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(54) **HEAT EXCHANGE SYSTEM HAVING AN INTEGRATED SUB-COOLER**

(57) A heat exchange system includes a casing enclosing a cavity therein, and a first heat exchange device configured to channel a first heat absorbing fluid therethrough and extending longitudinally within the cavity. Steam received within the cavity is condensable via thermal communication with the first heat absorbing fluid to form a first exhaust stream. The heat exchange system also includes a sub-cooler configured to channel a sub-cooler fluid therethrough and extending longitudinally within the cavity. The sub-cooler is positioned beneath the first heat exchange device such that the first exhaust stream is receivable into thermal communication with the sub-cooler fluid. In some embodiments, the sub-cooler includes a housing that includes a flat topmost surface. Additionally or alternatively, the heat exchange system includes an anti-flash plate that extends longitudinally within the casing between the upper portion and the lower portion of the cavity.

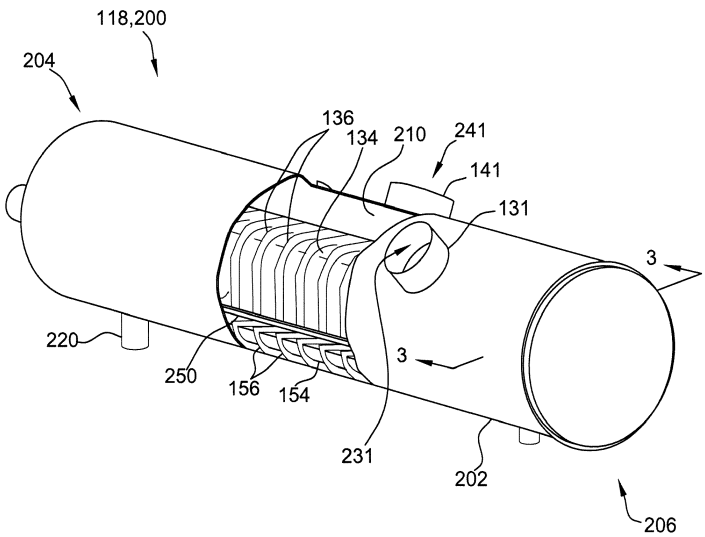


FIG. 2

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## Description

### BACKGROUND

**[0001]** The field of the disclosure relates generally to heat exchange systems for steam turbine systems, and more particularly to an integrated sub-cooler for a low-pressure heater installed in a condenser.

**[0002]** At least some known steam turbine systems channel streams of steam and condensed water drawn from various points in the system into thermal communication, in order to recover and use heat that would otherwise be lost from the streams. In order to improve an efficiency of such heat recovery, in at least some cases it is desirable to locate the heat exchange device as close as possible to the point from which the streams are extracted, for example to reduce heat losses in the extraction conduit. Additionally or alternatively, in order to reduce a footprint of the system, it is desirable to co-locate the heat exchange devices with each other and/or with other components of the steam turbine system.

**[0003]** For example, at least some known steam turbine systems include a plurality of heat exchange devices installed in a condenser neck of a steam turbine. In at least some cases, a sub-cooling zone co-located with another heat exchange device in this location would improve the efficiency of heat recovery from the received steam and/or reduce a footprint of the system. However, certain low-pressure heat exchange devices, such as heat exchange devices that receive steam extracted from low pressure steam turbines associated with a nuclear steam source, operate at a sufficiently low pressure (for example, but not by way of limitation, around 160 mbar) such that the equilibrium between steam and water is very sensitive to pressure fluctuation. As such, a sub-cooling zone included in such a low-pressure heater may present risks such as steam flashing, resulting in decreased heat transfer efficiency in the sub-cooling zone and associated distortion and wear of the heat exchange devices, and/or liquid water ingestion into the blade path of the steam turbine and associated wear on the blades.

### BRIEF DESCRIPTION

**[0004]** In one aspect, a heat exchange system is provided. The heat exchange system includes a casing enclosing a cavity therein, and a first heat exchange device configured to channel a first heat absorbing fluid therethrough. The first heat exchange device extends longitudinally within the cavity. Steam received within the cavity is condensable via thermal communication with the first heat absorbing fluid to form a first exhaust stream. The heat exchange system also includes a sub-cooler configured to channel a sub-cooler fluid therethrough. The sub-cooler extends longitudinally within the cavity. The sub-cooler is positioned beneath the first heat exchange device such that the first exhaust stream is receivable into thermal communication with the sub-cooler fluid. The sub-cooler includes a sub-cooler housing that extends horizontally from a first side to a second side. The sub-cooler housing includes a flat topmost surface that extends from the first side to the second side.

**[0005]** In another aspect, a steam turbine system is provided. The steam turbine system includes a steam turbine, and a first steam conduit configured to receive a first portion of steam tapped from a first intermediate stage of the steam turbine. The steam turbine system also includes a condenser configured to receive steam exhausted from the steam turbine. The condenser includes a neck portion. The steam turbine system further includes a heat exchange system that includes a casing enclosing a cavity therein. The cavity extends at least partially within the neck portion of the condenser. The casing includes a first inlet defined therein and coupled in flow communication between the cavity and the first steam conduit. The heat exchange system also includes a first heat exchange device configured to channel a first heat absorbing fluid therethrough. The first heat exchange device extends longitudinally within an upper portion of the cavity. The first portion of steam received through the first inlet is condensable via thermal communication with the first heat absorbing fluid to form a first exhaust stream. The heat exchange system further includes a sub-cooler configured to channel a sub-cooler fluid therethrough. The sub-cooler extends longitudinally within a lower portion of the cavity. The sub-cooler is positioned beneath the first heat exchange device such that the first exhaust stream is receivable into thermal communication with the sub-cooler fluid. In addition, the heat exchange system includes an anti-flash plate that extends longitudinally within the casing between the upper portion and the lower portion of the cavity.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]**

FIG. 1 is a schematic view of an exemplary steam turbine system;

FIG. 2 is a perspective cutaway view of an exemplary heat exchange system that may be used with the steam turbine system shown in FIG. 1; and

FIG. 3 is a cross-section of the heat exchange system shown in FIG. 2, taken along lines 3-3 shown in FIG. 2.

### DETAILED DESCRIPTION

**[0007]** The embodiments described herein overcome at least some of the disadvantages of known heat exchange devices having integral sub-coolers. The embodiments include a first heat exchange device and a sub-cooler located beneath the first heat exchange device within the same casing. For example, the casing is installed across the neck of a steam turbine condenser. The first heat exchange device uses steam tapped from an intermediate stage of the steam turbine to efficiently heat a first heat absorbing fluid for use elsewhere in the steam turbine system. The sub-cooler receives an exhaust stream of condensed water from the first heat exchange device into thermal communication with a sub-cooler fluid. Any of several features are used to facilitate operation of the first heater and sub-cooler with reduced potential for flashing within the casing and/or ingestion into the steam turbine, in particular (but not by way of limitation) at low pressures associated with a steam turbine system including a nuclear steam source. For one example, a housing of the sub-cooler extends horizontally from a first side to a second side, and a flat topmost surface of the sub-cooler housing extends from the first side to the second side, facilitating reduced accumulation of non-condensed steam. For another example, an anti-flash plate extends longitudinally within the casing between the first heat exchange device and the sub-cooler. For another example, sets of perforated impingement plates are positioned beneath the steam inlet to the casing.

**[0008]** Unless otherwise indicated, approximating language, such as "generally," "substantially," and "about," as used herein indicates that the term so modified may apply to only an approximate degree, as would be recognized by one of ordinary skill in the art, rather than to an absolute or perfect degree. Accordingly, a value modified by a term or terms such as "about," "approximately," and "substantially" is not to be limited to the precise value specified. In at least some instances, the approximating language may correspond to the precision of an instrument for measuring the value. Additionally, unless otherwise indicated, the terms "first," "second," etc. are used herein merely as labels, and are not intended to impose ordinal, positional, or hierarchical requirements on the items to which these terms refer. Moreover, reference to, for example, a "second" item does not require or preclude the existence of, for example, a "first" or lower-numbered item or a "third" or higher-numbered item.

