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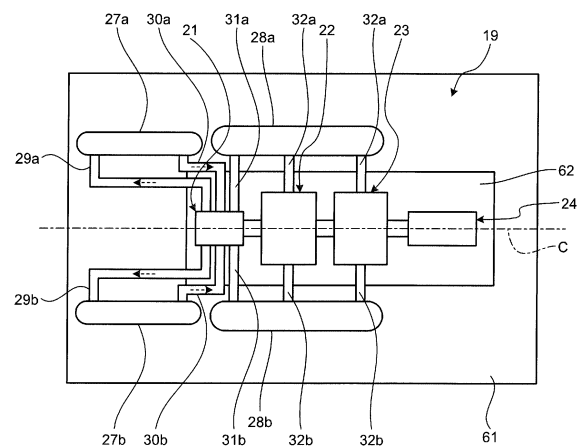
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(54) **STEAM TURBINE PLANT**

(57) Provided is a steam turbine plant that is provided with: a high and intermediate pressure turbine (21) having a high pressure turbine unit (25) at one end in an axial direction (C) and an intermediate pressure turbine unit (26) at the other end; low pressure turbines (22, 23) disposed coaxially with the high and intermediate pressure turbine (21); a high pressure moisture separating heater (27 (27a, 27b)) that removes moisture from steam from the high pressure turbine unit (25) and sends the steam to the intermediate pressure turbine unit (26); and a low pressure moisture separating heater (28 (28a, 28b)) that removes moisture from the steam from the intermediate pressure turbine unit (26) and sends the steam to the low pressure turbines (22, 23). The high pressure moisture separating heater (27) and the low pressure moisture separating heater (28) are each disposed symmetrically with respect to the center line along the axial direction (C) of the high and intermediate pressure turbine (21), whereby the structure of the steam turbine plant can be simplified and equipment cost can be reduced.

FIG.3



Description

Field

[0001] The present invention relates to a steam turbine plant used for nuclear power plants, thermal power plants, and the like.

Background

[0002] For example, a nuclear power plant sends steam generated by a steam generator to a steam turbine, and drives a connected generator to generate electricity. Generally, a steam turbine includes a high pressure turbine and a low pressure turbine, and steam used in the high pressure turbine is sent to the low pressure turbine after the moisture is removed by a moisture separating heater and the steam is heated. The steam used in the steam turbine is cooled by a condenser to become condensate, and the condensate is returned to the steam generator after being heated by a low pressure feed water heater, a high pressure feed water heater or the like.

[0003] As a system considering further performance improvement in such a nuclear power plant, a steam turbine (high pressure turbine, intermediate pressure turbine, and low pressure turbine), generator, high pressure moisture separating heater, low pressure moisture separating heater, and the like are disposed in one turbine building. An example of such a steam turbine plant is described in the following Patent Literature 1.

Citation List

Patent Literature

[0004] Patent Literature 1: JP S62-218606 A

Summary

Technical Problem

[0005] In a conventional steam turbine plant, in order to realize a system configuration disclosed in Patent Literature 1, in the high pressure moisture separating heater and the low pressure moisture separating heater, equipment and pipe become large in order to suppress increase in flow velocity of the steam to be processed. For this reason, the high pressure moisture separating heater and the low pressure moisture separating heater are generally disposed at a position separated from the steam turbine or on a floor a floor level of which is different from that of the floor on which the steam turbine is disposed. In this case, there is a problem that a turbine building increases in size, an equipment cost increases, and maintainability of the moisture separating heaters is not good.

[0006] An object of the present invention is to solve the above-mentioned problem, and to provide a steam tur-

bine plant that achieves simplification of the structure and reduction of equipment cost.

Solution to Problem

[0007] According to the present invention, there is provided a steam turbine plant comprising: a high and intermediate pressure turbine having a high pressure turbine unit at one end in an axial direction and an intermediate pressure turbine unit at the other end; at least one low pressure turbine disposed coaxially with the high and intermediate pressure turbine; at least one high pressure moisture separator arranged to remove moisture from steam from the high pressure turbine unit and send the steam to the intermediate pressure turbine unit; and at least one low pressure moisture separator arranged to remove the moisture from the steam from the intermediate pressure turbine unit and send the steam to the at least one low pressure turbine, wherein the at least one high pressure moisture separator and the at least one low pressure moisture separator are each disposed symmetrically with respect to a center line along the axial direction of the high and intermediate pressure turbine.

[0008] Therefore, by disposing the high pressure moisture separator and the low pressure moisture separator each symmetrically with respect to the center line of the high and intermediate pressure turbine, the high pressure moisture separator can be disposed in the vicinity of the high and intermediate pressure turbine or the low pressure turbine. Thus a pipe length is shortened, the structure can be simplified, the equipment cost can be reduced, and the turbine building can also be downsized.

[0009] According to the present invention, the steam turbine plant comprises the two high pressure moisture separators and the two low pressure moisture separators, wherein the two high pressure moisture separators are disposed on both sides of the high and intermediate pressure turbine, the two low pressure moisture separators are disposed on both sides of the high and intermediate pressure turbine, and the two high pressure moisture separators and the two low pressure moisture separators are disposed in series along the axial direction.

[0010] Therefore, by disposing the two high pressure moisture separators and the two low pressure moisture separators in series on both sides of the high and intermediate pressure turbine, it is possible to effectively utilize space in the longitudinal direction of various devices.

[0011] In the steam turbine plant according to the present invention, the at least one high pressure moisture separator is disposed on a side opposite to the at least one low pressure turbine in the axial direction of the high and intermediate pressure turbine, and the at least one low pressure moisture separator is disposed on a low pressure turbine side in the axial direction of the high and intermediate pressure turbine.

[0012] Therefore, by disposing the high pressure moisture separator on the high and intermediate pressure turbine side and disposing the low pressure moisture sep-

arator on the low pressure turbine side, the high pressure moisture separator is disposed in the vicinity of the high and intermediate pressure turbine, and the low pressure moisture separator is disposed in the vicinity of the low pressure turbine. Thus the pipe length is shortened, the structure can be simplified, and the equipment cost can be reduced.

[0013] According to the present invention, the steam turbine plant comprises the one high pressure moisture separator and the two low pressure moisture separators, wherein the one high pressure moisture separator is disposed along the center line on a side opposite to the at least one low pressure turbine in the axial direction of the high and intermediate pressure turbine, and the two low pressure moisture separators are disposed on both sides of the high and intermediate pressure turbine.

[0014] Therefore, by disposing the one high pressure moisture separator and the two low pressure moisture separators along the center line on the high and intermediate pressure turbine side and disposing the two low pressure moisture separators on both sides of the high and intermediate pressure turbine, it is possible to effectively utilize the space in the longitudinal direction of various devices.

[0015] In the steam turbine plant according to the present invention, the at least one high pressure moisture separator is disposed along a direction intersecting the axial direction.

[0016] Therefore, by disposing the high pressure moisture separator in a direction intersecting the high and intermediate pressure turbine and the low pressure turbine, the space in the axial direction can be effectively utilized, thereby downsizing the turbine building.

[0017] In the steam turbine plant according to the present invention, the at least one high pressure moisture separator and the at least one low pressure moisture separator are disposed on one of a first floor on which the high and intermediate pressure turbine and the at least one low pressure turbine are disposed and a second floor a floor level of which is different from that of the first floor.

[0018] Therefore, by disposing the high pressure moisture separator and the low pressure moisture separator on the same floor, it is possible to shorten the pipe length of a connecting pipe and reduce the equipment cost.

[0019] In the steam turbine plant according to the present invention, the at least one high pressure moisture separator is disposed on one of a first floor on which the high and intermediate pressure turbine and the at least one low pressure turbine are disposed and a second floor a floor level of which is different from that of the first floor, and the at least one low pressure moisture separator is disposed on another floor of the first floor and the second floor.

