(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 358 155 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.08.2018 Bulletin 2018/32

(51) Int Cl.:
F01K 13/02 *(2006.01)* ***F01C 21/00*** *(2006.01)*

(21) Application number: **17208350.3**

(22) Date of filing: **19.12.2017**

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

(30) Priority: **06.02.2017 JP 2017019368**

(71) Applicant: **Kabushiki Kaisha Kobe Seiko Sho (Kobe Steel, Ltd.)**
Kobe-shi, Hyogo, 651-8585 (JP)

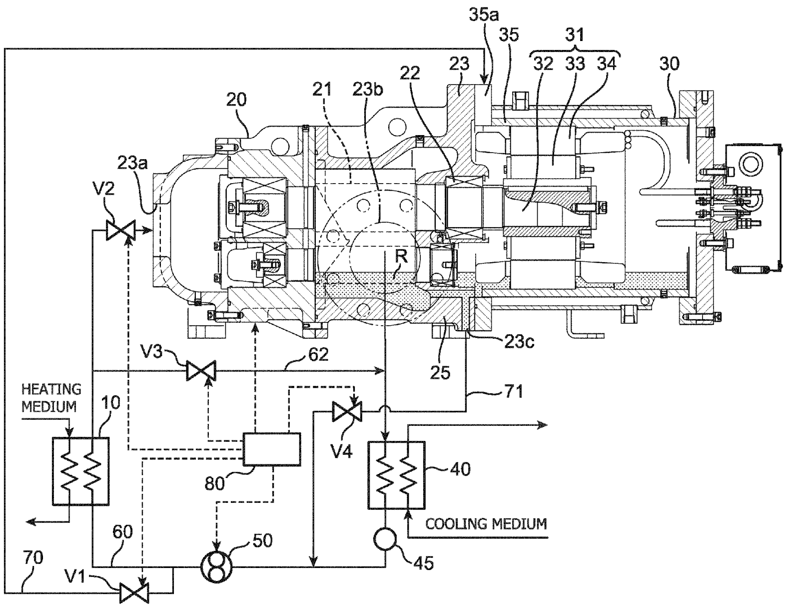
(72) Inventors:
- **ADACHI, Shigeto**
  Takasago-shi,, Hyogo 676-8670 (JP)
- **NARUKAWA, Yutaka**
  Takasago-shi,, Hyogo 676-8670 (JP)
- **NISHIMURA, Kazumasa**
  Takasago-shi,, Hyogo 676-8670 (JP)

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(54) THERMAL ENERGY RECOVERY DEVICE

(57) Provided is a thermal energy recovery device in which poor lubrication of a bearing can be inhibited when an expander is driven. The thermal energy recovery device includes an evaporator (10), an expander (20), a power recovery machine (30), a condenser (40), a pump (50), a circulation flow path (60), a cooling flow path (70) for supplying working fluid from the pump (50) partially to the power recovery machine (30), an on-off valve (V1) provided in the cooling flow path (70), and a control unit (80), in which the expander (20) has a rotor (21), a bearing (22), and a primary casing (23), and in which the power recovery machine (30) has a power recovery unit (31) and a secondary casing (35), and in which upon reception of a stop signal for stopping power recovery by the power recovery machine (30), the control unit (80) closes the on-off valve (V1).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

[0001] The present invention relates to a thermal energy recovery device.

(DESCRIPTION OF THE RELATED ART)

[0002] There have conventionally been known thermal energy recovery devices for recovering power from exhaust heat from various types of equipment such as plants. For example, JP 2012-97725 discloses a generator system (thermal energy recovery device) including an evaporator, a closed generator, a condenser, a fluid supply pump, a circulation flow path connecting the evaporator, the closed generator, the condenser, and the fluid supply pump in this order, and a cooling tube. The evaporator evaporates working medium. The closed generator generates electric power from the expansion energy of working medium flowing out of the evaporator. Specifically, the closed generator has a screw turbine for expanding working medium, a generator connected to the screw turbine via an output shaft, and a housing case housing the screw turbine, the output shaft, and the generator therein. The condenser condenses working medium flowing out of the closed generator. The fluid supply pump delivers working medium flowing out of the condenser to the evaporator. The cooling tube connects a site downstream the fluid supply pump in the circulation flow path and the housing case such that working medium of liquid phase discharged from the fluid supply pump is partially supplied into the housing case.

[0003] In the thermal energy recovery device, since working medium of liquid phase discharged from the fluid supply pump during operation is partially supplied into the housing case through the cooling tube, the generator is cooled effectively during operation of the device.

[0004] Such a thermal energy recovery device as described in JP 2012-97725 has a concern that the lubrication of the bearing of the screw turbine may be insufficient when the device restarts after stopping. Specifically, when the thermal energy recovery device comes into a stop operation, the rotational speed of the pump starts decreasing. In this state, if working medium of liquid phase continues to be supplied into the expander through the cooling tube, working medium of liquid phase that has existed in the evaporator and heated by heating medium to be evaporated and then flowing into the expander, for example, may be cooled and thereby condensed by the working medium of liquid phase supplied through the cooling tube to be reserved within the expander. When the accumulation of the working medium of liquid phase then causes the bearing of the screw turbine to be immersed in the working medium of liquid phase, there is a concern of poor lubrication of the bearing when the device restarts (when the screw turbine is driven).