**[0009]** FIG. 1 is a schematic view of an exemplary steam turbine system 100. Steam turbine system 100 includes a steam source 102 that provides steam 103 at an initially elevated pressure and temperature. In the exemplary embodiment, steam source 102 is a nuclear source. In alternative embodiments, steam source 102 is any suitable source of steam.

**[0010]** Steam 103 is channeled in any suitable fashion to a steam turbine 104. In the exemplary embodiment, steam turbine 104 is an opposed-flow steam turbine. In alternative embodiments, steam turbine 104 is a single-flow steam turbine. Moreover, in the exemplary embodiment, steam turbine 104 is a low-pressure steam turbine, and steam 103 is channeled in succession through a high pressure steam turbine (not shown) and an intermediate pressure steam turbine (not shown) prior to being channeled to steam turbine 104 at a relatively decreased pressure and temperature. In alternative embodiments, steam 103 is channeled through any suitable arrangement and number, including zero, of steam turbines prior to steam turbine 104.

**[0011]** Steam turbine 104 converts thermal energy of steam 103 to mechanical rotational energy. For example, steam 103 impacts rotor blades of steam turbine 104 and induces rotation of a rotor of steam turbine 104. The rotational energy of the rotor may be used to drive a load (not shown) such as, but not limited to, an electrical generator or a mechanical drive application.

**[0012]** Steam turbine system 100 also includes a condenser 106 that receives steam 103 exhausted from steam turbine 104 and condenses the exhausted steam 103 to liquid water. More specifically, in the exemplary embodiment, condenser 106 includes a neck portion 110 that directs low pressure exhausted steam 103 over a plurality of condenser tubes, designated generally by 112, of condenser 106. Steam turbine system 100 further includes a cooling system 108 that circulates a flow of condenser cooling fluid 109 through condenser tubes 112 into thermal communication with the exhausted steam 103, cooling and condensing the exhausted steam 103 into a stream of water 113. In alternative embodiments, condenser 106 is arranged in any suitable fashion, and/or is configured to condense the exhausted steam 103 in any suitable fashion, that enables steam turbine system 100 to function as described herein. In the exemplary embodiment, steam turbine system 100 further includes a heat exchange system 118 coupled to condenser 106. More specifically, heat exchange system 118 includes a plurality of heat exchange devices 120 extending at least partially within condenser 106.

**[0013]** In the exemplary embodiment, at least a portion of stream of water 113 is channeled, such as via a pump 114, to one or more of heat exchange devices 120, as described below. Additionally or alternatively, at least a portion of stream of water 113 is channeled for suitable treatment and/or use to one or more other elements of steam turbine system 100, designated generally by 116. For example, but not by way of limitation, other elements 116 include at least one of a purification or "polishing" system, a degassing tank, a water supply for steam source 102, one or more heat exchange devices associated with another steam turbine located upstream, with respect to the flow of steam 103, from steam turbine 104, and other suitable elements of steam turbine system 100 as known in the art. In alternative embodiments, stream of water 113 is channeled in any suitable fashion that enables steam turbine system 100 to function as described herein.

**[0014]** In the exemplary embodiment, each heat exchange device 120 is mechanically coupled to, and extends for at least fifty percent of its length within, neck portion 110 of condenser 106. Moreover, in some such embodiments, each heat exchange device 120 extends for at least eighty percent of its length within neck portion 110 of condenser 106. It should be noted that, as used herein, the term "couple" is not limited to a direct mechanical, thermal, electrical, and/or communication connection between components, but may also include an indirect mechanical, thermal, electrical, and/or communication connection between multiple components. In alternative embodiments, heat exchange devices 120 are coupled to any suitable portion of condenser 106 and/or extend to any suitable extent within condenser 106 that enables heat exchange system 118 to function as described herein.

**[0015]** Plurality of heat exchange devices 120 includes a first heat exchange device 130 configured to channel a first heat absorbing fluid 133 therethrough. First heat exchange device 130 also receives a first portion 105 of steam 103 tapped from a first intermediate stage of steam turbine 104 via a first steam conduit 131, and channels first portion 105 of steam 103 into thermal communication with first heat absorbing fluid 133. More specifically, first portion 105 of steam 103 is condensable via thermal communication with first heat absorbing fluid 133 and exhausted in at least partially liquid form from first heat exchange device 130 as first exhaust stream 135.

**[0016]** In certain embodiments, first heat absorbing fluid 133 is drawn from stream of water 113. For one example, in the exemplary embodiment, first heat absorbing fluid 133 is drawn from stream of water 113 after stream of water 113 is routed through at least one of the other elements 116, such as a purification system, and after stream of water 113 is routed through a second heat exchange device 140 of plurality of heat exchange devices 120. In alternative embodiments, first heat absorbing fluid 133 is drawn from any suitable source that enables first heat exchange device 130 to function as described herein. In the exemplary embodiment, first heat absorbing fluid 133 exhausted from first heat exchange device 130 is channeled back to at least another of the other elements 116, such as a heat exchange device associated with another steam turbine located upstream, with respect to the flow of steam 103, from steam turbine 104. In alternative embodiments, first heat absorbing fluid 133 exhausted from first heat exchange device 130 is channeled to any suitable location that enables heat exchange system 118 to function as described herein.

**[0017]** In the exemplary embodiment, the plurality of heat exchange devices 120 also includes second heat exchange device 140. Second heat exchange device 140 receives a second portion 107 of steam 103 tapped from a second intermediate stage of steam turbine 104 via a second steam conduit 141, and channels second portion 107 of steam 103 into thermal communication with a second heat absorbing fluid 143. In the exemplary embodiment, second steam conduit 141 is tapped from steam turbine 104 downstream from first steam conduit 131, such that first portion 105 of steam 103 is at a higher pressure and temperature than second portion 107 of steam 103. In alternative embodiments, second steam conduit 141 is tapped from steam turbine 104 at any suitable location relative to first steam conduit 131. Second portion 107 of steam 103 is exhausted from second heat exchange device 140 as second exhaust stream 145.

**[0018]** In certain embodiments, second heat absorbing fluid 143 is drawn from stream of water 113. For one example, in the exemplary embodiment, second heat absorbing fluid 143 is drawn from stream of water 113 after stream of water 113 is routed through at least one of the other elements 116, such as a purification system. In alternative embodiments, first heat absorbing fluid 133 is drawn from any suitable source that enables first heat exchange device 130 to function as described herein. In the exemplary embodiment, second heat absorbing fluid 143 exhausted from second heat exchange device 140 is channeled to first heat exchange device 130 as first heat absorbing fluid 133. In alternative embodiments, second heat absorbing fluid 143 exhausted from second heat exchange device 140 is channeled to any suitable location that enables heat exchange system 118 to function as described herein.

**[0019]** In alternative embodiments, heat exchange system 118 does not include second heat exchange device 140.

**[0020]** Plurality of heat exchange devices 120 further includes a sub-cooler 150. In the exemplary embodiment, sub-cooler 150 receives first exhaust stream 135 exhausted from first heat exchange device 130, and channels first exhaust stream 135 into thermal communication with a sub-cooler fluid 153. As discussed above, in the exemplary embodiment, first exhaust stream 135 is received by sub-cooler 150 in at least partially liquid form, and thus in certain embodiments some amount of steam remains in first exhaust stream 135. First exhaust stream 135 is exhausted from sub-cooler 150 as sub-cooler exhaust stream 155.

**[0021]** In certain embodiments, sub-cooler fluid 153 is drawn from at least one of the other elements 116. For one example, in the exemplary embodiment, sub-cooler fluid 153 is drawn from stream of water 113 after stream of water 113 is routed through a heat exchange device associated with another steam turbine located upstream, with respect to the flow of steam 103, from steam turbine 104. In alternative embodiments, sub-cooler fluid 153 is drawn from any suitable source that enables sub-cooler 150 to function as described herein. In the exemplary embodiment, sub-cooler fluid 153 exhausted from sub-cooler 150 is channeled to a water supply for steam source 102. In alternative embodiments, sub-cooler fluid 153 exhausted from sub-cooler 150 is channeled to any suitable location that enables heat exchange system 118 to function as described herein.