[0020] Therefore, by disposing the high pressure moisture separator and the low pressure moisture separator on different floors, it is possible to secure the pipe length of the connecting pipe to alleviate an adverse effect due

to thermal stress, and it is possible to efficiently utilize each of the floors to secure a maintenance space and to improve maintainability.

[0021] In the steam turbine plant according to the present invention, the at least one high pressure moisture separator is a high pressure moisture separating heater.

[0022] Therefore, by properly heating the steam, thermal efficiency of the turbine plant can be further improved.

Advantageous Effects of Invention

[0023] According to the steam turbine plant of the present invention, since the high pressure moisture separator and the low pressure moisture separator are each disposed symmetrically with respect to the center line along the axial direction of the high and intermediate pressure turbine, the structure can be simplified, and the equipment cost can be reduced.

Brief Description of Drawings

[0024]

FIG. 1 is a schematic configuration diagram showing a nuclear power plant according to a first embodiment.

FIG. 2 is a schematic diagram showing flow of condensate and steam in a steam turbine plant of the first embodiment.

FIG. 3 is a plan view showing an arrangement of the steam turbine plant according to the first embodiment.

FIG. 4 is a front view showing an arrangement of the steam turbine plant.

FIG. 5 is a front view showing another arrangement of the steam turbine plant.

FIG. 6 is a front view showing another arrangement of the steam turbine plant.

FIG. 7 is a plan view showing an arrangement of a steam turbine plant according to a second embodiment.

FIG. 8 is a plan view showing an arrangement of a steam turbine plant according to a third embodiment.

FIG. 9 is a plan view showing an arrangement of a steam turbine plant according to a fourth embodiment.

Description of Embodiments

[0025] Preferred embodiments of a steam turbine plant of the present invention will be described in detail below with reference to the accompanying drawings. It is to be noted that the present invention is not limited by these embodiments. In addition, when there are a plurality of embodiments, the present invention also includes a combination of these embodiments.

[First Embodiment]

[0026] FIG. 1 is a schematic configuration diagram showing a nuclear power plant according to a first embodiment.

[0027] A nuclear reactor of the first embodiment is a pressurized water reactor (PWR) that uses light water as nuclear reactor coolant and neutron moderator, produces high temperature and high pressure water without boiling over the whole reactor core, sends this high temperature and high pressure water to the steam generator to generate steam by heat exchange, and sends this steam to a turbine generator to generate electricity.

[0028] In the nuclear power plant having the pressurized water reactor of the first embodiment, as shown in FIG. 1, a reactor containment 11 has a pressurized water reactor 12 and a steam generator 13 therein, and the pressurized water reactor 12 and the steam generator 13 are connected via pipes 14, 15. A pressurizer 16 is provided in the pipe 14, and a primary cooling water pump 17 is provided in the pipe 15. In this case, light water is used as moderator and primary cooling water (coolant). In order to suppress boiling of the primary cooling water in a reactor core, a primary cooling system is controlled by the pressurizer 16 so as to maintain a high pressure state of about 150 to 160 atm. Therefore, in the pressurized water reactor 12, the light water is heated as primary cooling water by low enriched uranium or MOX as fuel (nuclear fuel), and the high temperature primary cooling water is sent to the steam generator 13 through the pipe 14 while being maintained at a predetermined high pressure by the pressurizer 16. In this steam generator 13, heat exchange is performed between the high temperature and high pressure primary cooling water and secondary cooling water, and the cooled primary cooling water is returned to the pressurized water reactor 12 through the pipe 15.

[0029] The steam generator 13 is connected to a steam turbine 19 via a pipe 18, and a main steam isolation valve 20 is provided in the pipe 18. The steam turbine 19 has a high and intermediate pressure turbine 21 and two low pressure turbines 22 and 23, and a generator 24 is connected coaxially. The high and intermediate pressure turbine 21 has a high pressure turbine unit 25 and an intermediate pressure turbine unit 26, and a high pressure moisture separating heater 27 is provided between the high pressure turbine unit 25 and the intermediate pressure turbine unit 26. Furthermore, a low pressure moisture separating heater 28 is provided between the high and intermediate pressure turbine 21 (intermediate pressure turbine unit 26) and the low pressure turbines 22 and 23. That is, the pipe 18 from the steam generator 13 is connected to an inlet portion of the high pressure turbine unit 25, a steam pipe 29 is connected from an outlet portion of the high pressure turbine unit 25 to the inlet portion of the high pressure moisture separating heater 27, and a steam pipe 30 is connected from an outlet portion of the high pressure moisture separating heater 27

to an inlet portion of the intermediate pressure turbine unit 26. Furthermore, a steam pipe 31 is connected from an outlet portion of the intermediate pressure turbine unit 26 to an inlet portion of the low pressure moisture separating heater 28, and a steam pipe 32 is connected from an outlet portion of the low pressure moisture separating heater 28 to respective inlet portions of the low pressure turbines 22 and 23.

[0030] In the steam turbine 19, condensers 33 and 34 are provided below the low pressure turbines 22 and 23. The condensers 33 and 34 cool steam used in the low pressure turbines 22 and 23 with cooling water and condense the steam to make condensate. Seawater is used as the cooling water, and the condensers 33 and 34 are connected to an intake pipe 35 and a drain pipe 36 for supplying and discharging the cooling water. The intake pipe 35 has a circulating water pump 37, and one end portion thereof is disposed in the sea together with the drain pipe 36.

[0031] A pipe 38 is connected to the condensers 33 and 34, and a condensate pump 39, a gland condenser 40, a condensate demineralizer 41, a condensate booster pump 42, and low pressure feed water heaters 43, 44, 45, and 46 are provided in this pipe 38 in order along the flow direction of the condensate. Here, the first low pressure feed water heater 43 and the second low pressure feed water heater 44 are provided in the condensers 33 and 34, and the condensate is heated by the steam used in the low pressure turbines 22 and 23. Furthermore, the third low pressure feed water heater 45 and the fourth low pressure feed water heater 46 are provided outside the condensers 33 and 34. In the third low pressure feed water heater 45, the condensate is heated by the steam extracted from the low pressure turbines 22 and 23, and in the fourth low pressure feed water heater 46, the condensate is heated by the steam exhausted from the intermediate pressure turbine unit 26.

[0032] Furthermore, on the downstream side of the fourth low pressure feed water heater 46, the pipe 38 is provided with a deaerator 47, a main feed water pump 48, a high pressure feed water heater 49, and a main feed water control valve 50 in this order along the flow direction of the condensate.

[0033] Therefore, the steam generated by performing the heat exchange with the high temperature and high pressure primary cooling water in the steam generator 13 is sent to the steam turbine 19 through the pipe 18, the high and intermediate pressure turbine 21 and each of the low pressure turbines 22 and 23 are operated to obtain rotational force, and the generator 24 is driven by this rotational force to generate electricity. At this time, after the steam from the steam generator 13 drives the high pressure turbine unit 25, the moisture contained in the steam is removed by the high pressure moisture separating heater 27, and the steam is heated to drive the intermediate pressure turbine unit 26. Furthermore, the steam that has driven the intermediate pressure turbine unit 26 drives the low pressure turbines 22 and 23 after

the moisture contained in the steam is removed by the low pressure moisture separating heater 28 and the steam is heated. Then, the steam that has driven the low pressure turbines 22 and 23 is cooled by the seawater in the condensers 33, 34 to become condensate, flows through the pipe 38 by the condensate pump 39, and is returned through the gland condenser 40, the condensate demineralizer 41, the low pressure feed water heaters 43, 44, 45, and 46, the deaerator 47, the high pressure feed water heater 49, and the like to the steam generator 13.

[0034] Described here are flows of the condensate and the steam in the high and intermediate pressure turbine 21, the low pressure turbines 22 and 23, the high pressure moisture separating heater 27, the low pressure moisture separating heater 28, and the low pressure feed water heaters 43, 44, 45, and 46. FIG. 2 is a schematic diagram showing the flow of the condensate and the steam in a steam turbine plant of the first embodiment.