[0005] It is hence an object of the present invention to provide a thermal energy recovery device in which poor lubrication of a bearing can be inhibited when an expander is driven.

[0006] In order to achieve the foregoing object, the present invention provides a thermal energy recovery device including an evaporator for evaporating working medium through heat exchange between heating medium and the working medium, an expander for expanding working medium flowing out of the evaporator, a power recovery machine connected to the expander, a condenser for condensing working medium flowing out of the expander, a pump for delivering working medium flowing out of the condenser to the evaporator, a circulation flow path connecting the evaporator, the expander, the condenser, and the pump in this order, a cooling flow path for supplying working medium of liquid phase flowing out of the pump partially to the power recovery machine, an on-off valve provided in the cooling flow path, and a control unit, in which the expander has a rotor to be rotationally driven by the expansion energy of the working medium, a bearing that bears the rotor such that the rotor is rotatable, and a primary casing housing the rotor and the bearing therein, and in which the power recovery machine has a power recovery unit connected to the rotor to rotate together with the rotor and thereby recover power and a secondary casing housing the power recovery unit therein and having a shape in communication with the interior of the primary casing, and in which upon reception of a stop signal for stopping power recovery by the power recovery machine, the control unit closes the on-off valve.

[0007] In the thermal energy recovery device, upon reception of a stop signal for stopping power recovery by the power recovery machine (when the power recovery unit is not required to be cooled), the control unit closes the on-off valve that is provided in the cooling flow path, whereby working medium of liquid phase is inhibited from being accumulated within the secondary casing and the primary casing. Accordingly, the bearing of the expander is inhibited from being immersed in the working medium of liquid phase and thereby poor lubrication of the bearing is inhibited when the thermal energy recovery device restarts.

[0008] In the case above, the secondary casing may have an introducing portion connectable to the cooling flow path and capable of introducing working medium of liquid phase supplied through the cooling flow path into the secondary casing.

[0009] In the aspect above, the power recovery unit is cooled effectively by the working medium of liquid phase supplied through the cooling flow path into the secondary casing.

[0010] Alternatively, the power recovery machine may further have a jacket provided in the secondary casing to form a cooling space that allows working medium of liquid phase to flow between the jacket and the secondary casing, in which the jacket has an introducing portion connectable to the cooling flow path and capable of introducing working medium of liquid phase supplied through the cooling flow path into the cooling space.

[0011] In the aspect above, the power recovery unit is cooled effectively via the secondary casing by the working medium of liquid phase supplied through the cooling flow path into the cooling space.

[0012] The present invention also provides a thermal energy recovery device including an evaporator for evaporating working medium through heat exchange between heating medium and the working medium, an expander for expanding working medium flowing out of the evaporator, a power recovery machine connected to the expander, a condenser for condensing working medium flowing out of the expander, a pump for delivering working medium flowing out of the condenser to the evaporator, a circulation flow path connecting the evaporator, the expander, the condenser, and the pump in this order, a cooling flow path for supplying cooling medium different from the working medium to the power recovery machine to cool the power recovery machine, an on-off valve provided in the cooling flow path, and a control unit, in which the expander has a rotor to be rotationally driven by the expansion energy of the working medium, a bearing that bears the rotor such that the rotor is rotatable, and a primary casing housing the rotor and the bearing therein, and in which the power recovery machine has a power recovery unit connected to the rotor to rotate together with the rotor and thereby recover power and a secondary casing housing the power recovery unit therein and having a shape in communication with the interior of the primary casing, and in which upon reception of a stop signal for stopping power recovery by the power recovery machine, the control unit closes the on-off valve.

[0013] Also in the thermal energy recovery device above, poor lubrication of the bearing of the expander is inhibited when the device is driven (starts to operate).

[0014] The thermal energy recovery device preferably further includes a liquid draining flow path for returning working medium of liquid phase within the primary casing or the secondary casing to the downstream side of the expander and the upstream side of the pump.

[0015] With the arrangement above, since the working medium of liquid phase within the primary casing or the secondary casing is discharged effectively from the primary casing or the secondary casing through the liquid draining flow path, the bearing is more reliably inhibited from being immersed in the working medium of liquid phase.

[0016] In the case above, the thermal energy recovery device preferably further includes a liquid draining valve provided in the liquid draining flow path, a bypass flow path for bypassing the expander, a bypass valve provided in the bypass flow path, and a shutoff valve provided at a site of the circulation flow path between a portion where the circulation flow path and an upstream end portion of the bypass flow path are connected and the expander, in which upon reception of a stop signal for stopping power recovery by the power recovery machine, the control unit reduces the rotational speed of the pump, closes the shutoff valve and opens the bypass valve, and closes the on-off valve and, after the pump is stopped, opens the liquid draining valve.

