We Claim:

[1] A solid oxide fuel cell system comprising:

a reformer configured to generate a hydrogen-containing gas by using a raw material and water;

a solid oxide fuel cell including an anode and a cathode, and configured to generate electric power by using the hydrogen-containing gas supplied from the reformer to the anode and air supplied to the cathode;

a heat radiator configured to radiate heat from at least one of an anode off-gas discharged from the anode and a combustion exhaust gas generated by combusting the anode off-gas to generate condensed water;

a condensed water circulating passage configured to circulate the condensed water supplied from the heat radiator;

a condensed water tank provided on the condensed water circulating passage and configured to store the condensed water therein;

a condensed water pump provided on the condensed water circulating passage and configured to circulate the condensed water; and

a condensed water/off-gas heat exchanger provided on the condensed water circulating passage and configured to exchange heat between the condensed water and an off-gas discharged from the solid oxide fuel cell to heat the condensed water by the off-gas;

wherein at least a part of the water supplied to the reformer is the condensed water.

[2] The solid oxide fuel cell system according to claim 1, wherein in the solid oxide fuel cell, a temperature of the anode and a temperature of the cathode during power generation are equal to or higher than 600 degrees C and equal to or lower than 1000 degrees C.

[3] A solid oxide fuel cell system comprising:

a reformer configured to generate a hydrogen-containing gas by using humidified air and a raw material;

a solid oxide fuel cell including an anode and a cathode, and configured to generate electric power by using the hydrogen-containing gas supplied from the reformer to the anode and air supplied to the cathode;

an anode off-gas heat radiator configured to radiate heat from an anode off-gas discharged from the anode to generate condensed water;

a condensed water circulating passage configured to circulate the condensed water supplied from the anode off-gas heat radiator;

a condensed water tank provided on the condensed water circulating passage and configured to store the condensed water therein;

a condensed water pump provided on the condensed water circulating passage and configured to circulate the condensed water;

a condensed water/off-gas heat exchanger provided on the condensed water circulating passage and configured to exchange heat between the condensed water and an off-gas discharged from the solid oxide fuel cell to heat the condensed water by the off-gas; and

a humidifier provided on the condensed water circulating passage and configured to humidify the air by using the condensed water to generate the humidified air to be supplied to the reformer.

[4] The solid oxide fuel cell system according to claim 3, wherein in the solid oxide fuel cell, a temperature of the anode and a temperature of the cathode during power generation are equal to or higher than 600 degrees C and equal to or lower than 1000 degrees C.

[5] The solid oxide fuel cell system according to claim 3 or 4, wherein a minimum discharge amount of the condensed water pump is equal to or more than 50g/minute.

[6] The solid oxide fuel cell system according to any one of claims 3 to 5, wherein the off-gas used for heat exchange in the condensed water/off-gas heat exchanger is a cathode off-gas discharged from the cathode.

[7] The solid oxide fuel cell system according to any one of claims 3 to 5, wherein the

off-gas used for heat exchange in the condensed water/off-gas heat exchanger is the anode off-gas discharged from the anode.

[8] The solid oxide fuel cell system according to any one of claims 3 to 7, further comprising:

a condensed water heat radiator provided on the condensed water circulating passage in a location which is downstream of the humidifier and upstream of the condensed water tank and configured to radiate heat from the condensed water.

[9] The solid oxide fuel cell system according to any one of claims 3 to 8, further comprising:

a bypass air passage configured to bypass the humidifier such that unhumidified air is supplied to the reformer; and

a first switch configured to perform switching between a state in which the air is supplied to the reformer through the humidifier and a state in which the air is supplied to the reformer through the bypass air passage.

[10] The solid oxide fuel cell system according to any one of claims 3 to 9, further comprising:

a control unit configured to deactivate the condensed water pump during start-up.