[0035] As shown in FIG. 2, the steam pipe 31 from the outlet portion of the intermediate pressure turbine unit 26 to the inlet portion of the low pressure moisture separating heater 28 is connected to a base end portion of a steam branch pipe 51 branched from a middle portion of the steam pipe 31, and a distal end portion of the steam branch pipe 51 is connected to the fourth low pressure feed water heater 46. Further, a distal end portion of a bleed air pipe 52 from the low pressure turbines 22 and 23 is connected to the third low pressure feed water heater 45. Therefore, the third low pressure feed water heater 45 heats the condensate with the steam extracted from the low pressure turbines 22 and 23, and the fourth low pressure feed water heater 46 heats the condensate with the steam exhausted from the intermediate pressure turbine unit 26.

[0036] In addition, drain (water) is generated in each of the low pressure feed water heaters 43, 44, 45, and 46 as the steam heats and condenses the condensate. Therefore, a drain pipe 53 is connected from the fourth low pressure feed water heater 46 to the third low pressure feed water heater 45, a drain pipe 54 is connected from the third low pressure feed water heater 45 to the second low pressure feed water heater 44, and a drain pipe 55 is connected from the second low pressure feed water heater 44 to the first low pressure feed water heater 43. A drain pipe 56 is connected from the first low pressure feed water heater 43 to a portion in the pipe 38 between the first low pressure feed water heater 43 and the second low pressure feed water heater 44, and a drain pump 57 is provided in the drain pipe 56.

[0037] In the steam turbine plant of the first embodiment configured as described above, the high pressure moisture separating heater 27, the low pressure moisture separating heater 28, and the like are disposed efficiently in the limited space with respect to the steam turbine 19.

[0038] FIG. 3 is a plan view showing an arrangement of the steam turbine plant of the first embodiment, and FIG. 4 is a front view showing an arrangement of the

steam turbine plant.

[0039] As shown in FIGS. 3 and 4, the steam turbine plant of the first embodiment includes the high and intermediate pressure turbine 21, the low pressure turbines 22 and 23, the generator 24, the high pressure moisture separating heater 27 (27a and 27b), and the low pressure moisture separating heater 28 (28a and 28b).

[0040] A turbine building (not shown) includes a plurality of floors. A foundation 62 is laid at a center of a predetermined floor (first floor) 61, and on the foundation 62, the high and intermediate pressure turbine 21, the two low pressure turbines 22 and 23, and the generator 24 are installed coaxially along the axial direction C.

[0041] The low pressure moisture separating heater 28 includes two low pressure moisture separating heaters 28a and 28b, and they are disposed on the floor 61 so as to be positioned on both sides of the high and intermediate pressure turbine 21 in a width direction (vertical direction in FIG. 3). Each of the low pressure moisture separating heaters 28a and 28b is disposed at a predetermined distance from the high and intermediate pressure turbine 21 and each of the low pressure turbines 22, 23, and is arranged parallel to the axial direction C. Each of the low pressure moisture separating heaters 28a and 28b removes the moisture from the steam exhausted from the high and intermediate pressure turbine 21 and sends the steam to the low pressure turbines 22 and 23. Two steam pipes 31a and 31b extend from the outlet portion of the intermediate pressure turbine unit 26 (see FIG. 2), and distal end portions thereof are respectively connected to the inlet portions of the low pressure moisture separating heaters 28a and 28b. Steam pipes 32a and 32b are connected to the inlet portions of the low pressure turbines 22 and 23 from the outlet portions of the low pressure moisture separating heaters 28a and 28b. In addition, each of the low pressure moisture separating heaters 28a and 28b is provided with a group of heat transfer tubes as heating sources for heating the steam, in which the steam from the steam generator 13 circulates.

[0042] Furthermore, the high pressure moisture separating heater 27 includes two high pressure moisture separating heaters 27a and 27b, and they are disposed on the floor 61 so as to be positioned on both sides of the high and intermediate pressure turbine 21 in the width direction (vertical direction in FIG. 3). Each of the high pressure moisture separating heaters 27a and 27b removes the moisture from the steam exhausted from the high pressure turbine unit 25 and sends the steam to the intermediate pressure turbine unit 26. Steam pipes 29a and 29b extend from the outlet portion of the high pressure turbine unit 25 (see FIG. 2), and distal end portions thereof are respectively connected to the inlet portions of the high pressure moisture separating heaters 27a and 27b. Steam pipes 30a and 30b are connected to the inlet portion of the intermediate pressure turbine unit 26 from the outlet portions of the high pressure moisture separating heaters 27a and 27b. In addition, each of the high

pressure moisture separating heaters 27a and 27b is provided with a group of heat transfer tubes as heating sources for heating the steam, in which the steam from the steam generator 13 circulates.

[0043] Then, the high and intermediate pressure turbine 21, the low pressure turbines 22 and 23, the generator 24, the high pressure moisture separating heater 27 (27a and 27b), and the low pressure moisture separating heater 28 (28a and 28b) are disposed on the same floor 61.

[0044] The high pressure moisture separating heaters 27a and 27b and the low pressure moisture separating heaters 28a and 28b are disposed on both sides in a horizontal direction orthogonal to the axial direction C of the high and intermediate pressure turbine 21 and the low pressure turbines 22 and 23, symmetrically with respect to the center line along the axial direction C. In this case, the two high pressure moisture separating heaters 27a and 27b are disposed on both sides of the high and intermediate pressure turbine 21 in parallel with the axial direction C. The two low pressure moisture separating heaters 28a and 28b are disposed on both sides of the high and intermediate pressure turbine 21 and the low pressure turbines 22 and 23 in parallel with the axial direction C. That is, the high pressure moisture separating heaters 27a and 27b are disposed on a side opposite to the low pressure turbines 22 and 23 in the axial direction C of the high and intermediate pressure turbine 21, and the low pressure moisture separating heaters 28a and 28b are disposed on a side of the low pressure turbines 22 and 23 in the axial direction C of the high and intermediate pressure turbine 21. The high pressure moisture separating heaters 27a and 27b and the low pressure moisture separating heaters 28a and 28b are disposed in series along the axial direction C.

[0045] Although not shown, the deaerator 47 (see FIG. 2) is disposed on the floor 61 on one side in the axial direction C of the high and intermediate pressure turbine 21, along a direction intersecting the axial direction C of the high and intermediate pressure turbine 21. The deaerator 47 removes impurities such as dissolved oxygen and uncondensed gas (ammonia gas) in the condensate (feed water) from the fourth low pressure feed water heater 46 (see FIG. 2). The high pressure moisture separating heaters 27a and 27b are disposed between the high and intermediate pressure turbine 21 and the deaerator 47.

[0046] In the above-described embodiment, the high pressure moisture separating heater 27 (27a and 27b) and the low pressure moisture separating heater 28 (28a and 28b) are disposed on the same floor 61 as a floor on which the high and intermediate pressure turbine 21, the low pressure turbines 22 and 23, and the like are disposed; however, the present invention is not limited to this configuration. FIG. 5 and FIG. 6 are front views each showing another arrangement of the steam turbine plant.

[0047] As shown in FIG. 5, a floor (second floor) 63 is provided below the floor 61. The high pressure moisture separating heaters 27a (27b) are disposed on the lower

floor 63 different from the floor 61 on which the high and intermediate pressure turbine 21, the low pressure turbines 22 and 23, the low pressure moisture separating heater 28 (28a and 28b), and the like are installed. However, similarly to the above description, the high pressure moisture separating heaters 27a (27b) are disposed on both sides in the horizontal direction orthogonal to the axial direction C, symmetrically with respect to the center line along the axial direction C so as to be parallel with the axial direction C. The deaerator 47 is disposed on the floor 61 on one side in the axial direction C of the high and intermediate pressure turbine 21, along a direction intersecting the axial direction C of the high and intermediate pressure turbine 21.