[0017] With the arrangement above, the working medium of liquid phase within the primary casing or the secondary casing is discharged effectively from the casing and, in addition thereto, the working medium is inhibited from flowing into the primary casing until the pump is stopped. Specifically, if the liquid draining valve were opened before the pump is stopped, the working medium discharged from the pump to flow through the bypass flow path to the downstream side of the expander might counterflow from the downstream side of the expander through the circulation flow path to flow into the primary casing of the expander to be liquefied within the primary casing. In contrast, in the thermal energy recovery device, since the control unit is arranged to open the liquid draining valve after the pump is stopped, such a trouble as described above is inhibited.

[0018] As described heretofore, in accordance with the present invention, it is possible to provide such a thermal energy recovery device in which poor lubrication of a bearing can be inhibited when an expander is driven.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a schematic view showing the configuration of a thermal energy recovery device according to a first embodiment of the present invention.

FIG. 2 is a flow chart showing control details by a control unit.

FIG. 3 is a schematic view showing the configuration of a thermal energy recovery device according to a second embodiment of the present invention.

FIG. 4 is a schematic view showing the configuration of a thermal energy recovery device according to a third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Modes for carrying out the present invention will hereinafter be described in detail with reference to the accompanying drawings.

(First Embodiment)

[0021] FIG. 1 shows the configuration of a thermal energy recovery device according to a first embodiment of the present invention. The thermal energy recovery device includes an evaporator 10, an expander 20, a power recovery machine 30, a condenser 40, a pump 50, a circulation flow path 60 connecting the evaporator 10, the expander 20, the condenser 40, and the pump 50 in this order, a cooling flow path 70, and a control unit 80.

[0022] The evaporator 10 evaporates working medium through heat exchange between the working medium and heating medium.

[0023] The expander 20 is provided at a site downstream the evaporator 10 in the circulation flow path 60. The expander 20 expands working medium of gas phase flowing out of the evaporator 10. In this embodiment, the expander 20 employs a volumetric screw expander having a rotor to be rotationally driven by the expansion energy of working medium of gas phase. Specifically, the expander 20 has a pair of male and female screw rotors (rotors) 21 to be rotationally driven by the expansion energy of working medium, bearings 22 that bear the screw rotors 21 such that the screw rotors 21 are rotatable, and a primary casing 23 housing the pair of screw rotors 21 and the bearings 22 collectively. The primary casing 23 has a suction port 23a for sucking therethrough working medium flowing out of the evaporator 10 and a discharge port 23b for discharging therethrough expanded working medium (after the pair of screw rotors 21 are rotationally driven) to the circulation flow path 60. In this embodiment, the primary casing 23 is installed in a posture in which the discharge port 23b is arranged horizontally. The bearings 22 are held on the primary casing 23.

[0024] The power recovery machine 30 is connected to the expander 20. Specifically, the power recovery machine 30 has a power recovery unit 31 and a secondary casing 35.

[0025] The power recovery machine 30 is connected to one of the pair of screw rotors 21 to rotate together with the screw rotor 21 and thereby recover power. In this embodiment, the power recovery machine 30 employs a generator. That is, the power recovery unit 31 has a rotating shaft 32 connected to one of the pair of screw rotors 21, a rotor 33 fixed on the rotating shaft 32, and a stator 34 arranged around the rotor 33. It is noted that the power recovery machine 30 may employ a compressor or the like.

[0026] The secondary casing 35 houses the power recovery unit 31 therein. The secondary casing 35 is fixed to the primary casing 23. The interior of the secondary casing 35 is in communication with the interior of the primary casing 23. This allows working medium expanded within the primary casing 23 to partially flow into the secondary casing 35.

[0027] The condenser 40 is provided at a site downstream the expander 20 in the circulation flow path 60. The condenser 40 condenses working medium flowing out of the expander 20 through heat exchange between the working medium and cooling medium (e.g. cooling water).

[0028] In this embodiment, a reservoir (receiver) 45 for reserving working medium of liquid phase is provided at a site downstream the condenser 40 in the circulation flow path 60. It is noted, however, that the reservoir 45 may be formed by a part of the circulation flow path 60 or may be omitted.

[0029] The pump 50 is provided at a site downstream the condenser 40 (between the condenser 40 and the evaporator 10) in the circulation flow path 60. The pump 50 delivers working medium of liquid phase flowing out of the condenser 40 to the evaporator 10 at a predetermined pressure.

[0030] The cooling flow path 70 supplies working medium of liquid phase flowing out of the pump 50 partially to the power recovery machine 30. In this embodiment, the cooling flow path 70 connects a site of the circulation flow path 60 between the pump 50 and the evaporator 10 and the secondary casing 35. Specifically, the secondary casing 35 has an introducing portion 35a capable of introducing working medium of liquid phase into the secondary casing 35, and a downstream end portion of the cooling flow path 70 is connected to the introducing portion 35a. Accordingly, working medium of liquid phase discharged from the pump 50 is partially supplied into the secondary casing 35 through the cooling flow path 70. This allows the power recovery unit 31 to be cooled effectively.

