximate an inner casing of a steam turbine; and an upper portion connected to the lower portion and the inner casing and configured to be disposed proximate the inner casing of the steam turbine, the upper portion substantially defining a flowpath about the inner casing.

[0004] A second aspect of the invention includes an upper cowling portion configured to connect to a lower cowling portion and substantially complement an inner casing of a steam turbine, the upper cowling portion configured to be disposed proximate the inner casing of the steam turbine and substantially define a flowpath about the inner casing.

[0005] A third aspect of the invention includes a steam turbine having: a rotor member; and a stator member at least partially surrounding the rotor member, the stator member including: an external casing; an inner casing

disposed within the external casing; and a steam turbine cowling system disposed between the external casing and the inner casing, the steam turbine cowling system including: a lower portion configured to be disposed proximate the inner casing; and an upper portion connected to at least one of the lower portion and the inner casing and configured to be disposed proximate the inner casing of the steam turbine, the upper portion substantially defining a flowpath about the inner casing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] These and other features of this invention will be more readily understood from the following detailed description of the various aspects of the invention taken in conjunction with the accompanying drawings that depict various embodiments of the invention, in which:

FIG. 1 a three-dimensional partial cut-away perspective view of a portion of a turbine according to an embodiment of the invention.

FIG. 2 shows a three-dimensional perspective view of a portion of a steam turbine system according to embodiments of the invention.

FIG. 3 shows a three-dimensional perspective view of a steam turbine cowling shell system according to embodiments of the invention.

FIG. 4 shows a schematic illustration of portions of a multi-shaft combined cycle power plant in accordance with embodiments of the invention.

FIG. 5 shows a schematic illustration of portions of a single-shaft combined cycle power plant in accordance with embodiments of the invention.

[0007] It is noted that the drawings of the invention are not necessarily to scale. The drawings are intended to depict only typical aspects of the invention, and therefore should not be considered as limiting the scope of the invention. It is understood that elements similarly numbered between the FIGURES may be substantially similar as described with reference to one another. Further, in embodiments shown and described with reference to FIGS. 1-5, like numbering may represent like elements. Redundant explanation of these elements has been omitted for clarity. Finally, it is understood that the components of FIGS. 1-5 and their accompanying descriptions may be applied to any embodiment described herein.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Aspects of the invention provide for a steam turbine cowling system. Specifically, the subject matter disclosed herein relates to a steam turbine cowling system configured to insulate (e.g., provide heat lagging, isolate

stagnant steam proximate thermal extreme sections of a steam turbine, separate exhaust steam from the inner casing, etc.) steam turbine components and act as a flow guide to the condenser in a steam turbine system, by forming a flowpath about the inner casing of the steam turbine. The cowling system may be shaped to isolate steam proximate sections of the inner casing and may include a smooth surface (e.g., an aerodynamic surface) formed/shaped to provide a continuous flow surface for steam flow about the inner casing and to the condenser.

[0009] As described herein, conventional steam turbine shells include a plurality of components disposed on the inner casing to insulate turbine components. However, this plurality of components may complicate and lengthen steam turbine system assembly, requiring concurrent manufacture and assembly (e.g., customization) with the steam turbine itself. Additionally, this plurality of components may impede and/or obstruct steam flow from the top of the inner casing to a condenser beneath the inner casing. Further, this plurality of components, as a result of construction and assembly, may interrupt steam flows about the steam turbine, and/or contain gaps between them that allow steam to flow there between, thereby minimizing the insulation capabilities of the component.

[0010] In contrast to conventional shells for steam turbine inner casings, aspects of the invention provide for a cowling which is configured to insulate portions of the steam turbine and form a flowpath from a top of an inner casing to the condenser. The cowling includes a set of components disposed substantially about the inner casing and configured as a flow guide for steam from the top of the casing. In some embodiments, the cowling includes a set of detachable components (e.g., an upper half) which may be disposed about the inner casing in a non-permanent manner, thereby allowing for technician access to the inner casing.

[0011] In some embodiments, the cowling system includes a lower portion (e.g., half) connected (e.g., permanently) to the inner steam turbine casing and an upper portion (e.g., half) disposed substantially about the inner steam turbine casing and removably (e.g., detachable, releasably coupled, etc.) connected to a steam guide and/or the inner casing. In this embodiment, the cowling system may be disposed substantially proximate (e.g., at a thermal variation/expansion clearance, as close as limited by geometric constraints, etc.) the inner steam turbine casing.