**[0022]** In certain embodiments, location of heat exchange devices 120 at least partially within condenser 106 facilitates improving an efficiency of heat recovery from steam 103 at various stages within steam turbine system 100 by reducing thermal losses in at least one of steam conduits 131 and 141 and streams 133, 143, and 153. Additionally or alternatively, in some embodiments, location of heat exchange devices 120 at least partially within condenser 106 facilitates reducing a footprint of steam turbine system 100.

**[0023]** FIG. 2 is a perspective cutaway view of an exemplary embodiment of heat exchange system 118, designated heat exchange system 200. FIG. 3 is a cross-section of the heat exchange system 200 taken along lines 3-3 shown in FIG. 2. Heat exchange system 200 includes a hollow casing 202 that extends longitudinally from a first end 204 to a second end 206 and encloses a cavity 208 therein. In the exemplary embodiment, casing 202 is generally cylindrical in shape. In alternative embodiments, casing 202 has any suitable shape that enables heat exchange system 200 to function as described herein.

**[0024]** In certain embodiments, first end 204 is configured to couple to a first side 160 of neck portion 110 of condenser 106 (shown in FIG. 1), and second end 206 is configured to couple to an opposite second side 162 of neck portion 110 of condenser 106 (shown in FIG. 1), such that cavity 208 extends for at least fifty percent of its volume within neck portion 110 of condenser 106. Moreover, in some such embodiments, first end 204 is configured to couple to first side 160 and second end 206 is configured to couple to second side 162 such that cavity 208 extends for at least eighty percent of its volume within neck portion 110. In alternative embodiments, heat exchange system 200 is coupled to condenser 106 in any suitable fashion, and cavity 208 extends within condenser 106 to any suitable extent, that enables heat exchange system 200 to function as described herein.

**[0025]** In the exemplary embodiment, heat exchange system 200 includes a partition wall 210 that extends longitudinally within casing 202 such that cavity 208 is partitioned into a first sub-cavity 212 and a horizontally adjacent second sub-cavity 214. In the exemplary embodiment, partition wall 210 is oriented vertically within cavity 208. In alternative embodiments, partition wall 210 is oriented in any suitable fashion that enables heat exchange system 200 to function as described herein. In the exemplary embodiment, partition wall 210 is positioned generally centrally within cavity 208 such that first sub-cavity 212 and second sub-cavity 214 are of substantially equal size.

**[0026]** Moreover, heat exchange system 200 includes first heat exchange device 130 and sub-cooler 150 positioned within first sub-cavity 212 and second heat exchange device 140 positioned within second sub-cavity 214, and partition wall 210 is configured to prevent flow communication between first sub-cavity 212 and second sub-cavity 214. In some embodiments, co-location of first heat exchange device 130, sub-cooler 150, and second heat exchange device 140 within a single casing 202 facilitates reducing a footprint of steam turbine system 100 (shown in FIG. 1). In other alternative embodiments, heat exchange system 200 does not include partition wall 210, and second heat exchange device 140 is positioned in a separate casing (not shown) or is not included in heat exchange system 200, such that first sub-cavity 212 is identical to cavity 208.

**[0027]** In the exemplary embodiment, first steam conduit 131 is coupled in flow communication with first sub-cavity 212 via a first inlet 231 defined in casing 202. Thus, first steam conduit 131 is configured to channel first portion 105 of steam 103 to first sub-cavity 212. In alternative embodiments, first steam conduit 131 is configured for flow communication with cavity 208 in any suitable fashion that enables heat exchange system 200 to function as described herein. Although first steam conduit 131 is illustrated as being coupled to casing 202 and in flow communication with first sub-cavity 212 at a single first inlet 231 in FIG. 2, in some embodiments, first steam conduit 131 is coupled to casing 202 and in flow communication with first sub-cavity 212 at a plurality of first inlets 231 defined in, and longitudinally spaced apart along, casing 202.

**[0028]** Similarly in the exemplary embodiment, second steam conduit 141 is coupled in flow communication with second sub-cavity 214 via a second inlet 241 defined in casing 202. Thus, second steam conduit 141 is configured to channel second portion 107 of steam 103 to second sub-cavity 214. In alternative embodiments, second steam conduit 141 is configured for flow communication with cavity 208 in any suitable fashion that enables heat exchange system 200 to function as described herein. Although second steam conduit 141 is illustrated as being coupled to casing 202 and in flow communication with second sub-cavity 214 at a single second inlet 241 in FIG. 2, in some embodiments, second steam conduit 141 is coupled to casing 202 and in flow communication with second sub-cavity 214 at a plurality of second inlets 241 defined in, and longitudinally spaced apart along, casing 202. In other alternative embodiments, for example embodiments in which second heat exchange device 140 is positioned in a separate casing (not shown) or is not included in heat exchange system 200, second steam conduit 141 is not in flow communication with cavity 208.

**[0029]** In the exemplary embodiment, first heat exchange device 130 includes a plurality of first tubes 132 that extend longitudinally within first sub-cavity 212 between first end 204 and second end 206. First tubes 132 are configured to channel first heat absorbing fluid 133 therethrough, such that first heat absorbing fluid 133 is coupled in thermal communication with first portion 105 of steam 103 received within first sub-cavity 212. In alternative embodiments, first heat exchange device 130 is configured to channel first heat absorbing fluid 133 therethrough in any suitable fashion that enables first heat exchange device 130 to function as described herein.

**[0030]** In the exemplary embodiment, first tubes 132 are enclosed in a longitudinally extending first housing 134. First housing 134 is configured to seal first tubes 132 against direct contact with first portion 105 of steam 103, while facilitating thermal communication between first portion 105 of steam 103 and first tubes 132. In some embodiments, first housing 134 configured to prevent direct contact between first portion 105 of steam 103 and first tubes 132 facilitates preventing corrosion or other wear to first tubes 132. In alternative embodiments, first housing 134 is not configured to seal first tubes 132 against direct contact with first portion 105 of steam 103, and/or first heat exchange device 130 does not include first housing 134.

**[0031]** In the exemplary embodiment, first housing 134 is coupled to a plurality of first baffles 136 spaced longitudinally along first heat exchange device 130 to support, and inhibit vibration of, first tubes 132. First baffles 136 facilitate an even distribution of first portion 105 of steam 103 along first tubes 132. Additionally or alternatively, first baffles 136 facilitate reducing locally a longitudinal velocity component of first portion 105 of steam 103, thus reducing potential wear in heat exchange system 200 and/or reducing potential backflow through first inlet 231 into first steam conduit 131. In alternative embodiments, first heat exchange device 130 does not include first baffles 136.

**[0032]** In the exemplary embodiment, sub-cooler 150 extends longitudinally within first sub-cavity 212 beneath first heat exchange device 130. More specifically, first heat exchange device 130 is positioned in an upper portion 216 of first sub-cavity 212, and sub-cooler 150 is positioned in a lower portion 218 of first sub-cavity 212, such that first exhaust stream 135, condensed from first portion 105 of steam 103 into liquid water by first heat exchange device 130 as discussed above with respect to FIG. 1, is receivable via the force of gravity into thermal communication with sub-cooler 150. In some embodiments, lower portion 218 may be referred to as a "drain cooling zone."

**[0033]** In the exemplary embodiment, sub-cooler 150 includes a plurality of sub-cooler tubes 152 that extend longitudinally between first end 204 and second end 206. Sub-cooler tubes 152 are configured to channel sub-cooler fluid 153 therethrough, such that sub-cooler fluid 153 is coupled in thermal communication with first exhaust stream 135 received within lower portion 218 of first sub-cavity 212. In alternative embodiments, sub-cooler 150 is configured to channel sub-cooler fluid 153 therethrough in any suitable fashion that enables sub-cooler 150 to function as described herein.

**[0034]** In the exemplary embodiment, heat exchange system 200 further includes a drain 220 defined in casing 202 and extending therethrough. More specifically, drain 220 is in flow communication with lower portion 218 of first sub-cavity 212, such that drain 220 channels sub-cooler exhaust stream 155 (shown in FIG. 1) out of casing 202. In alternative embodiments, heat exchange system 200 is configured to channel sub-cooler exhaust stream 155 out of casing 202 in any suitable fashion that enables heat exchange system 200 to function as described herein.