[0031] The thermal energy recovery device of this embodiment further includes a liquid draining flow path 71. The liquid draining flow path 71 returns the working medium R of liquid phase within the primary casing 23 or the secondary casing 35 to the downstream side of the expander 20 and the upstream side of the pump 50, that is, to a region in which working medium exists in liquid phase. Specifically, the liquid draining flow path 71 connects a lead-out portion 23c formed in the primary casing 23 and a site of the circulation flow path 60 between the reservoir 45 and the pump 50. The lead-out portion 23c is provided in a bottom portion 25 positioned lowermost in the primary casing 23. It is noted that a downstream end portion of the liquid draining flow path 71 may be connected to a site of the circulation flow path 60 between the expander 20 and the condenser 40, the interior of the condenser 40, or the reservoir 45.

[0032] The thermal energy recovery device of this embodiment further includes a bypass flow path 62 for bypassing the expander 20, an on-off valve V1 provided in the cooling flow path 70, a shutoff valve V2 provided in the circulation flow path 60, a bypass valve V3 provided in the bypass flow path 62, and a liquid draining valve V4 provided in the liquid draining flow path 71. The valves V1 to V4 are arranged openable and closable.

[0033] An upstream end portion of the bypass flow path 62 is connected to a site of the circulation flow path 60 between the evaporator 10 and the expander 20. A downstream end portion of the bypass flow path 62 is connected to a site of the circulation flow path 60 between the expander 20 and the condenser 40.

[0034] The shutoff valve V2 is provided at a site of the circulation flow path 60 between a portion where the circulation flow path 60 and the upstream end portion of the bypass flow path 62 are connected and the expander 20.

[0035] During recovery of power (electric power in this embodiment) by the power recovery machine 30 (when the expander 20, the power recovery machine 30, and the pump 50 are driven), upon reception of a stop signal for stopping the power recovery by the power recovery machine 30, the control unit 80 stops cooling the power recovery unit 31, that is, supplying working medium of liquid phase discharged from the pump 50 partially to the power recovery machine 30 through the cooling flow path 70. Control details by the control unit 80 will hereinafter be described with reference to FIG. 2. It is noted that when the device is being driven, the on-off valve V1 and the shutoff valve V2 are opened, while the bypass valve V3 and the liquid draining valve V4 are closed.

[0036] Upon reception of the stop signal, the control unit 80 reduces the rotational speed of the pump 50, the expander 20, and the power recovery machine 30, closes the shutoff valve V2, and opens the bypass valve V3 (step S11). This causes working medium of gas phase flowing out of the evaporator 10 to run through the bypass flow path 62 (bypass the expander 20) to the condenser 40.

[0037] With the reduction in the rotational speed of the expander 20 and the power recovery machine 30, the power recovery unit 31 is not required to be cooled, and the control unit 80 therefore closes the on-off valve V1 (step S12). As a result, the supply of working medium of liquid phase through the cooling flow path 70 into the secondary casing 35 is stopped. Accordingly, the power recovery unit 31 is inhibited from being cooled excessively. In other words, accumulation of working medium R of liquid phase within the secondary casing 35 and the primary casing 23 is inhibited.

[0038] After the pump 50 is stopped, the control unit 80 then opens the liquid draining valve V4 (step S13). This causes the working medium R of liquid phase within the primary casing 23 or the secondary casing 35 is discharged effectively from the casing 23 or 35.

[0039] As described heretofore, in the thermal energy recovery device, upon reception of the stop signal (when the power recovery unit 31 is not required to be cooled), the control unit 80 stops supplying working medium of liquid phase discharged from the pump 50 partially to the power recovery machine 30 through the cooling flow path 70. Specifically, upon reception of the stop signal, the control unit 80 closes the on-off valve V1 that is provided in the cooling flow path 70. This inhibits accumulation of working medium of liquid phase within the secondary casing 35 and the primary casing 23. Accordingly, the bearings 22 of the expander 20 is inhibited from being immersed in the working medium R of liquid phase and thereby poor lubrication of the bearings 22 is inhibited when the thermal energy recovery device restarts.

[0040] In addition, since the control unit 80 opens the liquid draining valve V4 after the pump 50 is stopped in step S13, the working medium R of liquid phase within the primary casing 23 or the secondary casing 35 is discharged effectively from the casing 23 or 35 and, in addition thereto, the working medium is inhibited from flowing into the primary casing 23 until the pump 50 is stopped. Specifically, if the liquid draining valve V4 were opened before the pump 50 is stopped, the working medium discharged from the pump 50 to flow through the bypass flow path 62 to the downstream side of the expander 20 might counterflow from the downstream side of the expander 20 through the circulation flow path 60 to flow into the primary casing 23 of the expander 20 to be liquefied within the primary casing 23. In contrast, in this embodiment, since the control unit 80 is arranged to open the liquid draining valve V4 after the pump 50 is stopped, such a trouble as described above is inhibited.

(Second Embodiment)

[0041] Next will be described a thermal energy recovery device according to a second embodiment of the present invention with reference to FIG. 3. It is noted that in the second embodiment, only components different from the first embodiment will be described, and the same structures, operations, and effects as in the first embodiment will not be described.

[0042] In this embodiment, the power recovery machine 30 has a jacket 36, and the downstream end portion of the cooling flow path 70 is connected to the jacket 36.