[0048] Furthermore, as shown in FIG. 6, the high pressure moisture separating heaters 27a (27b) and the low pressure moisture separating heaters 28a (28b) are disposed on the lower floor 63 different from the floor 61 on which the high and intermediate pressure turbine 21, the low pressure turbines 22 and 23, and the like are installed. However, similarly to the above description, the high pressure moisture separating heaters 27a (27b) and the low pressure moisture separating heaters 28a (28b) are disposed on both sides in the horizontal direction orthogonal to the axial direction C, symmetrically with respect to the center line along the axial direction C so as to be parallel with the axial direction C.

[0049] Although not shown, the high pressure moisture separating heaters 27a (27b) may be disposed on the floor 61 on which the high and intermediate pressure turbine 21, the low pressure turbines 22 and 23, and the like are installed, and the low pressure moisture separating heaters 28a (28b) may be disposed on the lower floor 63.

[0050] Therefore, in the turbine plant of the present embodiment, as shown in FIGS. 3 to 6, the two high pressure moisture separating heaters 27 (27a and 27b) and the two low pressure moisture separating heaters 28 (28a and 28b) are symmetrically disposed with respect to the center line along the axial direction C of the high and intermediate pressure turbine 21 and the low pressure turbines 22 and 23. Thus, in particular, the high pressure moisture separating heater 27 can be disposed efficiently in the vicinity of the high and intermediate pressure turbine 21, and there is no need to expand the turbine building in a width direction (a horizontal direction orthogonal to the axial direction C) of the high and intermediate pressure turbine 21 and the low pressure turbines 22 and 23. Moreover, since the pipe lengths of the steam pipes 29 and 31 are shortened, the overall structure is simplified. Furthermore, since the high pressure moisture separating heater 27 and the low pressure moisture separating heater 28 are each disposed symmetrically, the flow rate of the steam is balanced well, and performance of the entire plant is improved.

[0051] The steam sent from the steam generator 13 through the pipe 18 drives the high pressure turbine unit 25 of the high and intermediate pressure turbine 21, and

is then sent by the steam pipe 29 to the high pressure moisture separating heater 27, where the steam is heated while moisture is removed. The steam processed by the high pressure moisture separating heater 27 drives the intermediate pressure turbine unit 26, and is then sent by the steam pipe 30 to the low pressure moisture separating heater 28, where the steam is heated while moisture is removed. The steam processed by the low pressure moisture separating heater 28 is sent to the low pressure turbines 22 and 23 by the steam pipe 32 to drive the low pressure turbines 22 and 23.

[0052] At this time, the steam exhausted from the intermediate pressure turbine unit 26 is sent to the low pressure moisture separating heater 28 by the steam pipe 31 (31a and 31b) and is also sent to the fourth low pressure feed water heater 46 by the steam branch pipe 51. The steam extracted from the low pressure turbines 22 and 23 is sent to the third low pressure feed water heater 45 through the bleed air pipe 52. Therefore, the third low pressure feed water heater 45 heats the condensate (feed water) flowing through the pipe 38 by the steam from the low pressure turbines 22 and 23, and the fourth low pressure feed water heater 46 heats the condensate (feed water) heated by the third low pressure feed water heater 45 and flowing through the pipe 38 by the steam from the intermediate pressure turbine unit 26.

[0053] As described above, the steam turbine plant of the first embodiment is provided with: the high and intermediate pressure turbine 21 having the high pressure turbine unit 25 at one end in the axial direction C and the intermediate pressure turbine unit 26 at the other end; the low pressure turbines 22 and 23 disposed coaxially with the high and intermediate pressure turbine 21; the high pressure moisture separating heater 27 (27a and 27b) that removes the moisture from the steam from the high pressure turbine unit 25 and sends the steam to the intermediate pressure turbine unit 26; and the low pressure moisture separating heater 28 (28a and 28b) that removes the moisture from the steam from the intermediate pressure turbine unit 26 and sends the steam to the low pressure turbines 22 and 23. The high pressure moisture separating heater 27 and the low pressure moisture separating heater 28 are each disposed symmetrically with respect to the center line along the axial direction C of the high and intermediate pressure turbine 21.

[0054] Accordingly, the high pressure moisture separating heater 27 can be disposed in the vicinity of the high and intermediate pressure turbine 21 or the low pressure turbines 22 and 23. Thus the pipe length is shortened, the structure can be simplified, the equipment cost can be reduced, and the turbine building can also be downsized.

[0055] In the steam turbine plant of the present embodiment, the two high pressure moisture separating heaters 27a and 27b are disposed respectively on both sides of the high and intermediate pressure turbine 21, and the two low pressure moisture separating heaters

28a and 28b are disposed respectively on both sides of the high and intermediate pressure turbine 21, with the high pressure moisture separating heaters 27a and 27b and the low pressure moisture separating heaters 28a and 28b disposed in series along the axial direction C. Therefore, it is possible to effectively utilize space in the longitudinal direction of the high pressure moisture separating heaters 27a and 27b and the low pressure moisture separating heaters 28a and 28b.

[0056] In the steam turbine plant of this embodiment, the high pressure moisture separating heater 27 is disposed on the side opposite to the low pressure turbines 22 and 23 in the axial direction C of the high and intermediate pressure turbine 21, and the low pressure moisture separating heater 28 is disposed on the side of the low pressure turbines 22 and 23 in the axial direction C of the high and intermediate pressure turbine 21. Thus the high pressure moisture separating heater 27 is disposed in the vicinity of the high and intermediate pressure turbine 21 and the low pressure moisture separating heater 28 is disposed in the vicinity of the low pressure turbines 22 and 23, whereby the pipe length is shortened, the structure can be simplified, and the equipment cost can be reduced.

[0057] In the steam turbine plant of the present embodiment, the high pressure moisture separating heater 27 and the low pressure moisture separating heater 28 are disposed on one of the floor 61 on which the high and intermediate pressure turbine 21 and the low pressure turbines 22 and 23 are disposed and the floor 63 the floor level of which is different from that of the floor 61. Therefore, by disposing the high pressure moisture separating heater 27 and the low pressure moisture separating heater 28 on the same floor 61 (63), it is possible to shorten the pipe length of a connecting pipe and reduce the equipment cost.

[0058] In the steam turbine plant of the present embodiment, the high pressure moisture separating heater 27 is disposed on one of the floor 61 on which the high and intermediate pressure turbine 21 and the low pressure turbines 22 and 23 are disposed and the floor 63 the floor level of which is different from that of the floor 61, and the low pressure moisture separating heater 28 is disposed on another floor of the floors 61 and 63. Therefore, by disposing the high pressure moisture separating heater 27 and the low pressure moisture separating heater 28 on the different floors 61 and 63, it is possible to secure the pipe length of the connecting pipe, to alleviate an adverse effect due to thermal stress, and it is possible to efficiently utilize each of the floors 61 and 63 to secure a maintenance space and to improve maintainability.

[Second Embodiment]

[0059] FIG. 7 is a plan view showing an arrangement of a steam turbine plant according to a second embodiment. Note that members having the same functions as

those in the above-described embodiment are denoted by the same reference numerals, and a detailed description thereof will be omitted.

[0060] As shown in FIG. 7, the steam turbine plant of the second embodiment includes the high and intermediate pressure turbine 21, the low pressure turbine 22, the pipe 31, the high pressure moisture separating heater 27, and the low pressure moisture separating heater 28.

[0061] The low pressure moisture separating heater 28 includes the two low pressure moisture separating heaters 28a and 28b, and they are disposed on the floor 61 so as to be positioned on both sides in the width direction of the high and intermediate pressure turbine 21, symmetrically with respect to the center line in the axial direction C. The one high pressure moisture separating heater 27 is disposed on the side opposite to the low pressure turbine 22 in the axial direction C of the high and intermediate pressure turbine 21. The high pressure moisture separating heater 27 is disposed on the floor 61 along the axial direction C adjacent to the high and intermediate pressure turbine 21. In this case, the high pressure moisture separating heater 27, the high and intermediate pressure turbine 21, and the low pressure turbine 22 are disposed in a straight line along the axial direction C.