[0012] In an embodiment, the cowling system may include a substantially smooth surface and may be configured to direct flow outside of an exhaust hood bottom flow plate of the steam turbine. In one embodiment, the cowling system may be disposed at a distance relative to the steam turbine inner casing which enables technicians to access the inner casing (e.g., access to horizontal joint bolts, turbine components, inner casing disassembly, etc.). The technical effect of the cowling systems and devices described herein is to provide thermal insu-

lation (e.g., heat lagging) to turbine components and to form a flow guide toward a condenser in a steam turbine system. Turning to the FIGURES, embodiments of systems and devices are shown, which are configured to insulate (e.g., provide heat lagging) steam turbine components and act as a flow guide to the condenser by forming a flowpath from the inner casing to the condenser. Each of the components in the FIGURES may be connected via conventional means, e.g., via a common conduit or other known means as is indicated in FIGS. 1-5. Referring to the drawings, FIG. 1 shows a perspective partial cut-away illustration of a gas or steam turbine 10. Turbine 10 includes a rotor 12 that includes a rotating shaft 14 and a plurality of axially spaced rotor wheels 18. A plurality of rotating blades 20 are mechanically coupled to each rotor wheel 18. More specifically, blades 20 are arranged in rows that extend circumferentially around each rotor wheel 18. A plurality of stationary vanes 22 extend circumferentially around shaft 14, and the vanes are axially positioned between adjacent rows of blades 20. Stationary vanes 22 cooperate with blades 20 to form a stage and to define a portion of a steam flow path through turbine 10.

[0013] In operation, gas or steam 24 enters an inlet 26 of turbine 10 and is channeled through stationary vanes 22. Vanes 22 direct gas or steam 24 downstream against blades 20. Gas or steam 24 passes through the remaining stages imparting a force on blades 20 causing shaft 14 to rotate. At least one end of turbine 10 may extend axially away from rotating shaft 12 and may be attached to a load or machinery (not shown) such as, but not limited to, a generator, and/or another turbine.

[0014] In one embodiment, turbine 10 may include five stages. The five stages are referred to as L0, L1, L2, L3 and L4. Stage L4 is the first stage and is the smallest (in a radial direction) of the five stages. Stage L3 is the second stage and is the next stage in an axial direction. Stage L2 is the third stage and is shown in the middle of the five stages. Stage L1 is the fourth and next-to-last stage. Stage L0 is the last stage and is the largest (in a radial direction). It is to be understood that five stages are shown as one example only, and each turbine may have more or less than five stages. Also, as will be described herein, the teachings of the invention do not require a multiple stage turbine.

[0015] Turning to FIG. 2, a three-dimensional exploded perspective view of a portion of a steam turbine system 100 including a cowling system 200 is shown according to embodiments. In this embodiment, steam turbine system 100 includes a base 150 configured to connect to and/or support an inner casing 190. A cap 140 may be connected to base 150 and disposed about inner casing 190 forming a substantially contained steam turbine system 100. Inner casing 190 may include a lower half casing 170 and an upper half casing 160 configured to connect to and/or complement lower half casing 170 and define a flowpath 'A' (shown in phantom) substantially about/through a set of turbine components 174 (e.g., a

rotor, vanes, seals, a flowpath, etc.). In an embodiment, cowling system 200 may be disposed between inner casing 190 and base 150 and cap 140. Cowling system 200 may be disposed substantially about inner casing 190 and be configured to insulate (e.g., thermally) components and/or portions of steam turbine system 100. In an embodiment, cowling system 200 may substantially define a flowpath 192 about inner casing 190 (e.g., between cowling system 200 and inner casing 190). Flowpath 192 may extend from a top of inner casing 190 to a condenser disposed in and/or connected to base 150. In one embodiment, cowling system 200 may be configured as a flow guide (e.g., a smooth path, an aerodynamic path, etc.) for flowpath 192. Flowpath 192 may include a smooth surface on upper half inner casing 160 which is shaped to direct steam coming out of/from the steam path back down to a condenser. In an embodiment, the smooth surface of flowpath 192 may reduce pressure requirements. In contrast to conventional shell systems for inner casing segments (e.g., inner casing 190), the cowling system 200 shown and described herein provides insulation and defines a flow path 192 about inner casing 190. Additionally, cowling system 200 may include detachable components (e.g., an upper portion 110).