**[0035]** In the exemplary embodiment, heat exchange system 200 further includes suitable manifolds (not shown) adjacent first end 204 and/or second end 206 to distribute first heat absorbing fluid 133 to first tubes 132, receive exhausted first heat absorbing fluid 133 from first tubes 132, distribute second heat absorbing fluid 143 to second tubes 142, receive exhausted second heat absorbing fluid 143 from second tubes 142, distribute sub-cooler fluid 153 to sub-cooler tubes 152, receive exhausted sub-cooler fluid 153 from sub-cooler tubes 152, and so forth.

**[0036]** In the exemplary embodiment, heat exchange system 200 is configured such that, during a baseline operational mode of steam turbine system 100 (shown in FIG. 1), sub-cooler 150 is submerged in liquid water received as first exhaust stream 135. For example, flow through drain 220 is controllable, and/or a precise positioning of sub-cooler 150 within lower portion 218 of first sub-cavity 212 is pre-selected, to facilitate submersion of sub-cooler 150. In some embodiments, the liquid water level is suitably controlled by system logic to inhibit non-condensed steam from first portion 105 of steam 103 from contacting a topmost surface 164 of sub-cooler housing 154 of sub-cooler 150.

**[0037]** In the exemplary embodiment, sub-cooler tubes 152 are enclosed in a longitudinally extending sub-cooler housing 154. Sub-cooler housing 154 is configured to seal sub-cooler tubes 152 against direct contact with first exhaust stream 135 and/or any steam present in lower portion 218, while facilitating thermal communication between first exhaust stream 135 and sub-cooler tubes 152. In some embodiments, sub-cooler housing 154 configured to prevent direct contact between first exhaust stream 135 and sub-cooler tubes 152 facilitates preventing corrosion or other wear to sub-cooler tubes 152. In alternative embodiments, sub-cooler housing 154 is not configured to seal sub-cooler tubes 152 against direct contact with first exhaust stream 135, and/or sub-cooler 150 does not include sub-cooler housing 154.

**[0038]** In the exemplary embodiment, sub-cooler housing 154 extends horizontally, i.e., perpendicularly to the longitudinal and vertical directions, from a first side 161 to a second side 163. Moreover, a topmost surface 164 of sub-cooler housing 154 extends over substantially an entire horizontal extent of sub-cooler housing 154 from first side 161 to second side 163, as well as longitudinally along sub-cooler 150. In addition, topmost surface 164 is substantially flat along its horizontal and longitudinal extent, and is spaced from a bottom of first housing 134 by a gap 166. In certain embodiments, gap 166 has a vertical depth of at least half of a vertical depth of sub-cooler housing 154. In some embodiments, gap 166 is calculated to facilitate the regulation of water level.

**[0039]** In some embodiments, topmost surface 164 being flat over the horizontal extent of sub-cooler housing 154 facilitates inhibiting accumulation of non-condensed steam within lower portion 218 of first sub-cavity 212, as compared to other potential cross-sectional shapes of sub-cooler housing 154. For example, but not by way of limitation, steam beginning to accumulate within lower portion 218, having a lower density than the liquid water in first exhaust stream 135, rises into gap 166 and spreads evenly along flat topmost surface 164, facilitating condensation. Thus, in certain embodiments, topmost surface 164 being flat over the horizontal extent of sub-cooler housing 154 facilitates maintaining heat transfer efficiency of sub-cooler 150 and reducing wear and distortion of sub-cooler housing 154. In alternative embodiments, sub-cooler housing 154 has any suitable shape that enables sub-cooler 150 to function as described herein.

**[0040]** In the exemplary embodiment, sub-cooler housing 154 is coupled to a plurality of sub-cooler baffles 156 spaced longitudinally along sub-cooler 150. Sub-cooler baffles 156 facilitate even distribution of first exhaust stream 135 along sub-cooler tubes 152. Additionally or alternatively, sub-cooler baffles 156 facilitate reducing a longitudinal velocity component of any flash steam arising from sub-cooler 150, thus reducing potential wear in heat exchange system 200 and/or reducing potential backflow through first inlet 231 into first steam conduit 131. In the exemplary embodiment, sub-cooler baffles 156 are arranged such that a respective opening or "window" is defined between an edge of each sub-cooler baffle 156 and an interior surface of casing 202, and such that a circumferential position along casing 202 of axially adjacent windows varies. Moreover, in the exemplary embodiment, sub-cooler baffles 156 are further arranged in a No Tubes In Window (NTIW) configuration, that is, none of sub-cooler tubes 152 extend through any of the windows defined between sub-cooler baffles 156 and the interior surface of casing 202. In some such embodiments, the NTIW configuration facilitates reduced condensate pressure loss, and thus reduced triggering of flash steam, as compared to other baffle arrangements. In alternative embodiments, sub-cooler baffles 156 are arranged in other than a NTIW configuration. Additionally, sub-cooler baffles 156 support, and inhibit vibration of, sub-cooler tubes 152.

**[0041]** In the exemplary embodiment, sub-cooler housing 154, and sub-cooler tubes 152 housed therein, are coupled to casing 202 by a plurality of tie rods 170 extending longitudinally within sub-cooler housing 154. More specifically, in the exemplary embodiment, tie rods 170 are secured to casing 202 proximate first end 204 and proximate second end 206, such that tie rods 170 support substantially an entire weight of sub-cooler 150. Thus, in some embodiments, tie rods 170 reduce or eliminate a need for sub-cooler baffles 156 to couple against an interior surface of casing 202 to further support the weight of sub-cooler 150. The ability to maintain a radial gap between at least some sub-cooler baffles 156 and the interior surface of casing 202 facilitates venting of lower portion 218 of first sub-cavity 212, for example during start-up and normal operation of steam turbine system 100. Additionally or alternatively, for Boiling Water Reactor plants, this venting facilitates the evacuation of hydrogen generated by radiolysis. In alternative embodiments, each of sub-cooler baffles 156 is coupled to the interior surface of casing 202.

**[0042]** In alternative embodiments, sub-cooler housing 154, and sub-cooler tubes 152 housed therein, are coupled to casing 202 in any suitable fashion that enables heat exchange system 200 to function as described herein.

**[0043]** In certain embodiments, heat exchange system 200 further includes an anti-flash plate 250 that extends longitudinally between upper portion 216 and lower portion 218 of first sub-cavity 212. For example, anti-flash plate 250 is positioned at a vertical level in first sub-cavity 212 above gap 166 and sub-cooler 150. In the exemplary embodiment, anti-flash plate 250 extends generally horizontally outward from a bottom portion of first housing 134 to the interior surface of casing 202. Moreover, first housing 134 extends horizontally inward to partition wall 210, such that anti-flash plate 250 and the bottom portion of first housing 134 cooperate to separate upper portion 216 and lower portion 218 of first sub-cavity 212. In alternative embodiments, anti-flash plate 250 is positioned between upper portion 216 and lower portion 218 of first sub-cavity 212 in any suitable fashion that enables anti-flash plate 250 to function as described herein.

**[0044]** In the exemplary embodiment, anti-flash plate 250 extends longitudinally from first end 204 to second end 206 of casing 202. In alternative embodiments, anti-flash plate 250 extends longitudinally between first end 204 and second end 206 to any suitable extent that enables anti-flash plate 250 to function as described herein. For example, in some embodiments, anti-flash plate 250 includes gaps or interruptions in the longitudinal extent of anti-flash plate 250.

**[0045]** In the exemplary embodiment, anti-flash plate 250 includes a plurality of perforations 252 defined therein and extending therethrough from a top surface to an opposite bottom surface of anti-flash plate 250. Perforations 252 are suitably sized and shaped to provide smooth drain of condensate to, and pressure relief to, lower portion 218, when necessary, while reducing a velocity of any steam passing from lower portion 218 back to upper portion 216. Additionally or alternatively, perforations 252 are suitably sized and shaped to inhibit passage of liquid water from lower portion 218 back to upper portion 216. For example, perforations 252 are sized and shaped to inhibit any water droplets entrained in flash steam from sub-cooler 150 from being carried back through upper portion 216 of first sub-cavity 212. Thus, anti-flash plate 250 facilitates reducing wear of the first heat exchange device 130 and/or liquid water ingestion into the blade path of steam turbine 104.