[0062] As described above, in the steam turbine plant of the second embodiment, the high pressure moisture separating heater 27 is disposed along the axial direction C of the high and intermediate pressure turbine 21. Therefore, it is possible to effectively utilize the space in the longitudinal direction of the high pressure moisture separating heater 27 and the low pressure moisture separating heater 28.

[Third Embodiment]

[0063] FIG. 8 is a plan view showing an arrangement of a steam turbine plant according to a third embodiment. Note that members having the same functions as those in the above-described embodiment are denoted by the same reference numerals, and a detailed description thereof will be omitted.

[0064] As shown in FIG. 8, the steam turbine plant of the third embodiment includes the high and intermediate pressure turbine 21, the low pressure turbine 22, the steam pipe 31, the high pressure moisture separating heater 27, and the low pressure moisture separating heater 28.

[0065] The low pressure moisture separating heater 28 includes the two low pressure moisture separating heaters 28a and 28b, and they are disposed on the floor 61 so as to be positioned symmetrically on both sides in the width direction of the high and intermediate pressure turbine 21. The high pressure moisture separating heater 27 includes the two high pressure moisture separating heaters 27a and 27b, and they are disposed on the side opposite to the low pressure turbine 22 in the axial direction C of the high and intermediate pressure turbine 21.

The high pressure moisture separating heaters 27a and 27b are disposed on the floor 61 along the direction intersecting the axial direction C while being adjacent to the high and intermediate pressure turbine 21, and moreover, the high pressure moisture separating heaters 27a and 27b are disposed symmetrically with respect to the center line in the axial direction C. The plurality of (two in the present embodiment) high pressure moisture separating heaters 27a and 27b are disposed in parallel at a predetermined interval.

[0066] As described above, in the steam turbine plant of the third embodiment, the two high pressure moisture separating heaters 27a and 27b as the high pressure moisture separating heater 27 are disposed in parallel, and also the high pressure moisture separating heaters 27a and 27b are disposed symmetrically with respect to the center line in the axial direction C while intersecting the center line. Therefore, by disposing the high pressure moisture separating heater 27 and the low pressure moisture separating heater 28 in an intersecting manner to effectively utilize the space, it is possible to downsize the turbine building, and to process the steam from the high pressure turbine unit 25 in a well-balanced manner.

[Fourth Embodiment]

[0067] FIG. 9 is a plan view showing an arrangement of a steam turbine plant of a fourth embodiment. Note that members having the same functions as those in the above-described embodiment are denoted by the same reference numerals, and a detailed description thereof will be omitted.

[0068] As shown in FIG. 9, the steam turbine plant of the fourth embodiment includes the high and intermediate pressure turbine 21, the low pressure turbine 22, the pipe 31, the high pressure moisture separating heater 27, and the low pressure moisture separating heater 28.

[0069] The low pressure moisture separating heater 28 includes the two low pressure moisture separating heaters 28a and 28b, and they are disposed on the floor 61 so as to be positioned symmetrically on both sides in the width direction of the high and intermediate pressure turbine 21. The one high pressure moisture separating heater 27 is disposed on the side opposite to the low pressure turbine 22 in the axial direction C of the high and intermediate pressure turbine 21. The high pressure moisture separating heater 27 is disposed on the floor 61 along the direction intersecting the axial direction C while being adjacent to the high and intermediate pressure turbine 21, and moreover, the high pressure moisture separating heater 27 is disposed symmetrically with respect to the center line in the axial direction C. The deaerator 47 is disposed adjacent and in parallel to the high pressure moisture separating heater 27.

[0070] As described above, in the steam turbine plant of the fourth embodiment, the one high pressure moisture separating heater 27 is disposed symmetrically with respect to the center line in the axial direction C while in-

tersecting the center line. Therefore, by effectively utilizing the space in the axial direction, it is possible to downsize the turbine building, and to process the steam from the high pressure turbine unit 25 in a well-balanced manner.

[0071] In each of the above-described embodiments, the four low pressure feed water heaters 43, 44, 45, and 46 are provided, of which the two low pressure feed water heaters 43 and 44 are disposed in the condensers 33 and 34, and the two low pressure feed water heaters 45 and 46 are disposed outside the condensers 33 and 34. However, the arrangement and the number of low pressure feed water heaters are not limited to those of the embodiments, and they may be set appropriately according to the scale of the steam turbine plant or the like.

[0072] Further, in the above-described embodiment, the steam exhausted from the final stage of the intermediate pressure turbine unit 26 is supplied to the low pressure moisture separating heater 28 (28a and 28b); however, the steam extracted from the middle stage of the intermediate pressure turbine unit 26 may be supplied to the low pressure moisture separating heater 28 (28a and 28b).

[0073] Further, in the above-described embodiment, the moisture separating heater has been described, but it may be a moisture separator.

[0074] Further, in the above-described embodiment, the steam turbine plant of the present invention is applied to a nuclear power plant; however, the present invention is not limited thereto, and for example, the present invention can be applied to a thermal power plant or the like.

Reference Signs List

[0075]

12 PRESSURIZED WATER REACTOR
13 STEAM GENERATOR
18, 38 PIPE
19 STEAM TURBINE
21 HIGH AND INTERMEDIATE PRESSURE TURBINE
22, 23 LOW PRESSURE TURBINE
24 GENERATOR
25 HIGH PRESSURE TURBINE UNIT
26 INTERMEDIATE PRESSURE TURBINE UNIT
27, 27a, 27b HIGH PRESSURE MOISTURE SEPARATING HEATER (HIGH PRESSURE MOISTURE SEPARATOR)
28, 28a, 28b LOW PRESSURE MOISTURE SEPARATING HEATER (LOW PRESSURE MOISTURE SEPARATOR)
29, 30, 31, 31a, 31b, 32, 32a, 32b STEAM PIPE
33, 34 CONDENSER
43 FIRST LOW PRESSURE FEED WATER HEATER
44 SECOND LOW PRESSURE FEED WATER HEATER

45 THIRD LOW PRESSURE FEED WATER HEATER

46 FOURTH LOW PRESSURE FEED WATER HEATER

51 STEAM BRANCH PIPE

52 BLEED AIR PIPE

61 FLOOR (FIRST FLOOR)

62 FOUNDATION

63 FLOOR (SECOND FLOOR)

C AXIAL DIRECTION

Claims

1. A steam turbine plant comprising:

a high and intermediate pressure turbine having a high pressure turbine unit at one end in an axial direction and an intermediate pressure turbine unit at the other end;

at least one low pressure turbine disposed coaxially with the high and intermediate pressure turbine;

at least one high pressure moisture separator arranged to remove moisture from steam from the high pressure turbine unit and send the steam to the intermediate pressure turbine unit; and

at least one low pressure moisture separator arranged to remove the moisture from the steam from the intermediate pressure turbine unit and send the steam to the at least one low pressure turbine, wherein

the at least one high pressure moisture separator and the at least one low pressure moisture separator are each disposed symmetrically with respect to a center line along the axial direction of the high and intermediate pressure turbine.

2. The steam turbine plant according to claim 1 comprising the two high pressure moisture separators and the two low pressure moisture separators, wherein the two high pressure moisture separators are disposed on both sides of the high and intermediate pressure turbine, the two low pressure moisture separators are disposed on both sides of the high and intermediate pressure turbine, and the two high pressure moisture separators and the two low pressure moisture separators are disposed in series along the axial direction.

3. The steam turbine plant according to claim 1 or 2, wherein the at least one high pressure moisture separator is disposed on a side opposite to the at least one low pressure turbine in the axial direction of the high and intermediate pressure turbine, and the at least one low pressure moisture separator is disposed on a low pressure turbine side in the axial

direction of the high and intermediate pressure turbine.