[0016] In one embodiment, cowling system 200 may include an upper portion 110 and a lower portion 120 configured to complement one another and form cowling system 200 about inner casing 190. Upper portion 110 and/or lower portion 120 may be disposed proximate inner casing 190 so as to define flowpath 192 there between. In one embodiment, lower portion 120 may be permanently connected (e.g., welded, integrally bolted, etc.) to inner casing 190. Upper portion 110 may be detachably connected (e.g., bolted, releaseably coupled, etc.) to inner casing 190, flow guides, and/or cap 140. In one embodiment, upper portion 110 may be modular and/or configured to be removable for maintenance processes/procedures. In an embodiment, upper portion 110 and lower portion 120 may be disposed at a thermal variation clearance (e.g., a safe distance so as to avoid contact/stress between components as a result of variances in thermal expansion) relative to inner casing 190. In one embodiment, upper portion 110 and/or lower portion 120 may be disposed at a distance relative to inner casing 190 so as to allow/enable technician access to inner casing 190 and components therein.

[0017] In an embodiment, cowling system 200 includes a set of substantially smooth radially inward facing surfaces 198 which substantially define flowpath 192 (e.g., act as flow guides). These substantially smooth radially inward facing surfaces 198 are dissimilar to the radially inward facing surfaces of conventional shell structures for inner casing segments, as those conventional shell structures which include a plurality of components permanently connected to the inner casing segment may obstruct or interfere with flow there about. Cowling system 200 may cover all features and surfaces (e.g., external ribs, protrusions, etc.) of the inner casing construc-

tion. As shown in FIG. 2, upper half casing 160 and lower half casing 170 include a plurality of steam flow channels 178, which extend substantially annularly about a rotor apparatus (omitted for clarity of illustration). That is, the steam flow channels 178 illustrated in FIG. 2 extend between the lower half casing 170 and upper half casing 160 so as to provide a steam flow path along and/or about the flow path A (indicated in phantom) when the casing segments are adjoined. In contrast to conventional shell systems, aspects of the invention allow for flowpath guidance/definition and insulation (e.g., heat lagging) by cowling system 200 (including, e.g., a detachable upper portion 110 and/or lower portion 120) described herein. For example, as shown in FIGS. 2-3, cowling system 200 may be disposed about inner casing 190 at a distance which substantially defines flowpath 192 and provides insulation to steam turbine system 100. Cowling system 200 may include fabricated sheet metal. In an embodiment, steam may travel about flowpath 192 such that a first portion of steam may pass from the lower half casing 170 directly down to the condenser and a second portion of steam may swirl in the upper half casing 160 and then exhaust down to the condenser.

[0018] Turning to FIG. 3, a three-dimensional perspective view of a steam turbine cowling system 240 is shown according to embodiments of the invention. In this embodiment, the cowling system 240 includes an upper portion 210 (e.g., an upper half shell configured to mate with the upper half casing 160 (e.g., inner casing) of FIG. 2), and a lower portion 220 (e.g., a lower half shell configured to mate with the lower half casing 170 (e.g., inner casing) of FIG. 2). In an embodiment, lower portion 220 may include a channel 250 shaped to surround geometry of the lower half casing 170 (e.g., inner casing). Upper portion 210 may include a flow aperture 216 configured to receive and/or complement a flow supply conduit (not shown for clarity). In one embodiment, upper portion 210 may include a set of covers 218 shaped to accommodate protrusions in inner casing 190 construction. Upper portion 210 may include a set of connectors 212 disposed circumferentially about upper portion 210 and configured to matingly engage inner casing 190 and/or cap 140. Set of connectors 212 may secure and/or orient upper portion 210 about inner casing 190 and adjacent components.

[0019] In an embodiment, lower portion 220 and/or upper portion 210 may include a set of substantially smooth radially inward facing surfaces 198 which substantially define flowpath 192 about inner casing 190. Lower portion 220 and upper portion 210 may be connected at a set of horizontal joints/surfaces 280.