[11] The solid oxide fuel cell system according to any one of claims 3 to 10, comprising:

a combustor configured to combust the anode off-gas and a cathode off-gas to generate a combustion gas,

wherein the off-gas used for heat exchange in the condensed water/off-gas heat exchanger is the combustion gas discharged from the combustor.

[12] The solid oxide fuel cell system according to any one of claims 3 to 11,

wherein the anode off-gas heat radiator is configured to exchange heat between a liquid cooling medium and the anode off-gas to radiate heat from the anode off-gas,

the solid oxide fuel cell system further comprising:

a water storage amount detector configured to detect an amount of water stored in the condensed water tank;

a cooling medium circulating passage configured to circulate the cooling medium;

a cooling medium pump provided on the cooling medium circulating passage and configured to circulate the cooling medium;

a cooling medium heat radiator provided on the cooling medium circulating passage and configured to exchange heat between the cooling medium and atmospheric air to radiate heat from the cooling medium; and

a control unit configured to control a discharge amount of the cooling medium pump based on a result of detection of the water storage amount detector.

[13] The solid oxide fuel cell system according to any one of claims 3 to 12,

wherein the condensed water circulating passage includes:

a heat exchanger bypass passage configured to circulate the condensed water such that the condensed water does not flow through the condensed water/off-gas heat exchanger; and

a second switch configured to perform switching between circulation of the condensed water through the condensed water/off-gas heat exchanger and circulation of the condensed water through the heat exchanger bypass passage.

[14] The solid oxide fuel cell system according to any one of claims 3 to 12,

wherein the condensed water circulating passage includes:

a humidifier bypass passage configured to circulate the condensed water such that the condensed water does not flow through the humidifier; and

a third switch configured to perform switching between circulation of the condensed water through the humidifier and circulation of the condensed water through the humidifier bypass passage.

[15] The solid oxide fuel cell system according to any one of claims 1 to 13, further comprising:

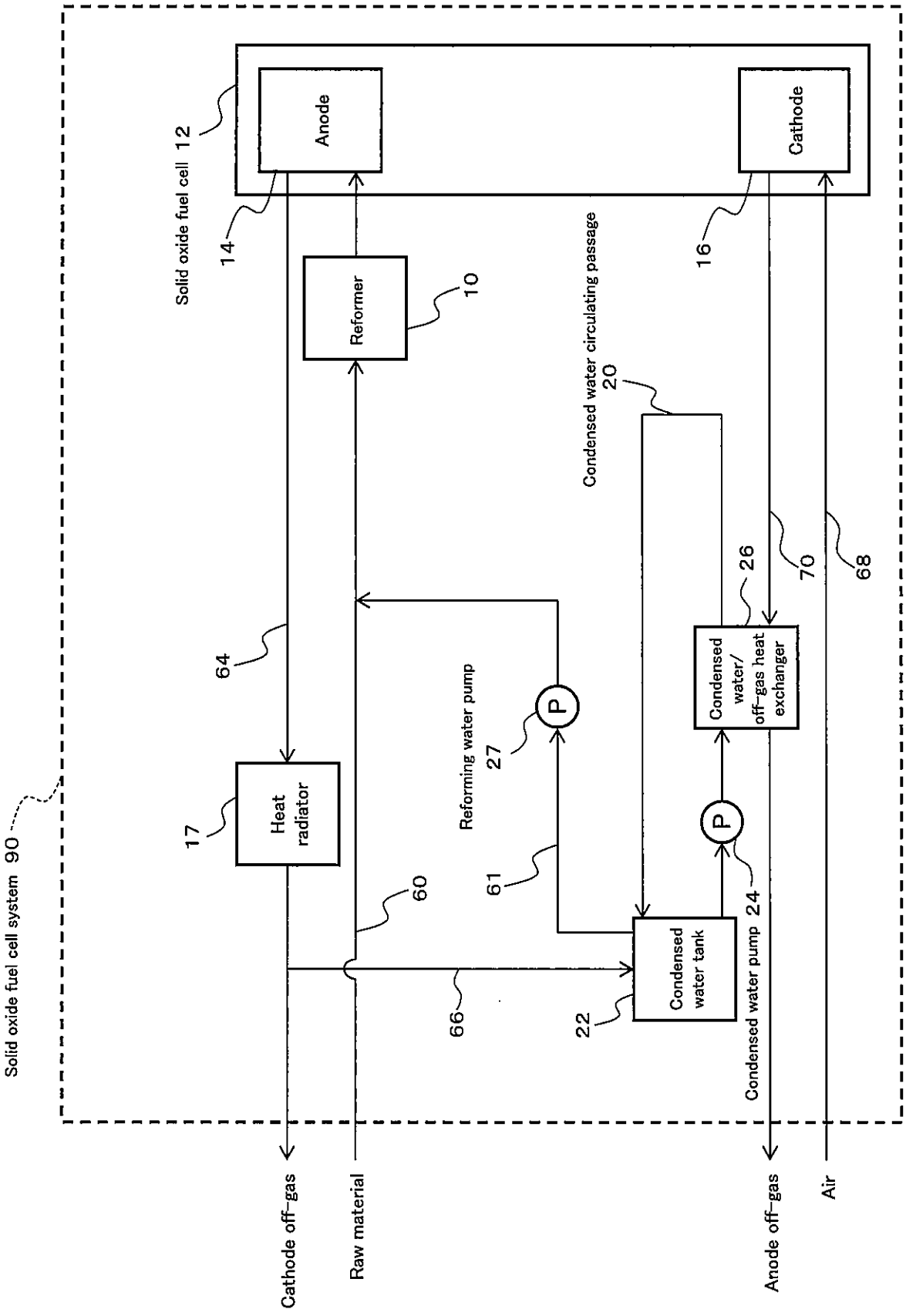
an ion concentration detector configured to detect an ion concentration of the condensed water stored in the condensed water tank;