**[0046]** In the exemplary embodiment, anti-flash plate 250 is angled upward adjacent to the interior surface of casing 202 to facilitate channeling first exhaust stream 135 towards lower portion 218 of first sub-cavity 212. It should be noted that this upward angle is within the meaning of the term "generally horizontally" as used above with respect to the orientation of anti-flash plate 250. In alternative embodiments, anti-flash plate 250 is not angled upward adjacent to the interior surface of casing 202. In other alternative embodiments, anti-flash plate 250 is oriented in any suitable fashion that enables anti-flash plate 250 to function as described herein.

**[0047]** In the exemplary embodiment, second heat exchange device 140 includes a plurality of second tubes 142 that extend longitudinally within second sub-cavity 214 between first end 204 and second end 206. Second tubes 142 are configured to channel second heat absorbing fluid 143 therethrough, such that second heat absorbing fluid 143 is coupled in thermal communication with second portion 107 of steam 103 received within second sub-cavity 214. In alternative embodiments, second heat exchange device 140 is configured to channel second heat absorbing fluid 143 therethrough in any suitable fashion that enables second heat exchange device 140 to function as described herein.

**[0048]** In the exemplary embodiment, second tubes 142 are enclosed in a longitudinally extending second housing 144. Second housing 144 is configured to seal second tubes 142 against direct contact with second portion 107 of steam 103, while facilitating thermal communication between second portion 107 of steam 103 and second tubes 142. In some embodiments, second housing 144 configured to prevent direct contact between second portion 107 of steam 103 and second tubes 142 facilitates preventing corrosion or other wear to second tubes 142. In alternative embodiments, second housing 144 is not configured to seal second tubes 142 against direct contact with second portion 107 of steam 103, and/or second heat exchange device 140 does not include second housing 144.

**[0049]** In the exemplary embodiment, second housing 144 is coupled to a plurality of second baffles 146 spaced longitudinally along second heat exchange device 140. Second baffles 146 facilitate an even distribution of second portion 107 of steam 103 along second tubes 142. In alternative embodiments, second heat exchange device 140 does not include second baffles 146.

**[0050]** In the exemplary embodiment, heat exchange system 200 further includes a respective set of inlet impingement plates 270 positioned within cavity 208 longitudinally adjacent to each first inlet 231 of first steam conduit 131 and each second inlet 241 of second steam conduit 141. For clarity of illustration of other features, the set of inlet impingement plates 270 adjacent to first inlet 231 is not illustrated in FIG. 3. It should be recalled that, although first steam conduit 131 and second steam conduit 141 are each illustrated as being coupled to casing 202 and in flow communication with cavity 208 at a single respective first inlet 231 and second inlet 241 in FIG. 2, in some embodiments, each of first steam conduit 131 and second steam conduit 141 is coupled to casing 202 and in flow communication with cavity 208 at a plurality of respective first inlets 231 and second inlets 241 longitudinally spaced apart along casing 202. In some such embodiments, a respective set of inlet impingement plates 270 is positioned longitudinally adjacent to each of the plurality of first inlets 231 and second inlets 241. In alternative embodiments, a respective set of inlet impingement plates 270 is positioned longitudinally adjacent to fewer than all of the plurality of first inlets 231 and second inlets 241.

**[0051]** Each inlet impingement plate 270 includes a first portion 274 positioned beneath under the respective first inlet 231 and second inlet 241. In the exemplary embodiment, first portion 274 is shaped to correspond to a contour of casing 202 surrounding the respective inlet. In alternative embodiments, first portion 274 has any suitable shape that enables set of inlet impingement plates 270 to function as described herein.

**[0052]** In the exemplary embodiment, each inlet impingement plate 270 further includes a second portion 276 that extends away from first portion 274 towards at least one of partition wall 210 and the respective one of first housing 134 and second housing 144. In alternative embodiments, at least one of the inlet impingement plates 270 does not include second portion 276.

**[0053]** Each set of inlet impingement plates 270 includes at least two inlet impingement plates 270 positioned sequentially beneath the respective first inlet 231 or second inlet 241. In the exemplary embodiment, inlet impingement plates 270 in each set have shapes that substantially conform to each other, such that a spacing between adjacent inlet impingement plates 270 in each set is substantially constant at each point along inlet impingement plates 270. For example, the set of inlet impingement plates 270 illustrated in FIG. 3 includes three inlet impingement plates 270, of which only an edge is visible for two of the three due to conformal stacking of the three contoured inlet impingement plates 270 beneath second inlet 241. In alternative embodiments, inlet impingement plates 270 in each set have other than substantially conforming shapes.

**[0054]** Each inlet impingement plate 270 includes a plurality of perforations 272 defined therein and extending therethrough from an outer surface to an opposite inner surface of inlet impingement plate 270. Perforations 272 are suitably sized and shaped to allow passage of first portion 105 of steam 103 from first steam conduit 131 to pass through to first housing 134, and to allow passage of second portion 107 of steam 103 from second steam conduit 141 to pass through to second housing 144. In the exemplary embodiment, perforations 272 in adjacent inlet impingement plates 270 in each set are staggered, or non-aligned, such that a direction of flow through one of perforations 272 in one inlet impingement plate 270 is not directly aligned with one of perforations 272 in the adjacent inlet impingement plate 270. In some embodiments, set of inlet impingement plates 270 including at least two adjacent inlet impingement plates 270 having non-aligned perforations 272 inhibits passage of liquid water droplets from respective first inlet 231 and second inlet 241 through the first layer of tubes 142, which facilitates reducing wear on first layer of tubes 142.

**[0055]** In the exemplary embodiment, first inlet 231 is oriented radially with respect to casing 202, that is, directed toward a center of cavity 208. Accordingly, first portion 105 of steam 103 is directed substantially toward first heat exchange device 130, rather than toward sub-cooler 150, facilitating reduced flow of non-condensed first portion 105 of steam 103 into lower portion 218. Also in the exemplary embodiment, second inlet 241 is oriented tangentially to casing 202, facilitating a more even vertical distribution of second portion 107 of steam 103 within second sub-cavity 214. In alternative embodiments, first inlet 231 and/or second inlet 241 are oriented with respect to casing 202 in any suitable fashion that enables heat exchange system 200 to function as described herein.

**[0056]** The above-described embodiments overcome at least some of the disadvantages of known heat exchange devices having integral sub-coolers. Specifically, the embodiments include a first heat exchange device and a sub-cooler located beneath the first heat exchange device within the same cavity, facilitating flow of an exhaust stream of condensed steam from the first heat exchange device to the sub-cooler with a reduced pressure drop. Also specifically, in some embodiments, a housing of the sub-cooler extends horizontally from a first side to a second side, and a flat topmost surface of the sub-cooler housing extends from the first side to the second side, facilitating reduced accumulation of non-condensed steam between the sub-cooler and first heat exchange device. Also specifically, in certain embodiments, an anti-flash plate extends longitudinally within the cavity between the first heat exchange device and the sub-cooler, reducing a velocity of any steam, and/or inhibiting liquid water from, passing from the sub-cooler portion of the cavity back to the upper portion of the cavity. Thus, the embodiments described herein reduce or eliminate obstacles to co-location of multiple heat exchange devices at least partially within the condenser neck, which facilitates improving an efficiency of heat recovery from steam at various stages within the steam turbine system and/or reducing a footprint of the steam turbine system.

**[0057]** Exemplary embodiments of a heat exchange system and steam turbine system incorporating a heat exchange system are described above in detail. The systems and methods are not limited to the specific embodiments described herein, but rather, components of systems and/or steps of methods may be utilized independently and separately from other components and/or steps described herein. For example, the heat exchange system may also be used in combination with other machines and methods, and is not limited to practice with only a steam turbine system as described herein. Rather, the embodiments can be implemented and utilized in connection with many other applications.

**[0058]** Although specific features of various embodiments of the disclosure may be shown in some drawings and not in others, this is for convenience only. Moreover, references to "one embodiment" in the above description are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. In accordance with the principles of the disclosure, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

**[0059]** This written description uses examples, including the best mode, to illustrate the disclosure and also to enable any person skilled in the art to practice the disclosure, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure 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.