[0020] Turning to FIG. 4, a schematic view of portions of a multi-shaft combined cycle power plant 500 is shown. Combined cycle power plant 500 may include, for example, a gas turbine 580 operably connected to a generator 570. Generator 570 and gas turbine 580 may be mechanically coupled by a shaft 515, which may transfer energy between a drive shaft (not shown) of gas turbine 580 and generator 570. Also shown in FIG. 4 is a heat exchanger

586 operably connected to gas turbine 580 and a steam turbine 592. Heat exchanger 586 may be fluidly connected to both gas turbine 580 and a steam turbine 592 via conventional conduits (numbering omitted). Gas turbine 580 and/or steam turbine 592 may be connected to cowl-
 ing system 200 of FIG. 2 or other embodiments described herein. Heat exchanger 586 may be a conventional heat recovery steam generator (HRSG), such as those used in conventional combined cycle power systems. As is known in the art of power generation, HRSG 586 may use hot exhaust from gas turbine 580, combined with a water supply, to create steam which is fed to steam turbine 592. Steam turbine 592 may optionally be coupled to a second generator system 570 (via a second shaft 515). It is understood that generators 570 and shafts 515 may be of any size or type known in the art and may differ depending upon their application or the system to which they are connected. Common numbering of the generators and shafts is for clarity and does not necessarily suggest these generators or shafts are identical. In another embodiment, shown in FIG. 5, a single shaft combined cycle power plant 990 may include a single generator 570 coupled to both gas turbine 580 and steam turbine 592 via a single shaft 515. Steam turbine 592 and/or gas turbine 580 may be connected to cowling system 200 of FIG. 2 or other embodiments described herein.

[0021] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0022] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

[0023] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A device comprising:

an upper cowling portion shaped to connect to a lower cowling portion and substantially complement an inner casing of a steam turbine, the upper cowling portion configured to be disposed proximate the inner casing of the steam turbine and substantially define a flowpath about the inner casing.

2. The device of clause 1, wherein the upper cowling portion is configured as an insulator about the inner casing.

3. The device of clause 1 or 2, the upper cowling portion is releasably coupled to the inner casing.

4. The device of any preceding clause, wherein the upper cowling portion substantially encloses a top segment of the inner casing and defines a flowpath from a top of the inner casing to the lower cowling portion.

5. The device of any preceding clause, wherein the upper cowling portion includes a steam inlet and is configured to guide a flow to the lower cowling portion.

6. The device of any preceding clause, wherein the upper cowling portion is modular and includes a substantially smooth radially inward facing surface.

Claims

1. A steam turbine cowling system (200) comprising:
 - a lower portion (120,220) configured to be disposed proximate an inner casing (190) of a steam turbine (10); and
 - an upper portion (110,210) connected to at least one of the lower portion (220) and the inner casing (190), the upper portion (210) shaped to be disposed proximate the inner casing (190) of the steam turbine (10) and substantially defining a flowpath (192) about the inner casing (190).
2. The steam turbine cowling system of claim 1, wherein at least one of the upper portion (110,210) and the lower portion (120,220) is configured as an insulator about the inner casing (190).
3. The steam turbine cowling system of claim 1 or 2, wherein the lower portion (110,220) is permanently connected to the inner casing (190).
4. The steam turbine cowling system of any of claims 1 to 3, wherein the upper portion (110,210) is connected to at least one of the inner casing (190) or a steam guide in the steam turbine (10).

5. The steam turbine cowling system of claim 4, wherein the upper portion (110,220) is releasably coupled to the inner casing (190).
6. The steam turbine cowling system of any preceding claim, wherein the at least one of the upper portion (110,210) and the lower portion (120,220) include a set of substantially smooth radially inward facing surfaces (198). 5
7. The steam turbine cowling system of any preceding claim, wherein the upper portion (110,210) includes a steam inlet (26). 10
8. The steam turbine cowling system of any preceding claim, wherein the upper portion (110,210) is configured to guide a flow toward the lower portion (120,220). 15
9. The steam turbine cowling system of any preceding claim, wherein the upper portion (110,210) and the lower portion (120,220) substantially enclose the inner casing (190) and define a flowpath from a top of the inner casing (190) to a condenser. 20
10. The steam turbine cowling system of any preceding claim, wherein the upper portion (110,210) is modular. 25
11. A steam turbine system (100) comprising: 30
 - a rotor member (20); and
 - a stator member (22) at least partially surrounding the rotor member (20), the stator member (22) including: 35
 - an external casing (160,170);
 - an inner casing (190) disposed within the external casing (160,170); and
 - the steam turbine cowling system (240) of any preceding claim disposed between the external casing (160,170) and the inner casing (190). 40
12. The steam turbine system of claim 11, further comprising a condenser operably connected to the stator, wherein the upper portion (110,210) and the lower portion (120,220) substantially enclose the inner casing (190) and define a flowpath (192) from a top of the inner casing (190) to the condenser. 45