4. The steam turbine plant according to claim 1 comprising the one high pressure moisture separator and the two low pressure moisture separators, wherein the one high pressure moisture separator is disposed along the center line on a side opposite to the at least one low pressure turbine in the axial direction of the high and intermediate pressure turbine, and the two low pressure moisture separators are disposed on both sides of the high and intermediate pressure turbine. 5
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5. The steam turbine plant according to claim 1, wherein the at least one high pressure moisture separator is disposed along a direction intersecting the axial direction. 15

6. The steam turbine plant according to any one of claims 1 to 5, wherein the at least one high pressure moisture separator and the at least one low pressure moisture separator are disposed on one of a first floor on which the high and intermediate pressure turbine and the at least one low pressure turbine are disposed and a second floor a floor level of which is different from that of the first floor. 20
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7. The steam turbine plant according to any one of claims 1 to 5, wherein the at least one high pressure moisture separator is disposed on one of a first floor on which the high and intermediate pressure turbine and the at least one low pressure turbine are disposed and a second floor a floor level of which is different from that of the first floor, and the at least one low pressure moisture separator is disposed on another floor of the first floor and the second floor. 30
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8. The steam turbine plant according to any one of claims 1 to 7, wherein the at least one high pressure moisture separator is a high pressure moisture separating heater. 40