[0043] The jacket 36 provided in the secondary casing 35 to form a cooling space S that allows working medium of liquid phase to flow between the jacket 36 and the secondary casing 35. The jacket 36 is arranged on the outside of the outer peripheral surface of the secondary casing 35. That is, the cooling space S is formed between the outer peripheral surface of the secondary casing 35 and the inner peripheral surface of the jacket 36. The jacket 36 has an introducing portion 36a connectable to the downstream end portion of the cooling flow path 70 and capable of introducing working medium of liquid phase supplied through the cooling flow path 70 into the cooling space S.

[0044] The cooling medium that has passed through the cooling space S to cool the power recovery unit 31 via the secondary casing 35 also flows into the circulation flow path 60 through a discharge flow path 72. An upstream end portion of the discharge flow path 72 is connected to a discharge portion 36b formed in the jacket 36, and a downstream end portion of the discharge flow path 72 is connected to a site of the circulation flow path 60 between the expander 20 and the condenser 40.

[0045] As described heretofore, also in this embodiment, the bearings 22 of the expander 20 is inhibited from being immersed in the working medium R of liquid phase and thereby poor lubrication of the bearings 22 is inhibited when the thermal energy recovery device restarts.

(Third Embodiment)

[0046] Next will be described a thermal energy recovery device according to a third embodiment of the present invention with reference to FIG. 4. It is noted that in the third embodiment, only components different from the first embodiment will be described, and the same structures, operations, and effects as in the first embodiment will not be described.

[0047] While this embodiment shares similarity with the second embodiment in that the power recovery machine 30 has a jacket 36, cooling medium (e.g. cooling water) different from the working medium is supplied to the cooling space S.

[0048] A cooling flow path 73 branched from a cooling medium supply line L1 for supplying cooling medium therethrough is connected to the jacket 36. Accordingly, in this embodiment, cooling medium passing through the cooling space S cools the power recovery unit 31 via the secondary casing 35. Cooling medium that has passed through the cooling space S is returned through a cooling medium recovery flow path 74 connected to the jacket 36 to a cooling medium discharge line L2 for discharging cooling medium therethrough.

[0049] As described heretofore, this embodiment also exhibits the same effect as the above-described embodiments.

[0050] It is noted that the above-disclosed embodiment should be construed as illustrative only and not restrictive in all aspects. The scope of the present invention is defined not by the above-described embodiment but by the appended claims and further includes all modifications within the meaning and scope equivalent to the appended claims.

[0051] For example, the secondary casing 35 and the jacket 36, which form the cooling space S, may be separate members or may be an integrally casted member.

[0052] Provided is a thermal energy recovery device in which poor lubrication of a bearing can be inhibited when an expander is driven. The thermal energy recovery device includes an evaporator (10), an expander (20), a power recovery machine (30), a condenser (40), a pump (50), a circulation flow path (60), a cooling flow path (70) for supplying working fluid from the pump (50) partially to the power recovery machine (30), an on-off valve (V1) provided in the cooling flow path (70), and a control unit (80), in which the expander (20) has a rotor (21), a bearing (22), and a primary casing (23), and in which the power recovery machine (30) has a power recovery unit (31) and a secondary casing (35), and in which upon reception of a stop signal for stopping power recovery by the power recovery machine (30), the control unit (80) closes the on-off valve (V1).

Claims

1. A thermal energy recovery device comprising:

an evaporator for evaporating working medium through heat exchange between heating medium and the working medium;
an expander for expanding working medium flowing out of the evaporator;
a power recovery machine connected to the expander;
a condenser for condensing working medium flowing out of the expander;
a pump for delivering working medium flowing out of the condenser to the evaporator;
a circulation flow path connecting the evaporator, the expander, the condenser, and the pump in this order;
a cooling flow path for supplying working medium of liquid phase flowing out of the pump partially to the power recovery machine;
an on-off valve provided in the cooling flow path; and
a control unit,
wherein the expander has:

a rotor to be rotationally driven by the expansion energy of the working medium;
a bearing that bears the rotor such that the rotor is rotatable; and
a primary casing housing the rotor and the bearing therein,

and wherein the power recovery machine has:

a power recovery unit connected to the rotor to rotate together with the rotor and thereby recover power; and
a secondary casing housing the power recovery unit therein and having a shape in communication with the interior of the primary casing,
and wherein upon reception of a stop signal for stopping power recovery by the power recovery machine, the control unit closes the on-off valve.

2. The thermal energy recovery device according to claim 1,
wherein the secondary casing has an introducing portion connectable to the cooling flow path and capable of introducing working medium of liquid phase supplied through the cooling flow path into the secondary casing.

3. The thermal energy recovery device according to claim 1,
wherein the power recovery machine further has a jacket provided in the secondary casing to form a cooling space that allows working medium of liquid phase to flow between the jacket and the secondary casing,
and wherein the jacket has an introducing portion connectable to the cooling flow path and capable of introducing working medium of liquid phase supplied through the cooling flow path into the cooling space.