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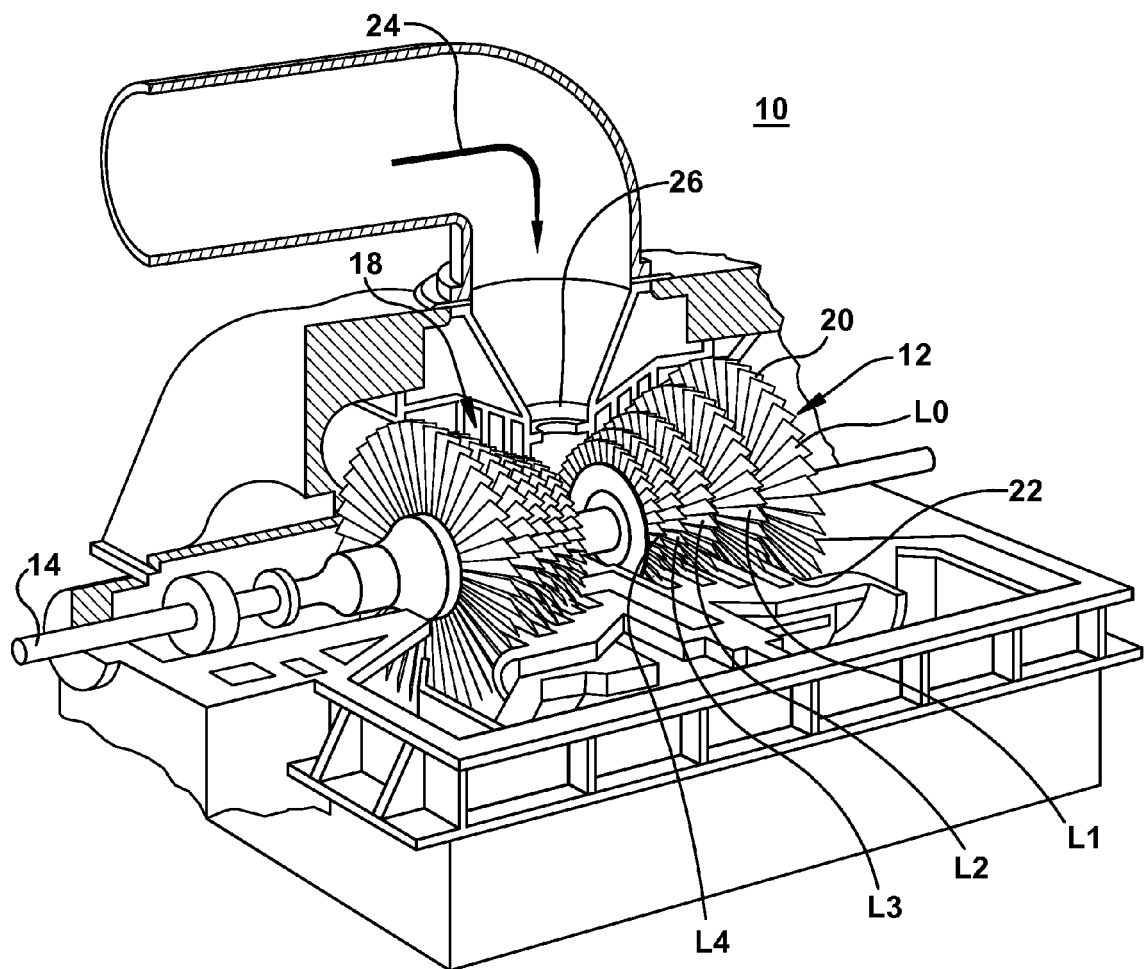