a notification unit; and

a control unit configured to cause the notification unit to output an alarm based on a result of detection of the ion concentration detector.

Dated this 17th day of October, 2014

ANAND CHOUBEY
OF K & S PARTNERS
AGENT FOR THE APPLICANT(S)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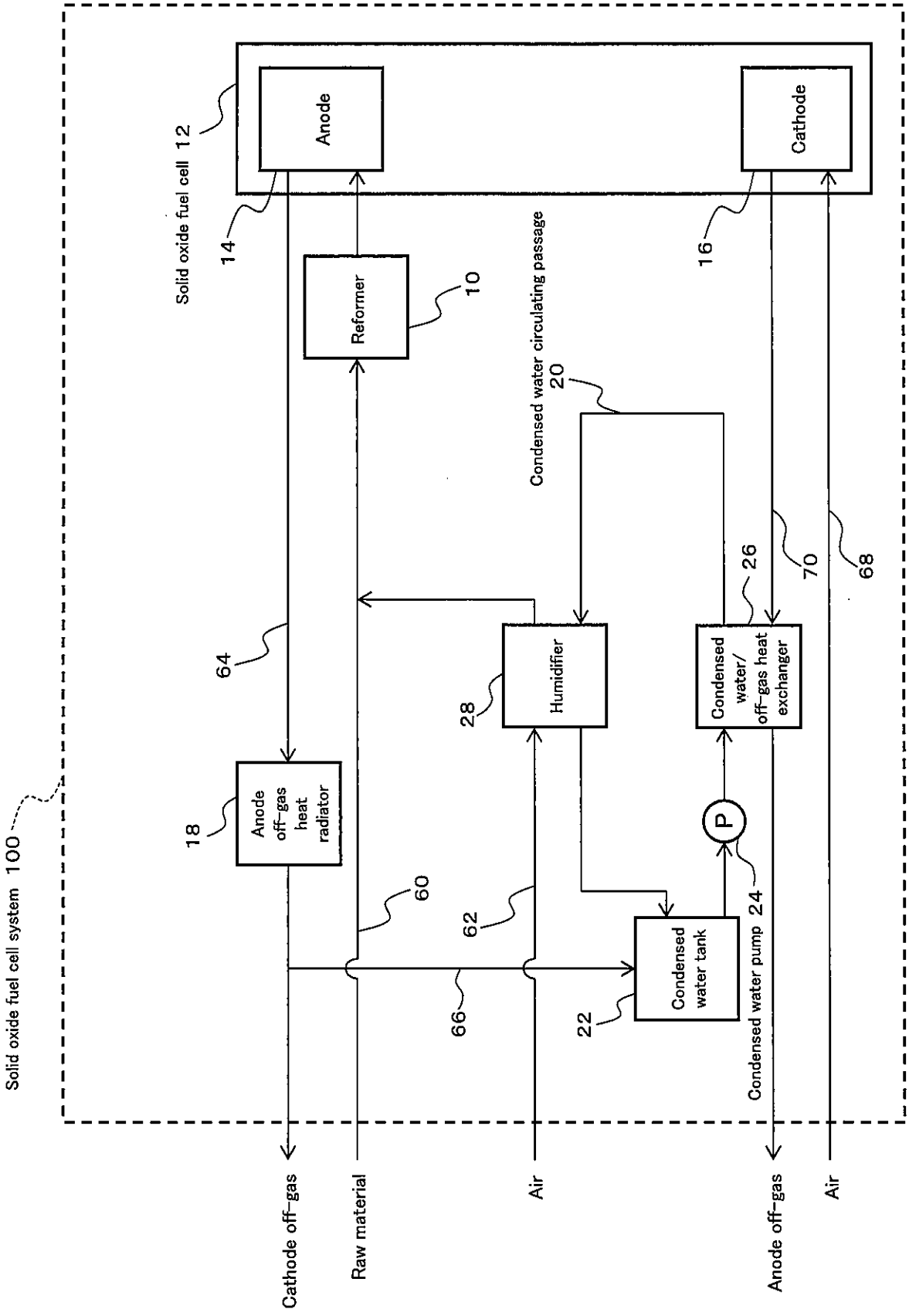
Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
64
68
70
26
Heat radiator
17
Reforming water pump
27
Condensed water/ off-gas heat exchanger
60
61
66
22
Condensed water tank
Condensed water pump 24
Cathode off-gas
Raw material
Anode off-gas
Air