**[0060]** Various aspects and embodiments of the present invention are defined by the following clauses:

1. A heat exchange system comprising:

a casing enclosing a cavity therein;

a first heat exchange device configured to channel a first heat absorbing fluid therethrough, said first heat exchange device extending longitudinally within said cavity, wherein steam received within said cavity is condensable via thermal communication with the first heat absorbing fluid to form a first exhaust stream; and

a sub-cooler configured to channel a sub-cooler fluid therethrough, said sub-cooler extending longitudinally within said cavity, said sub-cooler positioned beneath said first heat exchange device such that the first exhaust stream is receivable into thermal communication with the sub-cooler fluid, said sub-cooler comprising a sub-cooler housing that extends horizontally from a first side to a second side, said sub-cooler housing comprising a flat topmost surface that extends from said first side to said second side.

2. The heat exchange system according to Clause 1, wherein said first heat exchange device is positioned within an upper portion of said cavity and said sub-cooler is positioned within a lower portion of said cavity, said heat exchange system further comprising an anti-flash plate that extends longitudinally within said casing between said upper portion and said lower portion.

3. The heat exchange system according to Clause 2, wherein said first heat exchange device comprises a first housing, said anti-flash plate extends horizontally outward from a bottom portion of said first hous-

ing to an interior surface of said casing.

4. The heat exchange system according to Clause 2, wherein said anti-flash plate comprises a top surface, an opposite bottom surface, and a plurality of perforations defined therein and extending through said anti-flash plate from said top surface to said bottom surface.

5. The heat exchange system according to Clause 2, wherein said first heat exchange device comprises a first housing, said flat topmost surface is spaced from a bottom of said first housing by a gap.

6. The heat exchange system according to Clause 5, wherein said anti-flash plate is positioned at a vertical level in said cavity above said gap.

7. The heat exchange system according to Clause 1, further comprising a plurality of tie rods extending longitudinally within said sub-cooler housing, said tie rods coupling said sub-cooler to said casing such that said tie rods support substantially an entire weight of said sub-cooler.

8. The heat exchange system according to Clause 1, further comprising a partition wall extending longitudinally within said casing such that said cavity is partitioned into a first sub-cavity and a horizontally adjacent second sub-cavity, said first heat exchange device is positioned within an upper portion of said first sub-cavity and said sub-cooler is positioned within a lower portion of said first sub-cavity.

9. The heat exchange system according to Clause 8, further comprising a second heat exchange device configured to channel a second heat absorbing fluid therethrough, said second heat exchange device extending longitudinally within said second sub-cavity, wherein said partition wall is configured to prevent flow communication between said first sub-cavity and said second sub-cavity.

10. The heat exchange system according to Clause 1, further comprising:

a first inlet defined in said casing and coupled in flow communication with said cavity; and
a set of inlet impingement plates positioned within said cavity longitudinally adjacent to said first inlet, each of said set of inlet impingement plates comprising a first portion positioned beneath said first inlet.

11. A steam turbine system comprising:

a steam turbine;

a first steam conduit configured to receive a first portion of steam tapped from a first intermediate stage of said steam turbine;

a condenser configured to receive steam exhausted from said steam turbine, said condenser comprising a neck portion; and

a heat exchange system comprising:

a casing enclosing a cavity therein, said cavity extending at least partially within said neck portion of said condenser, said casing comprising a first inlet defined therein and coupled in flow communication between said cavity and said first steam conduit;

a first heat exchange device configured to channel a first heat absorbing fluid therethrough, said first heat exchange device extending longitudinally within an upper portion of said cavity, wherein the first portion of steam received through said first inlet is condensable via thermal communication with the first heat absorbing fluid to form a first exhaust stream;

a sub-cooler configured to channel a sub-cooler fluid therethrough, said sub-cooler extending longitudinally within a lower portion of said cavity, said sub-cooler positioned beneath said first heat exchange device such that the first exhaust stream is receivable into thermal communication with the sub-cooler fluid; and

an anti-flash plate that extends longitudinally within said casing between said upper portion and said lower portion of said cavity.

12. The steam turbine system according to Clause 11, wherein said first heat exchange device comprises a first housing, said anti-flash plate extends horizontally outward from a bottom portion of said first housing to an interior surface of said casing.

13. The steam turbine system according to Clause 11, wherein said sub-cooler comprises a sub-cooler housing that extends horizontally from a first side to a second side, said sub-cooler housing comprising a flat topmost surface that extends from said first side to said second side.

14. The steam turbine system according to Clause 13, wherein said first heat exchange device comprises a first housing, said flat topmost surface is spaced from a bottom of said first housing by a gap, and wherein said anti-flash plate is positioned at a vertical

level in said cavity above said gap.

15. The steam turbine system according to Clause 11, further comprising a second steam conduit configured to receive a second portion of steam tapped from a second intermediate stage of said steam turbine, and wherein said heat exchange system further comprises:

a partition wall extending longitudinally within said casing such that said cavity is partitioned into a first sub-cavity and a horizontally adjacent second sub-cavity, wherein said upper portion of said cavity comprises an upper portion of said first sub-cavity and said lower portion of said cavity comprises a lower portion of said first sub-cavity, and wherein said casing further comprises a second inlet defined therein and coupled in flow communication between said second sub-cavity and said second steam conduit; and

a second heat exchange device configured to channel a second heat absorbing fluid therethrough, said second heat exchange device extending longitudinally within said second sub-cavity, such that the second portion of steam received through said second inlet is in thermal communication with the second heat absorbing fluid to form a second exhaust stream.

16. The steam turbine system according to Clause 15, wherein said first inlet is oriented radially with respect to said casing, and said second inlet is oriented tangentially to said casing.

17. The steam turbine system according to Clause 15, wherein said partition wall is positioned generally centrally within said cavity such that first sub-cavity and said second sub-cavity are of substantially equal size.

18. The steam turbine system according to Clause 15, wherein said first heat exchange device comprises a first housing that extends horizontally inward to said partition wall, such that said anti-flash plate and a bottom portion of said first housing cooperate to separate said upper portion of said first sub-cavity and said lower portion of said first sub-cavity.

19. The steam turbine system according to Clause 11, wherein said heat exchange system further comprises a set of inlet impingement plates positioned within said cavity longitudinally adjacent to said first inlet, each of said set of inlet impingement plates comprising a first portion positioned beneath said first inlet.

20. The steam turbine system according to Clause 19, wherein each of said set of inlet impingement plates further comprises:

a shape that substantially conforms to a shape of another of said set of inlet impingement plates;

an outer surface and an opposite inner surface; and

a plurality of perforations defined therein and extending therethrough from said outer surface to said inner surface, said plurality of perforations are non-aligned with said plurality of perforations of an adjacent inlet impingement plate of said set.

## Claims

**1.** A heat exchange system (118, 200) comprising:

a casing (202) enclosing a cavity (208) therein;
a first heat exchange device (130) configured to channel a first heat absorbing fluid (133) therethrough, said first heat exchange device extending longitudinally within said cavity, wherein steam (105) received within said cavity is condensable via thermal communication with the first heat absorbing fluid to form a first exhaust stream (135); and
a sub-cooler (150) configured to channel a sub-cooler fluid (153) therethrough, said sub-cooler extending longitudinally within said cavity, said sub-cooler positioned beneath said first heat exchange device such that the first exhaust stream is receivable into thermal communication with the sub-cooler fluid, said sub-cooler comprising a sub-cooler housing (154) that extends horizontally from a first side (161) to a second side (162), said sub-cooler housing comprising a flat topmost surface (164) that extends from said first side to said second side.

**2.** The heat exchange system (118, 200) according to Claim 1, wherein said first heat exchange device (130) is positioned within an upper portion (216) of said cavity (208) and said sub-cooler is positioned within a lower portion (218) of said cavity, said heat exchange system further comprising an anti-flash plate (250) that extends longitudinally within said casing (202) between said upper portion and said lower portion.

**3.** The heat exchange system (118, 200) according to Claim 2, wherein said first heat exchange device (130) comprises a first housing (134), said anti-flash plate (250) extends horizontally outward from a bottom portion of said first housing to an interior surface of said casing (202).

4. The heat exchange system (118, 200) according to Claim 2 or 3, wherein said anti-flash plate (250) comprises a top surface, an opposite bottom surface, and a plurality of perforations (252) defined therein and extending through said anti-flash plate from said top surface to said bottom surface.