FIG. 1

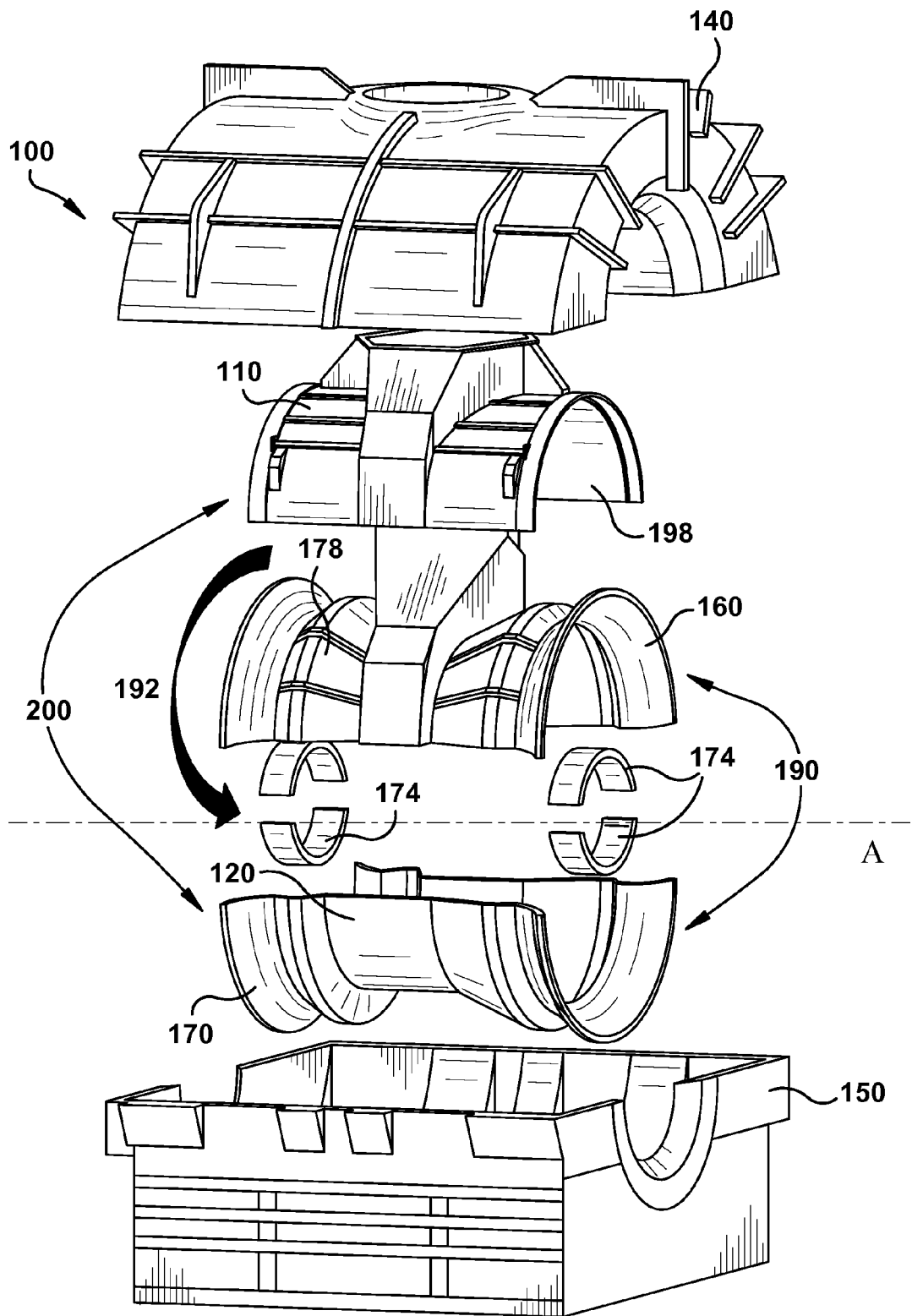


FIG. 2