Fig. 1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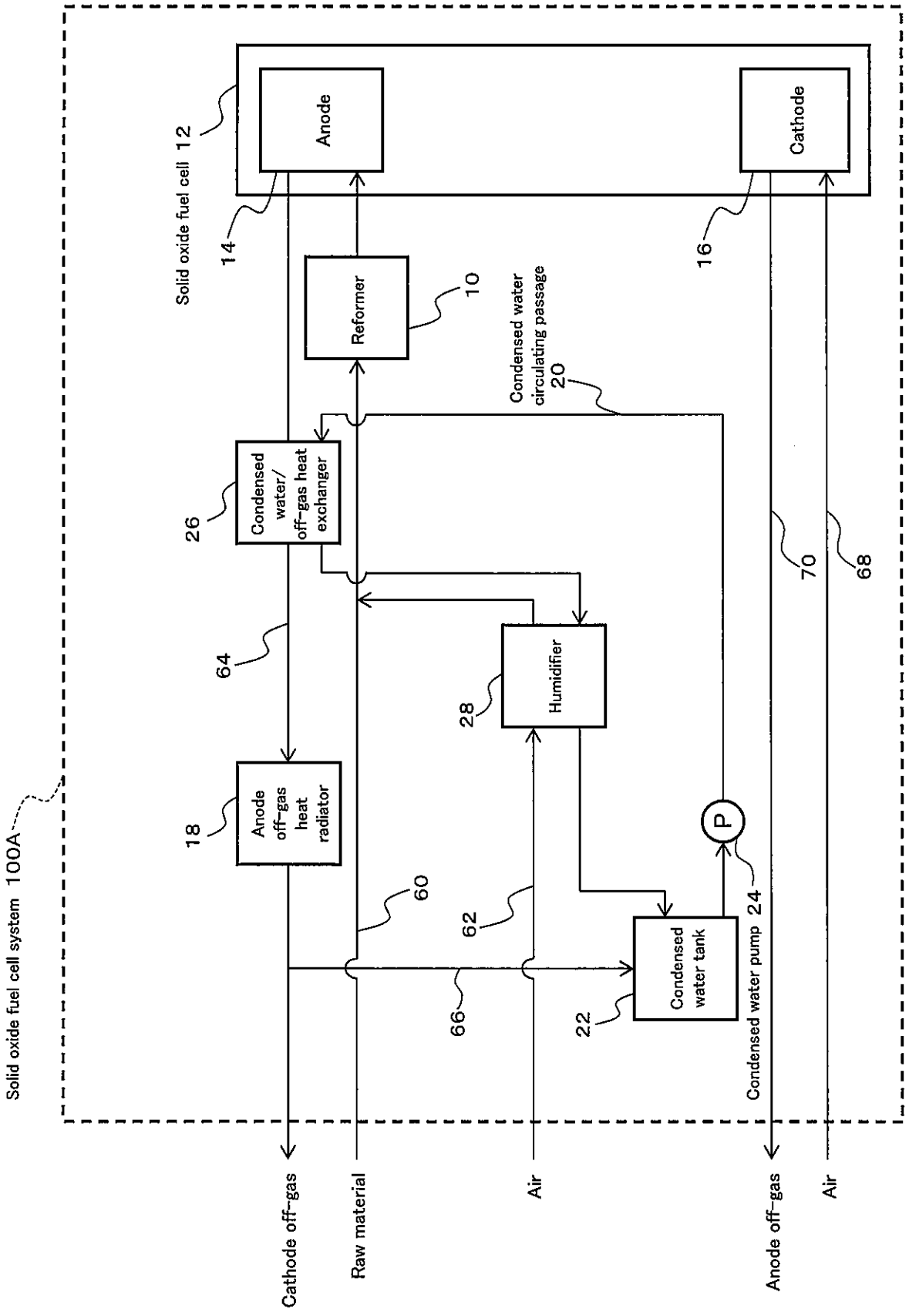
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
64
Humidifier
28
Condensed water/ off-gas heat exchanger
26
70
68
Anode off-gas heat radiator
18
60
62
66
Condensed water tank
22
Condensed water pump
24
P
Cathode off-gas
Raw material
Air
Anode off-gas
Air