5. The heat exchange system (118, 200) according to any one of Claims 2 to 5, wherein said first heat exchange device (130) comprises a first housing (134), said flat topmost surface (164) is spaced from a bottom of said first housing by a gap (166).

6. The heat exchange system (118, 200) according to Claim 5, wherein said anti-flash plate (250) is positioned at a vertical level in said cavity (208) above said gap (166).

7. The heat exchange system (118, 200) according to any one of Claims 1 to 6, further comprising a plurality of tie rods (170) extending longitudinally within said sub-cooler housing (154), said tie rods coupling said sub-cooler (150) to said casing (202) such that said tie rods support substantially an entire weight of said sub-cooler.

8. The heat exchange system (118, 200) according to any one of Claims 1 to 7, further comprising a partition wall (210) extending longitudinally within said casing (202) such that said cavity (208) is partitioned into a first sub-cavity (212) and a horizontally adjacent second sub-cavity (214), said first heat exchange device (130) is positioned within an upper portion (216) of said first sub-cavity and said sub-cooler (150) is positioned within a lower portion (218) of said first sub-cavity.

9. The heat exchange system (118, 200) according to Claim 8, further comprising a second heat exchange device (140) configured to channel a second heat absorbing fluid (143) therethrough, said second heat exchange device extending longitudinally within said second sub-cavity (214), wherein said partition wall (210) is configured to prevent flow communication between said first sub-cavity and said second sub-cavity.

10. The heat exchange system (118, 200) according to any one of Claims 1 to 9, further comprising:

a first inlet (231) defined in said casing (202) and coupled in flow communication with said cavity (208); and
a set of inlet impingement plates (270) positioned within said cavity longitudinally adjacent to said first inlet, each of said set of inlet impingement plates comprising a first portion (274) positioned beneath said first inlet.

11. A steam turbine system (100) comprising:

a steam turbine (104);
a first steam conduit (131) configured to receive a first portion (105) of steam (103) tapped from a first intermediate stage of said steam turbine;
a condenser (106) configured to receive steam (103) exhausted from said steam turbine, said condenser comprising a neck portion (110); and
a heat exchange system (118, 200) comprising:

a casing (202) enclosing a cavity (208) therein, said cavity extending at least partially within said neck portion of said condenser, said casing comprising a first inlet (231) defined therein and coupled in flow communication between said cavity and said first steam conduit;
a first heat exchange device (130) configured to channel a first heat absorbing fluid (133) therethrough, said first heat exchange device extending longitudinally within an upper portion (216) of said cavity, wherein the first portion of steam received through said first inlet is condensable via thermal communication with the first heat absorbing fluid to form a first exhaust stream (135);
a sub-cooler (150) configured to channel a sub-cooler fluid (153) therethrough, said sub-cooler extending longitudinally within a lower portion (218) of said cavity, said sub-cooler positioned beneath said first heat exchange device such that the first exhaust stream is receivable into thermal communication with the sub-cooler fluid; and
an anti-flash plate (250) that extends longitudinally within said casing between said upper portion and said lower portion of said cavity.

12. The steam turbine system (100) according to Claim 11, wherein said first heat exchange device (130) comprises a first housing (134), said anti-flash plate (250) extends horizontally outward from a bottom portion of said first housing to an interior surface of said casing (202).

13. The steam turbine system (100) according to Claim 11 or 12, wherein said sub-cooler (150) comprises a sub-cooler housing (154) that extends horizontally from a first side (161) to a second side (163), said sub-cooler housing comprising a flat topmost surface (164) that extends from said first side to said second side.

**14.** The steam turbine system (100) according to Claim 13, wherein said first heat exchange device (130) comprises a first housing (134), said flat topmost surface (164) is spaced from a bottom of said first housing by a gap (166), and wherein said anti-flash plate (250) is positioned at a vertical level in said cavity (208) above said gap.

**15.** The steam turbine system (100) according to any one of Claims 11 to 14, further comprising a second steam conduit (141) configured to receive a second portion (107) of steam (103) tapped from a second intermediate stage of said steam turbine (104), and wherein said heat exchange system (118, 200) further comprises:

a partition wall (210) extending longitudinally within said casing (202) such that said cavity (208) is partitioned into a first sub-cavity (212) and a horizontally adjacent second sub-cavity (214), wherein said upper portion (216) of said cavity comprises an upper portion (216) of said first sub-cavity and said lower portion (218) of said cavity comprises a lower portion (218) of said first sub-cavity, and wherein said casing further comprises a second inlet (241) defined therein and coupled in flow communication between said second sub-cavity and said second steam conduit; and

a second heat exchange device (140) configured to channel a second heat absorbing fluid (143) therethrough, said second heat exchange device extending longitudinally within said second sub-cavity, such that the second portion of steam received through said second inlet is in thermal communication with the second heat absorbing fluid to form a second exhaust stream (145).

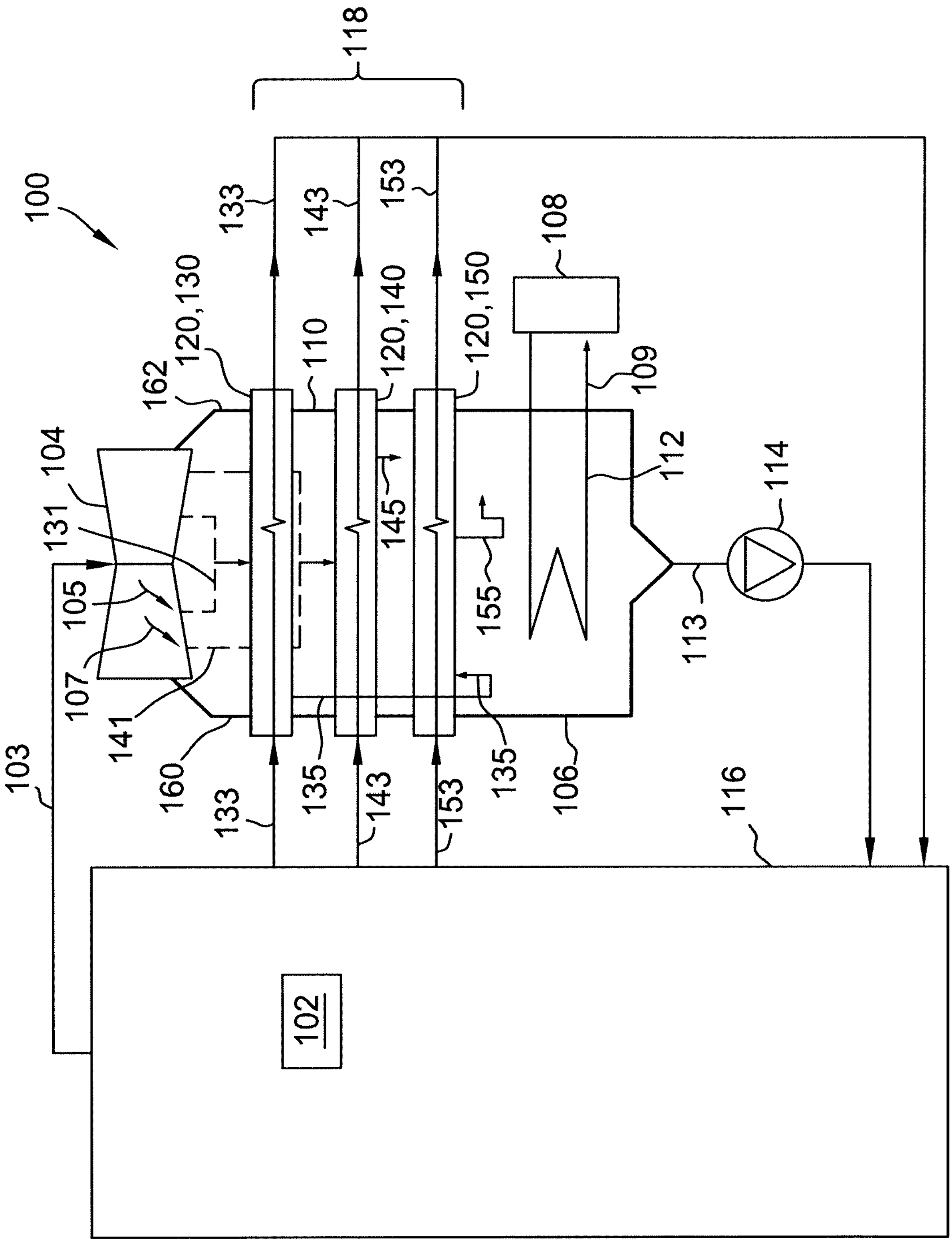
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FIG. 1