4. A thermal energy recovery device comprising:

an evaporator for evaporating working medium through heat exchange between heating medium and the working medium;
an expander for expanding working medium flowing out of the evaporator;
a power recovery machine connected to the expander;
a condenser for condensing working medium flowing out of the expander;
a pump for delivering working medium flowing out of the condenser to the evaporator;
a circulation flow path connecting the evaporator, the expander, the condenser, and the pump in this order;
a cooling flow path for supplying cooling medium different from the working medium to the power recovery machine to cool the power recovery machine;
an on-off valve provided in the cooling flow path; and
a control unit,
wherein the expander has:

a rotor to be rotationally driven by the expansion energy of the working medium;
a bearing that bears the rotor such that the rotor is rotatable; and
a primary casing housing the rotor and the bearing therein,

and wherein the power recovery machine has:

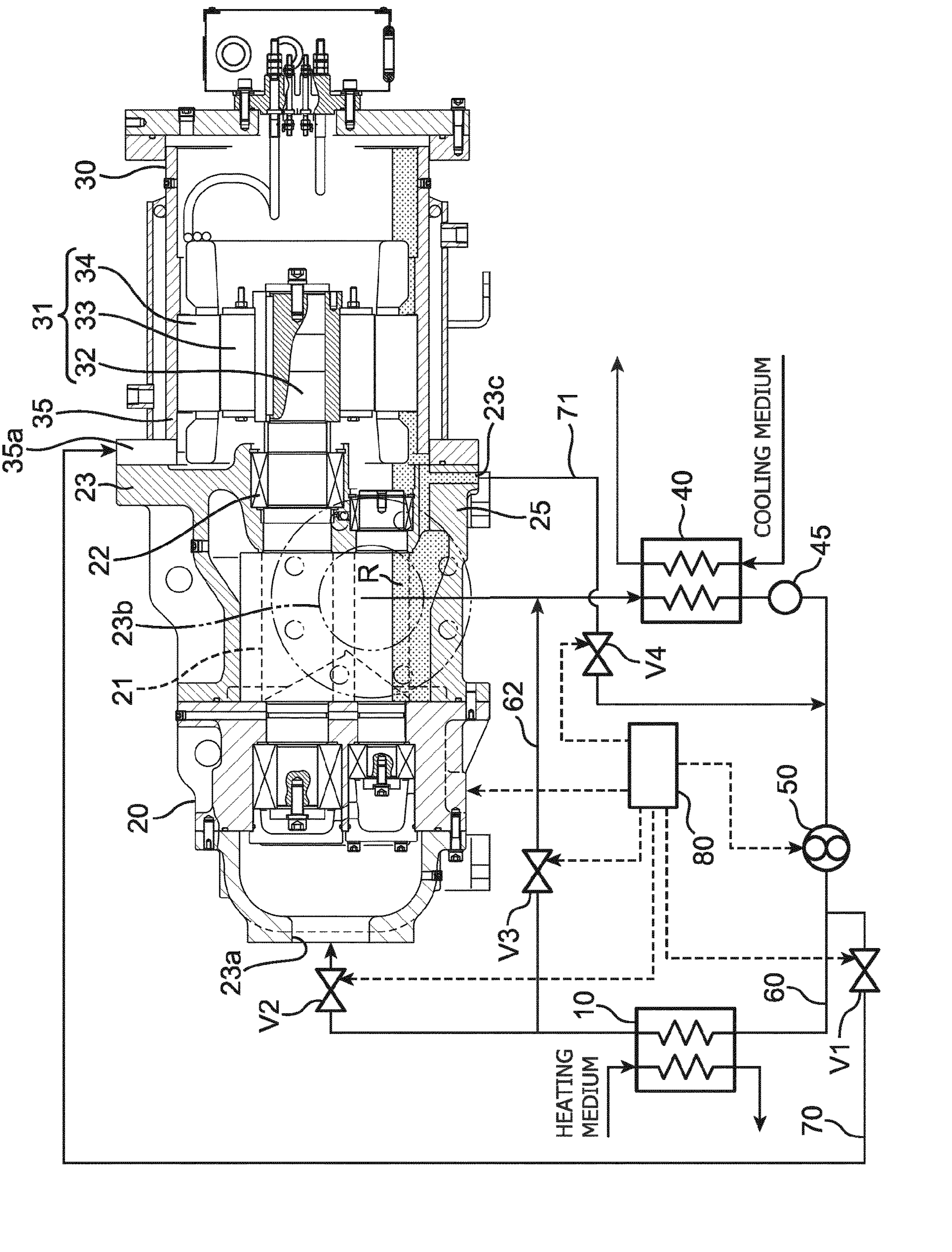
a power recovery unit connected to the rotor to rotate together with the rotor and thereby recover power; and
a secondary casing housing the power recovery unit therein and having a shape in communication with the interior of the primary casing,
and wherein upon reception of a stop signal for stopping power recovery by the power recovery machine, the control unit closes the on-off valve.

5. The thermal energy recovery device according to any one of claims 1 to 4, further comprising
a liquid draining flow path for returning working medium of liquid phase within the primary casing or the secondary casing to the downstream side of the expander and the upstream side of the pump.

6. The thermal energy recovery device according to claim 5, further comprising:

a liquid draining valve provided in the liquid draining flow path;
a bypass flow path for bypassing the expander;
a bypass valve provided in the bypass flow path; and
a shutoff valve provided at a site of the circulation flow path between a portion where the circulation flow path and an upstream end portion of the bypass flow path are connected and the expander,
wherein upon reception of a stop signal for stopping power recovery by the power recovery machine, the control unit reduces the rotational speed of the pump, closes the shutoff valve and opens the bypass valve, and closes the on-off valve and, after the pump is stopped, opens the liquid draining valve.