Fig. 2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Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
Condensed water/ off-gas heat exchanger
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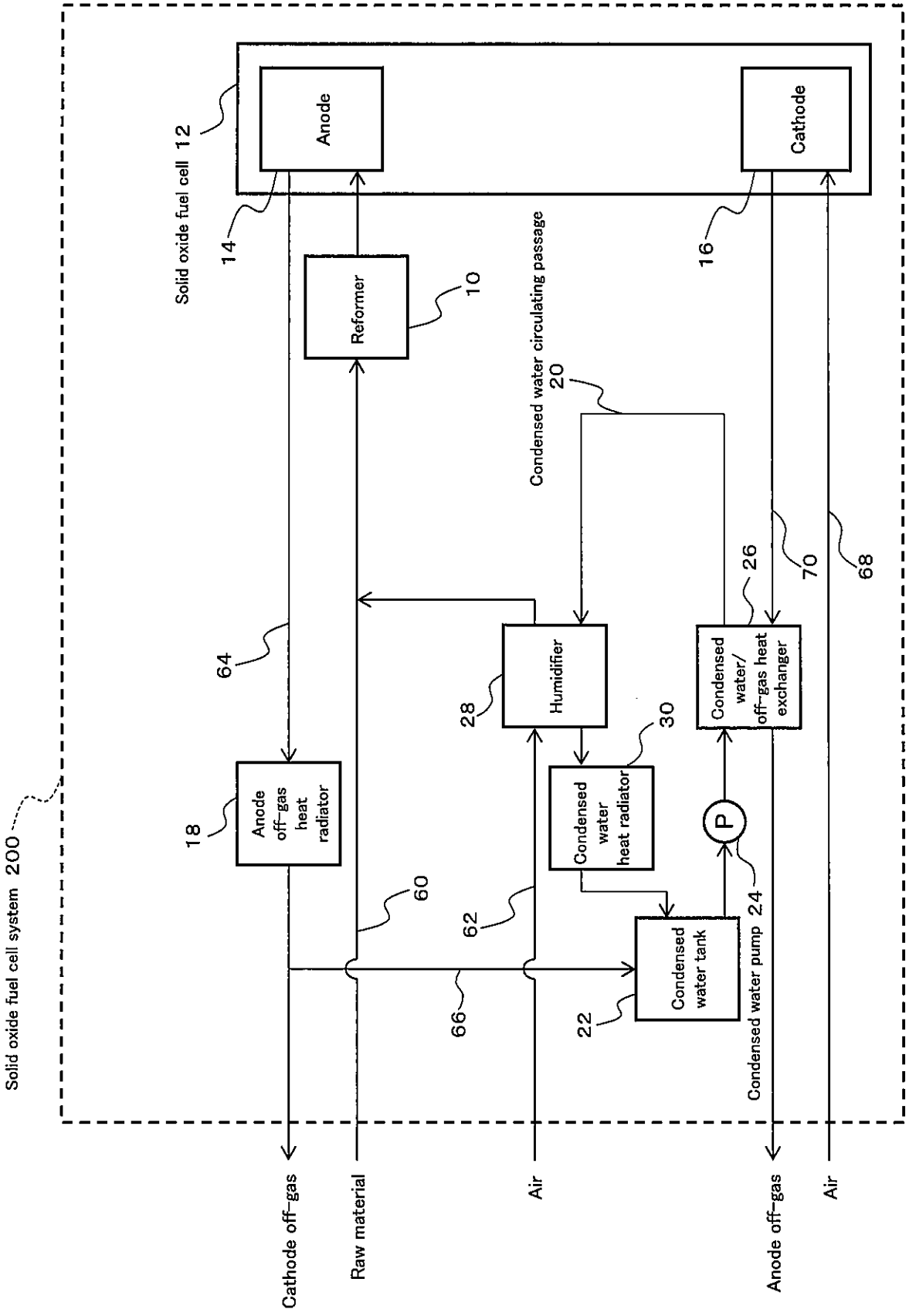
Humidifier
28
64
Anode off-gas heat radiator
18
60
62
66
Condensed water tank
22
P
Condensed water pump 24
70
68
Cathode off-gas
Raw material
Air
Anode off-gas
Air

Fig. 3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Solid oxide fuel cell 12
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Cathode
14
16
Reformer
10
Condensed water circulating passage
20
64
Humidifier
28
Condensed water/ off-gas heat exchanger
26
70
68
Anode off-gas heat radiator
18
Condensed water heat radiator
30
60
62
Condensed water tank
22
66
Condensed water pump
24
Cathode off-gas
Raw material
Air
Anode off-gas
Air