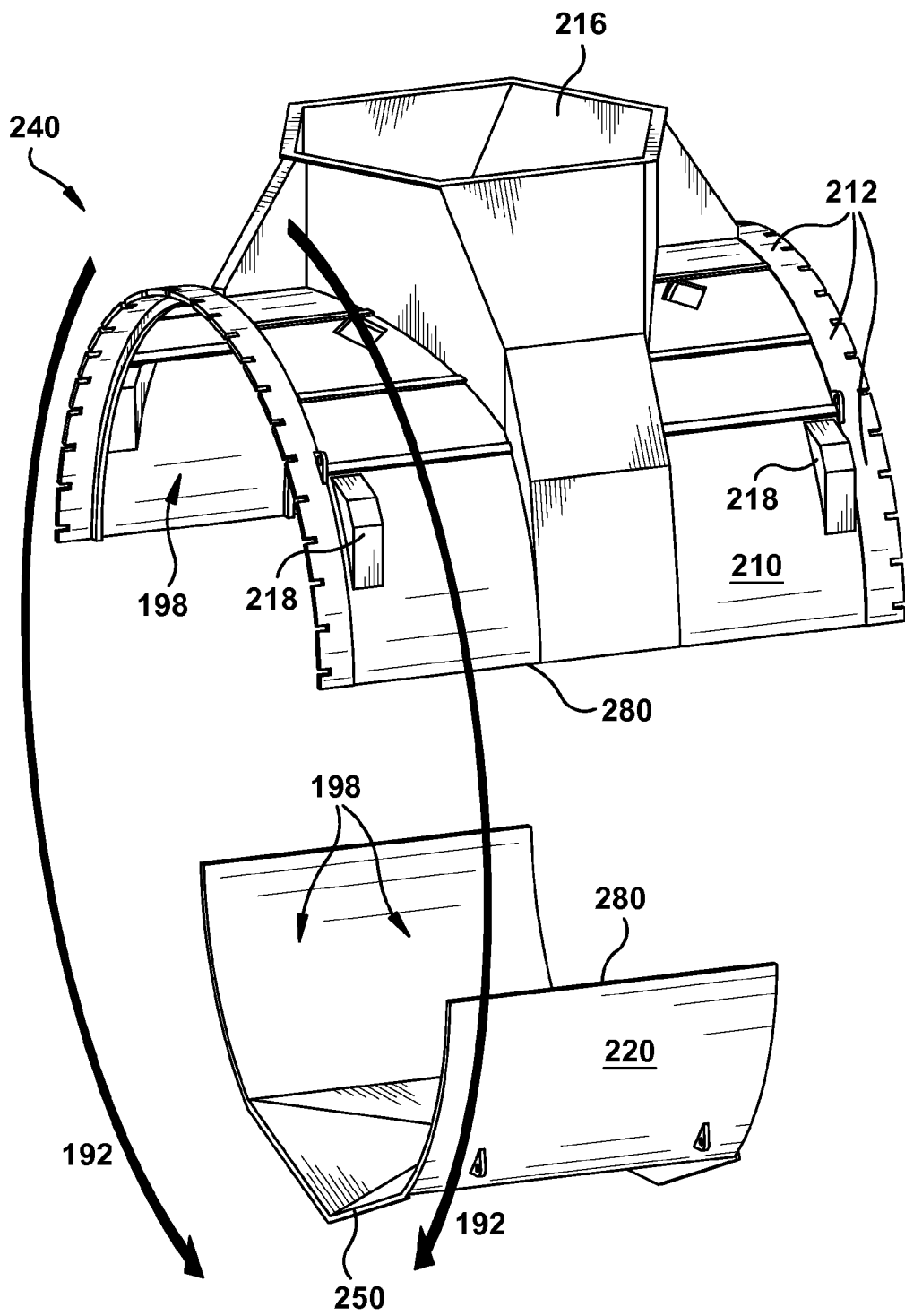


FIG. 3

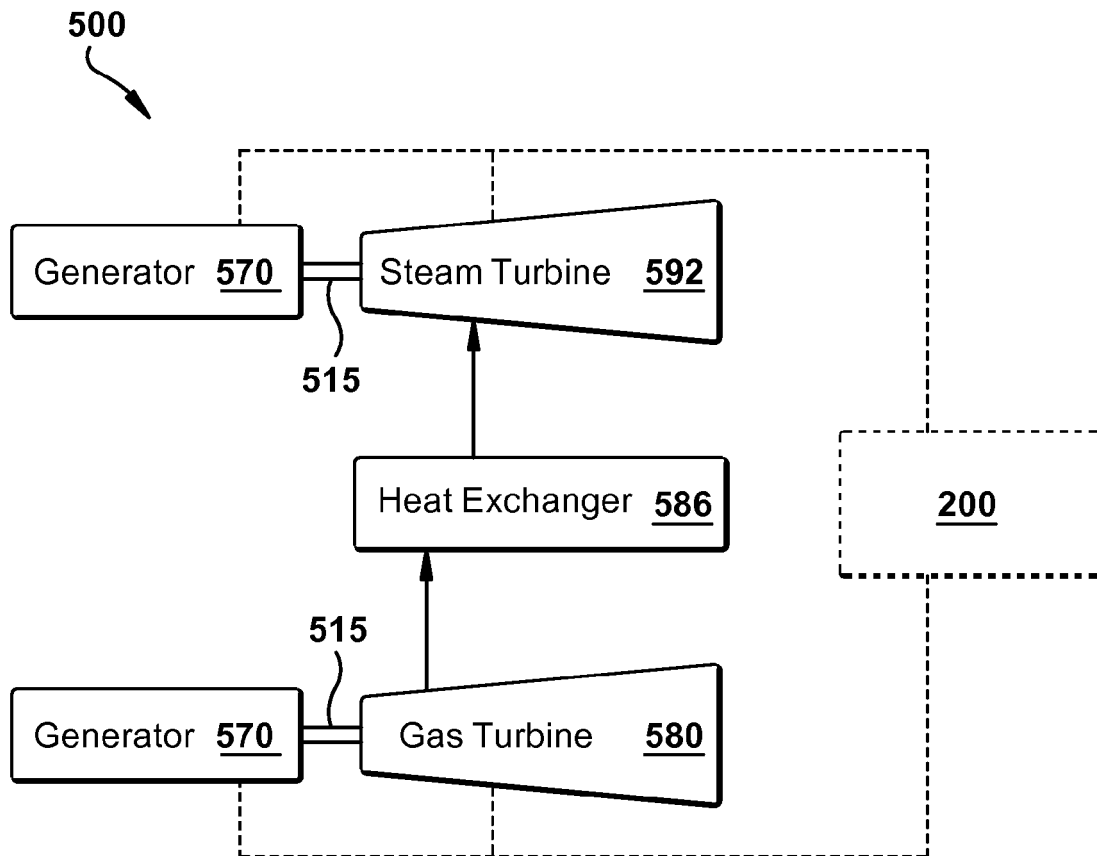