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FIG.1

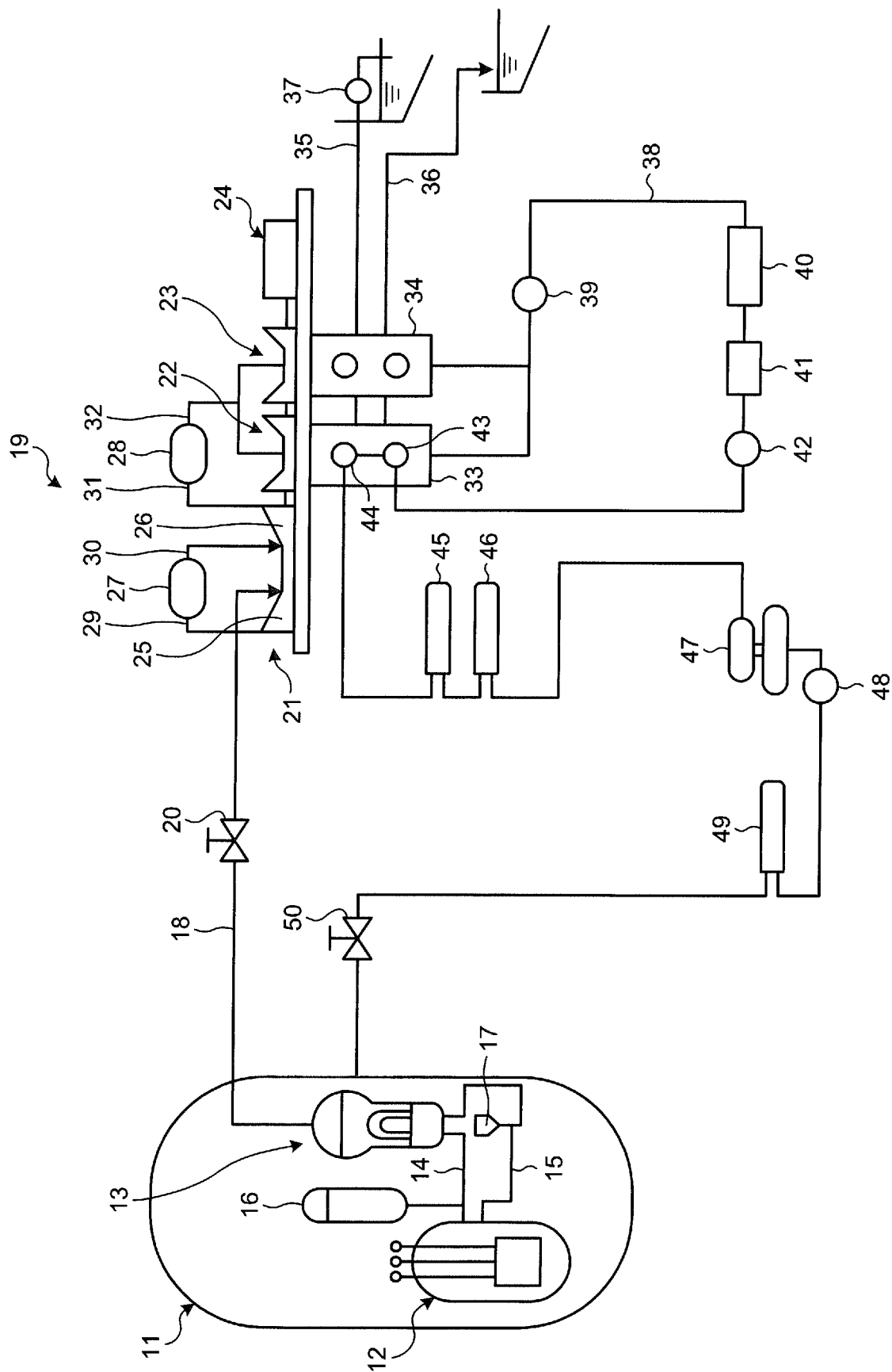


FIG. 2

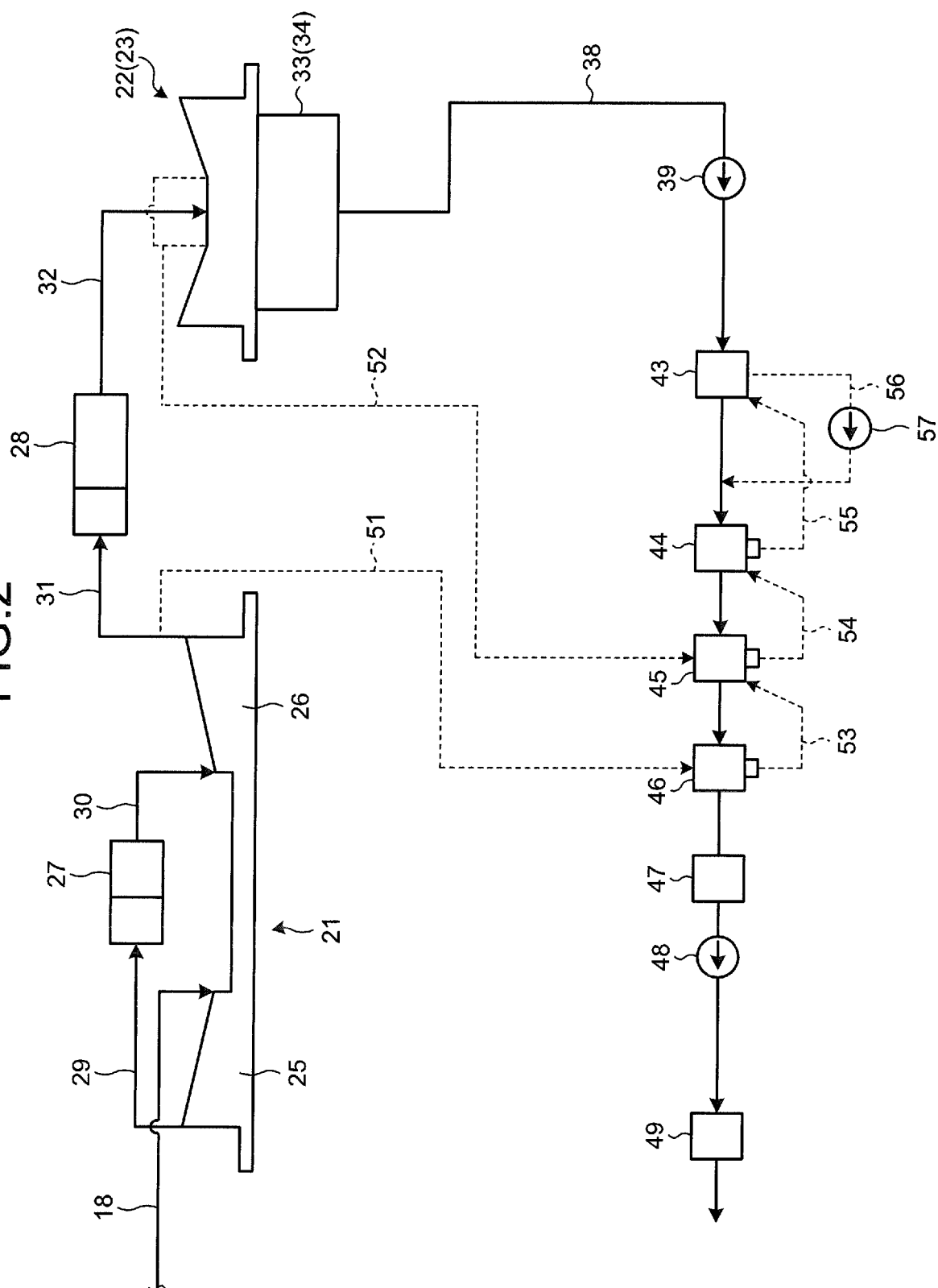


FIG.3

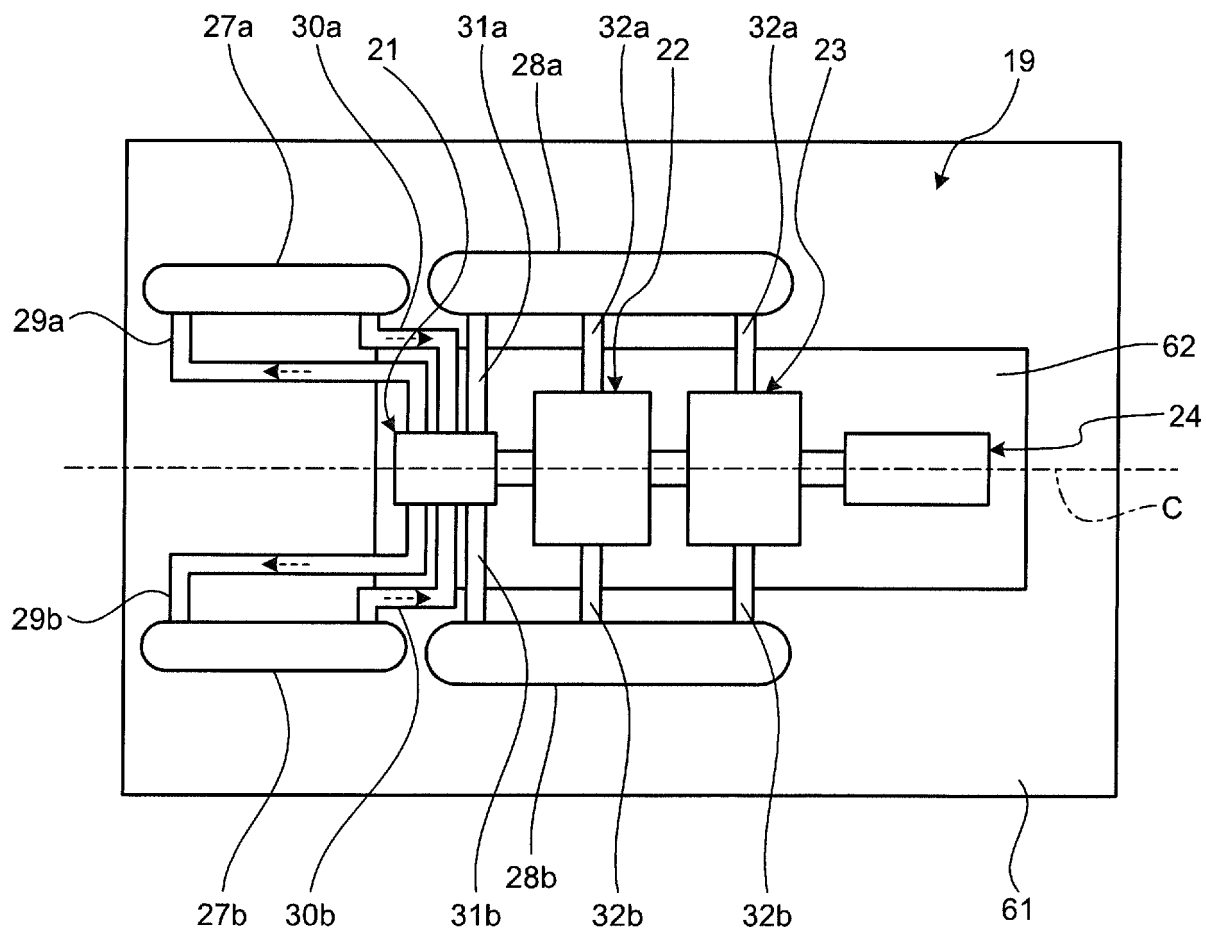


FIG.4

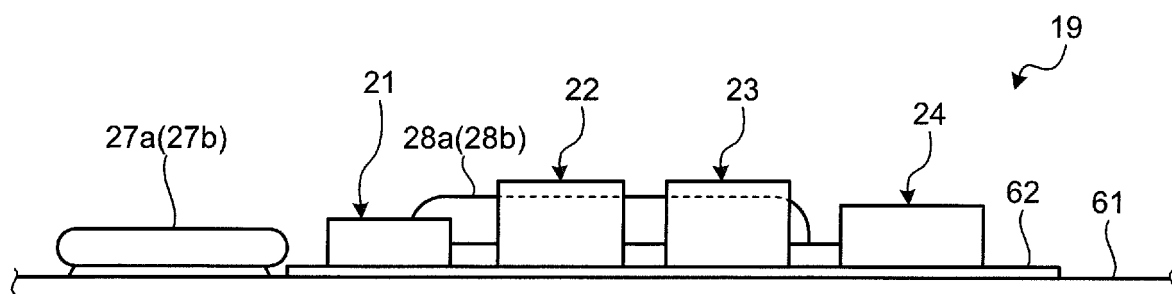


FIG.5

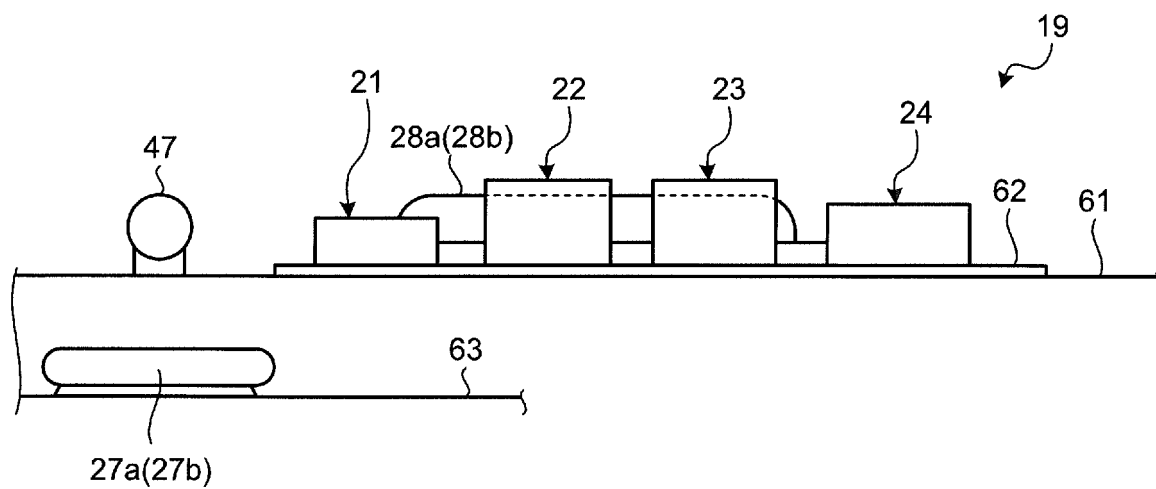


FIG.6

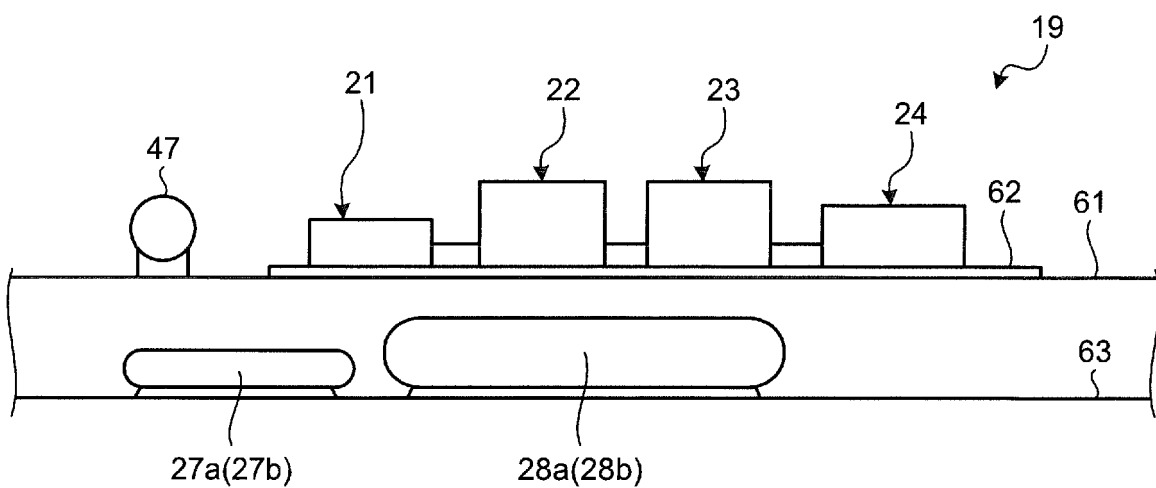


FIG.7

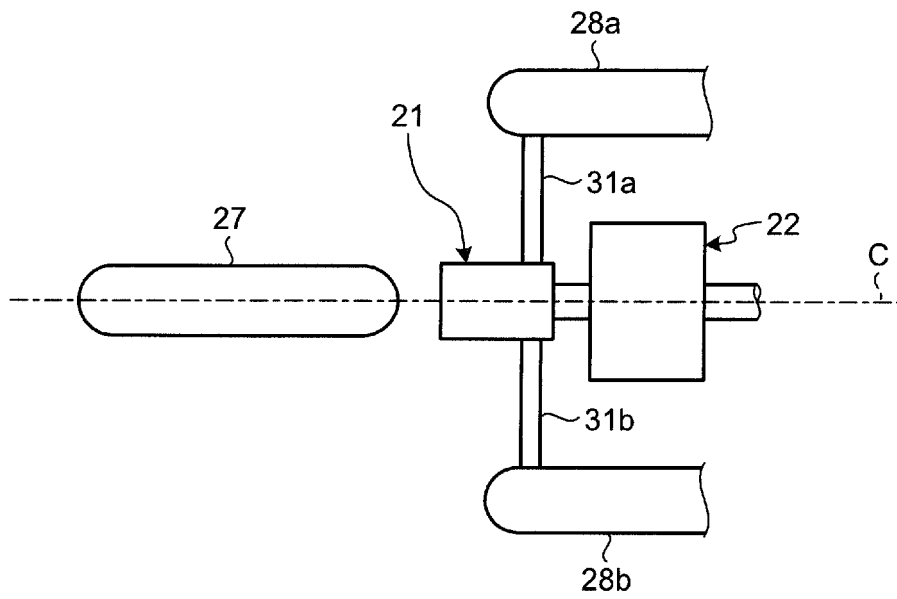


FIG.8

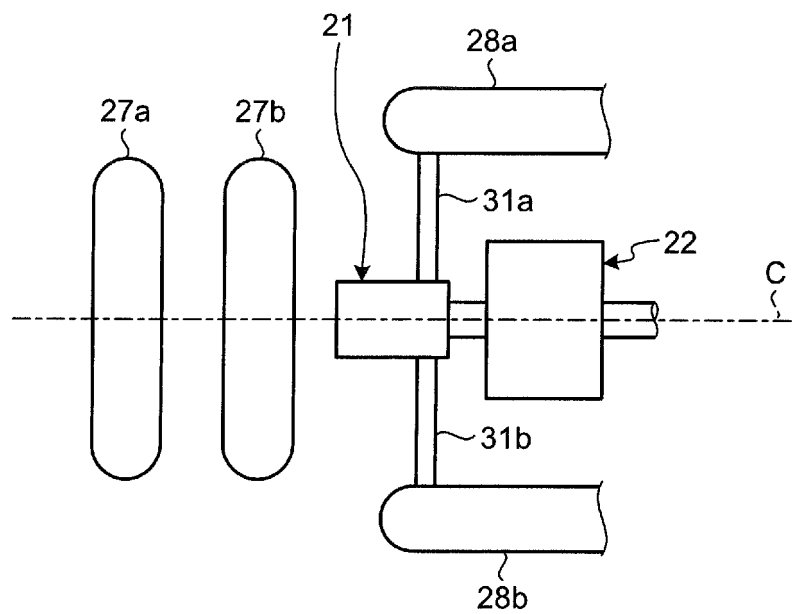
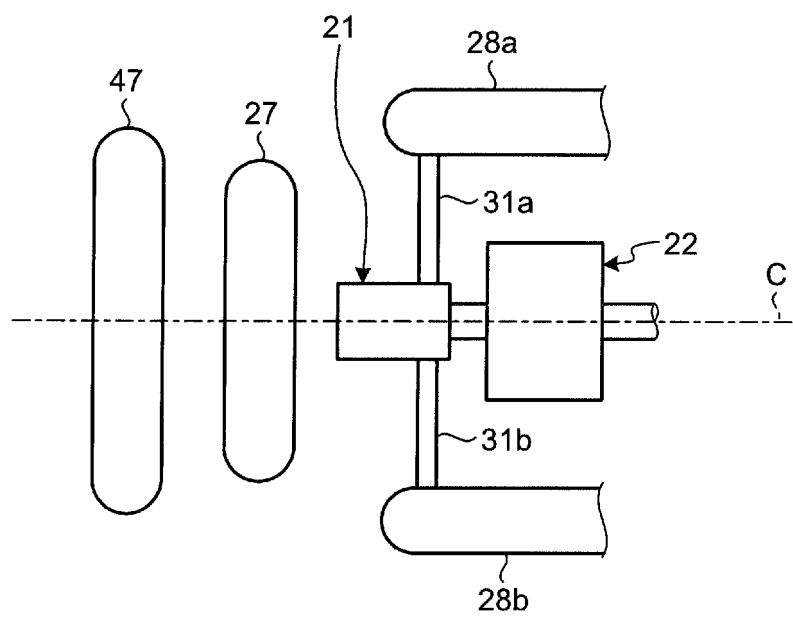


FIG.9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/072030

A. CLASSIFICATION OF SUBJECT MATTER

F01K13/00(2006.01)i, F01D25/32(2006.01)i, F01K7/22(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01K13/00, F01D25/32, F01K7/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012/0256420 A1 (ALSTOM TECHNOLOGY LTD.), 11 October 2012 (11.10.2012), entire text; drawings & EP 2472072 A1 & CN 102588019 A & RU 2011153167 A	1-8
A	JP 9-242357 A (Hitachi, Ltd.), 16 September 1997 (16.09.1997), entire text; drawings (Family: none)	1-8
A	JP 2014-25801 A (Toshiba Corp.), 06 February 2014 (06.02.2014), entire text; drawings (Family: none)	1-8

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
26 September 2016 (26.09.16)Date of mailing of the international search report
04 October 2016 (04.10.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/072030

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2001-3708 A (Mitsubishi Heavy Industries, Ltd.), 09 January 2001 (09.01.2001), entire text; drawings (Family: none)	1-8
A	JP 63-235605 A (Toshiba Corp.), 30 September 1988 (30.09.1988), entire text; drawings (Family: none)	1-8
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A	JP 2011-58489 A (General Electric Co.), 24 March 2011 (24.03.2011), entire text; drawings & US 2011/0056201 A1 entire text; drawings & US 2013/0333386 A1 & EP 2345794 A2 & CN 102011615 A	1-8

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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