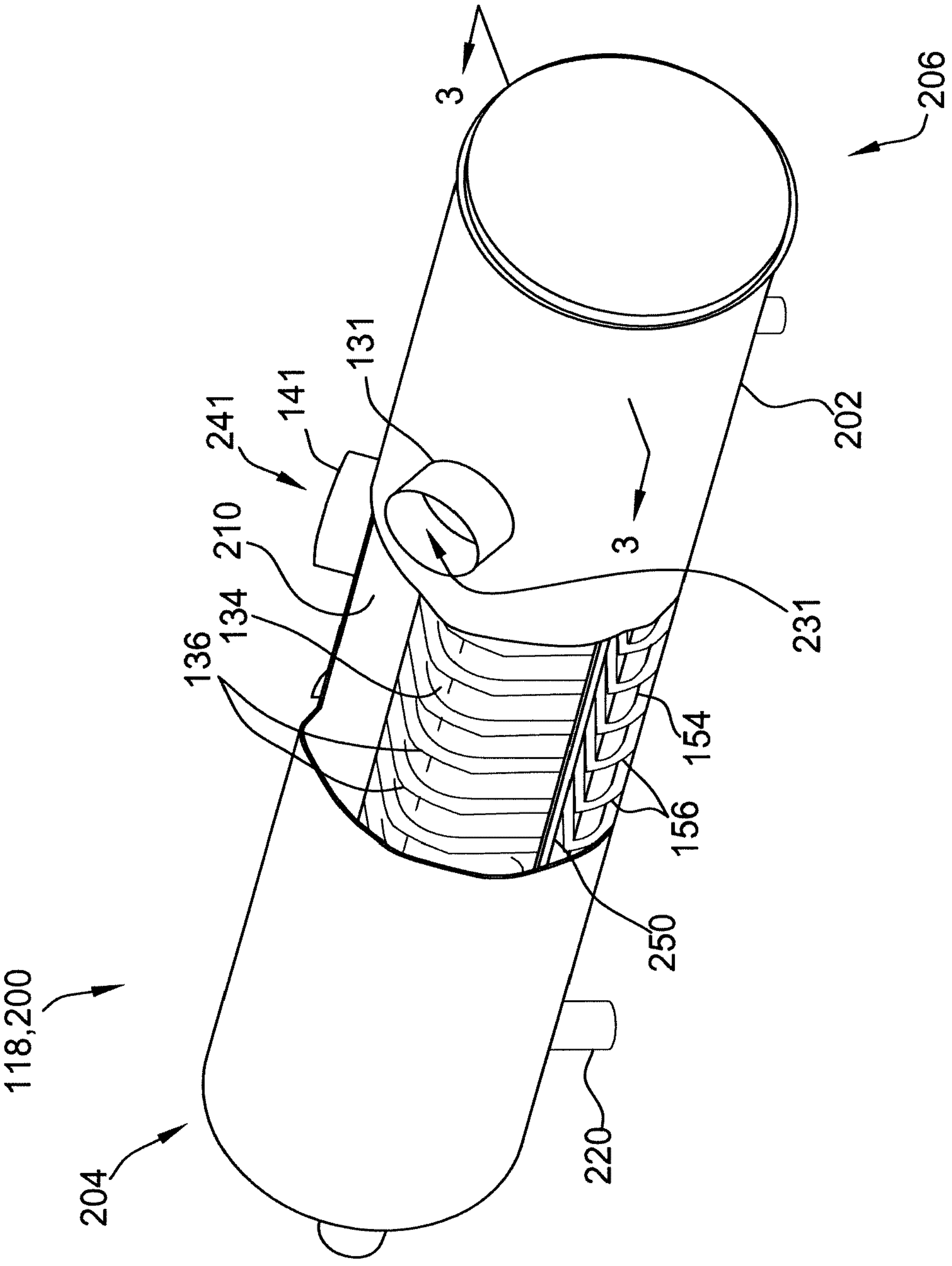
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FIG. 2

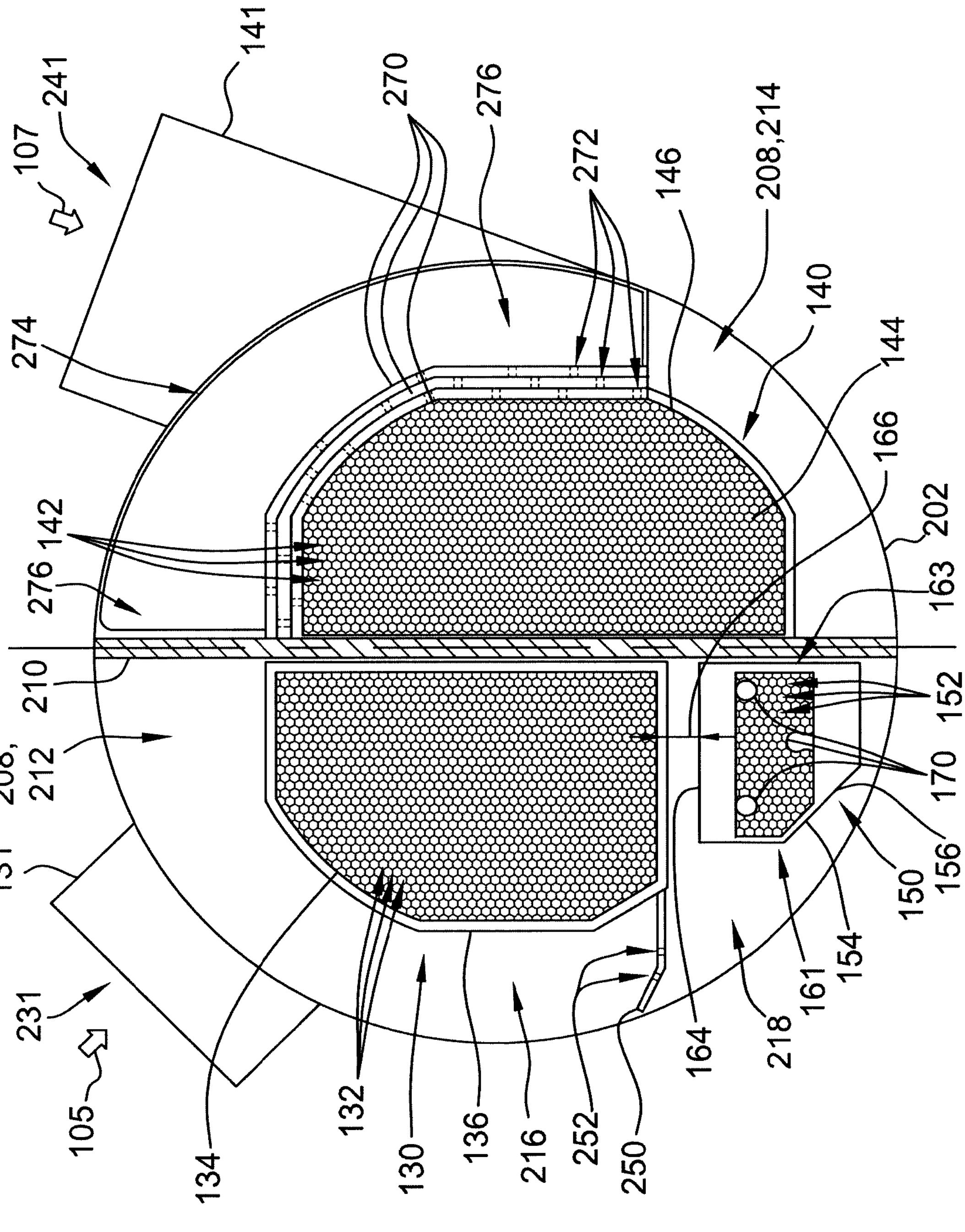
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FIG. 3

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# EUROPEAN SEARCH REPORT

Application Number
EP 18 29 0005

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