FIG. 4

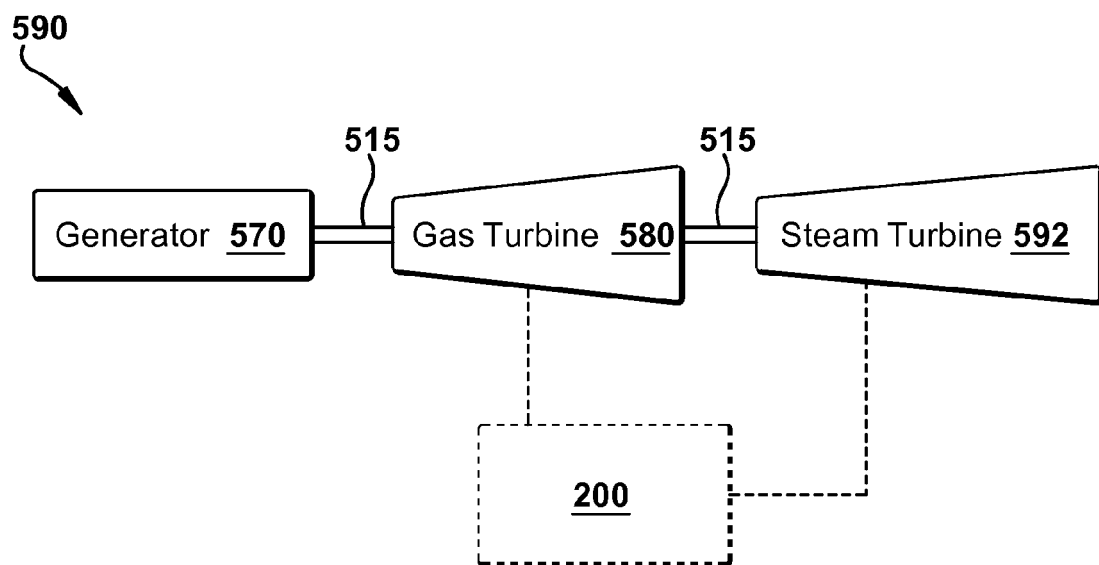


FIG. 5