F I G. 1


30
31
32
33
34
35
35a
23
22
23b
21
20
23a
V2
V3
62
10
HEATING MEDIUM
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V1
70
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V4
45
40
COOLING MEDIUM
71
23c
25
R

FIG. 2

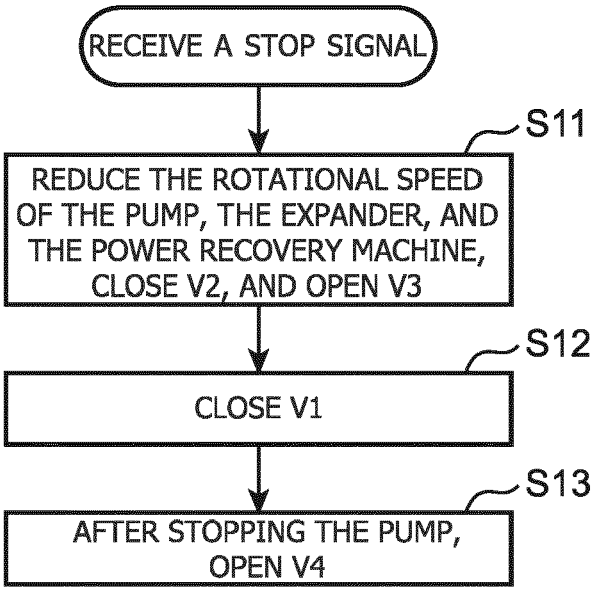
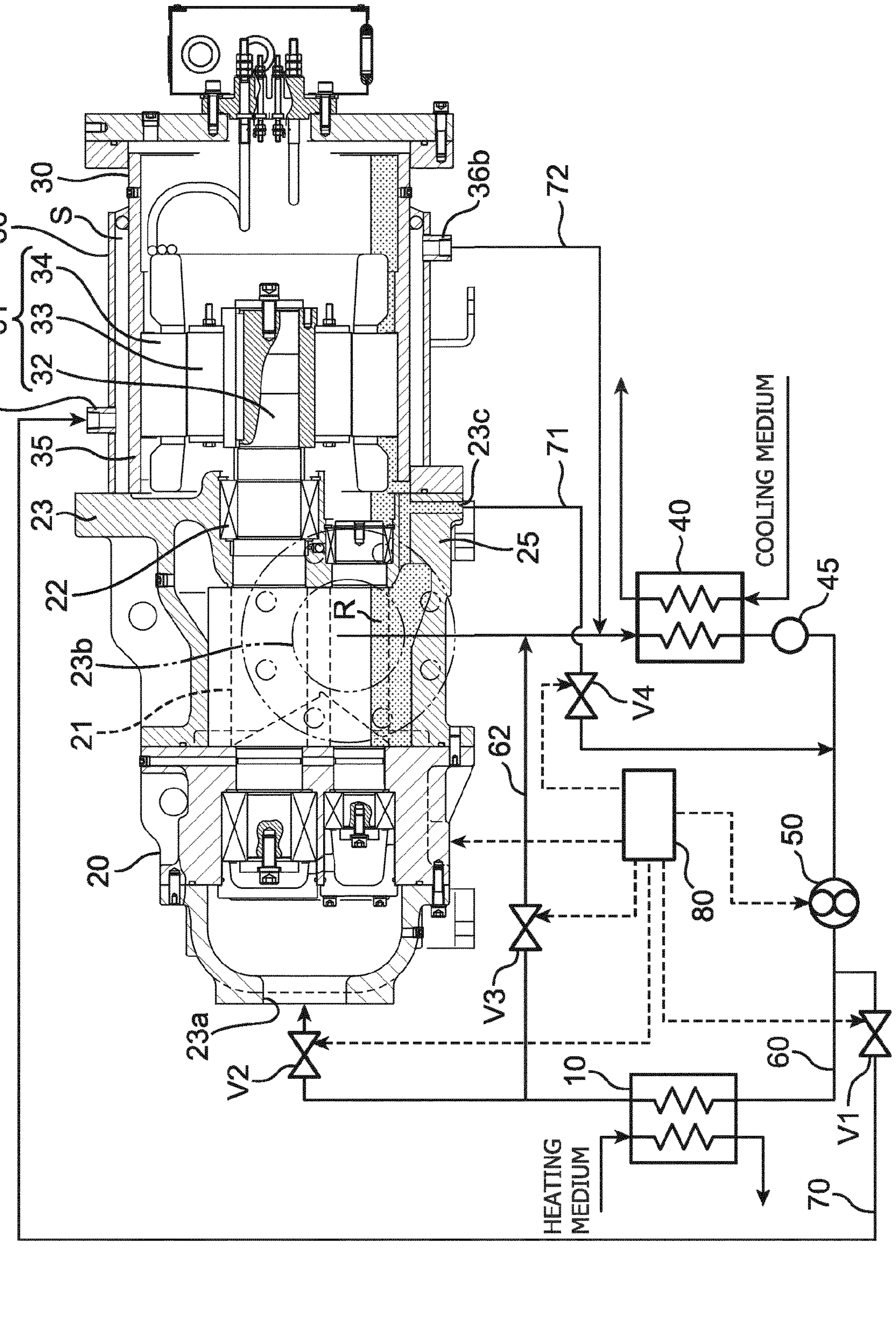

RECEIVE A STOP SIGNAL
S11
REDUCE THE ROTATIONAL SPEED OF THE PUMP, THE EXPANDER, AND THE POWER RECOVERY MACHINE, CLOSE V2, AND OPEN V3
S12
CLOSE V1
S13
AFTER STOPPING THE PUMP, OPEN V4

FIG. 3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V2
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V1
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80
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V4
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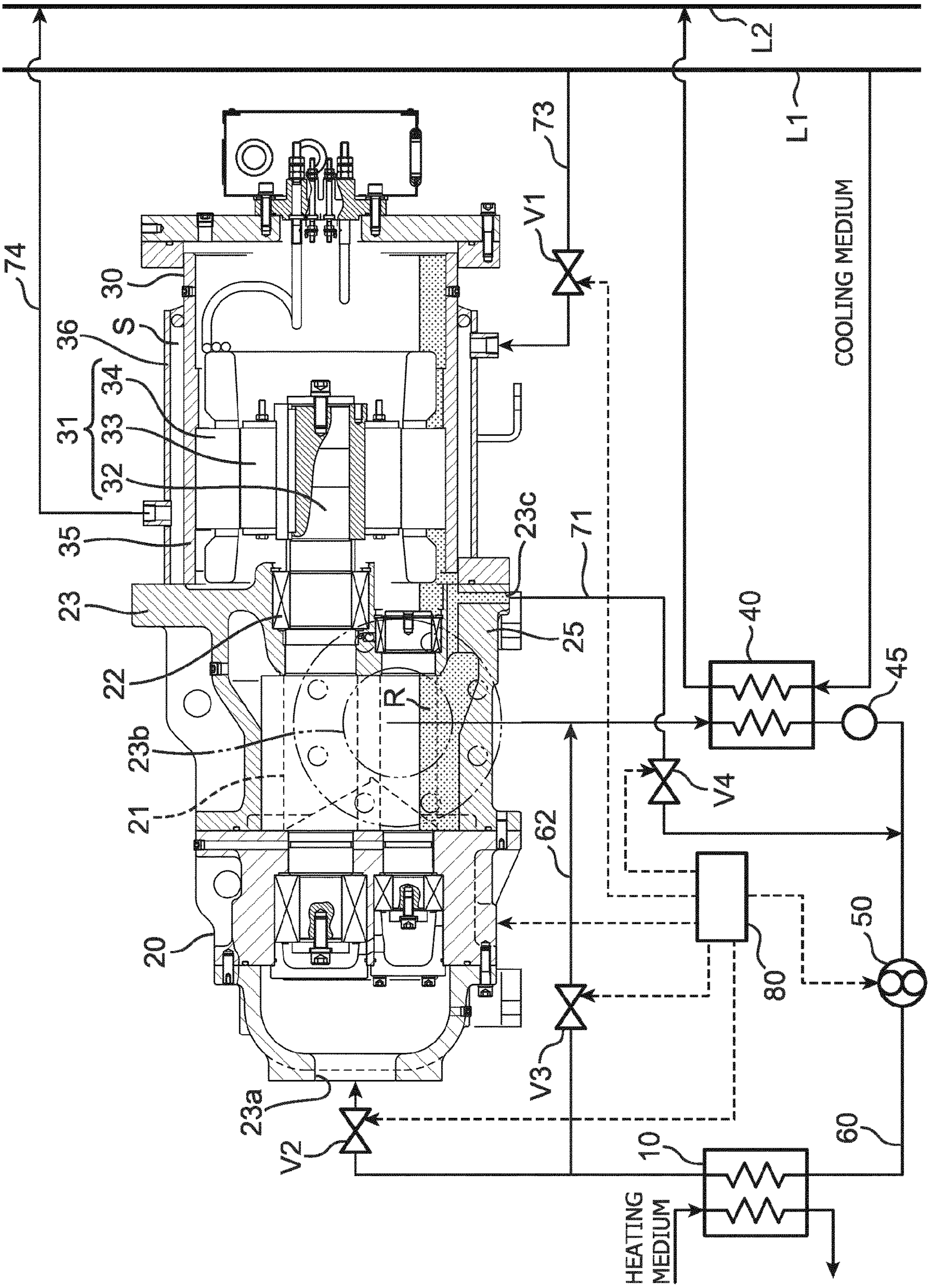
25
23c
71
45
40
COOLING MEDIUM
36b
72

FIG. 4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L1
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74
V1
30
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32
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V2
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60
HEATING MEDIUM

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 20 8350

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y A	US 2013/207396 A1 (TSUBOI NOBORU [JP]) 15 August 2013 (2013-08-15) * paragraphs [0076] - [0084]; figure 5 *	1-5 6	INV. F01K13/02 F01C21/00
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Place of search	Date of completion of the search	Examiner
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