Fig. 4

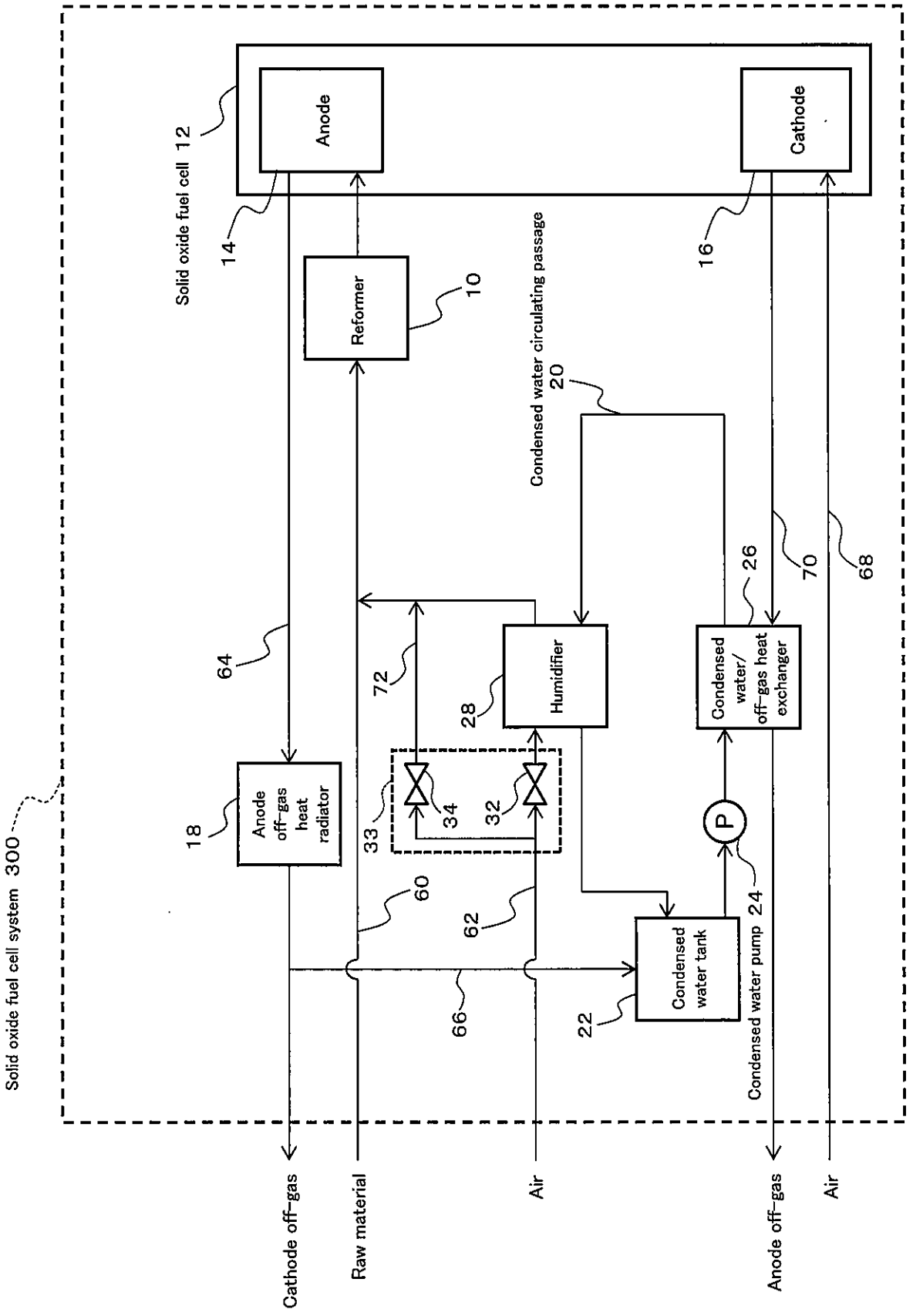

Solid oxide fuel cell system 300
Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
64
72
28
Humidifier
Condensed water/ off-gas heat exchanger
26
70
68
18
Anode off-gas heat radiator
33
34
32
P
60
62
24
Condensed water pump
66
22
Condensed water tank
Cathode off-gas
Raw material
Air
Anode off-gas
Air

Fig. 5

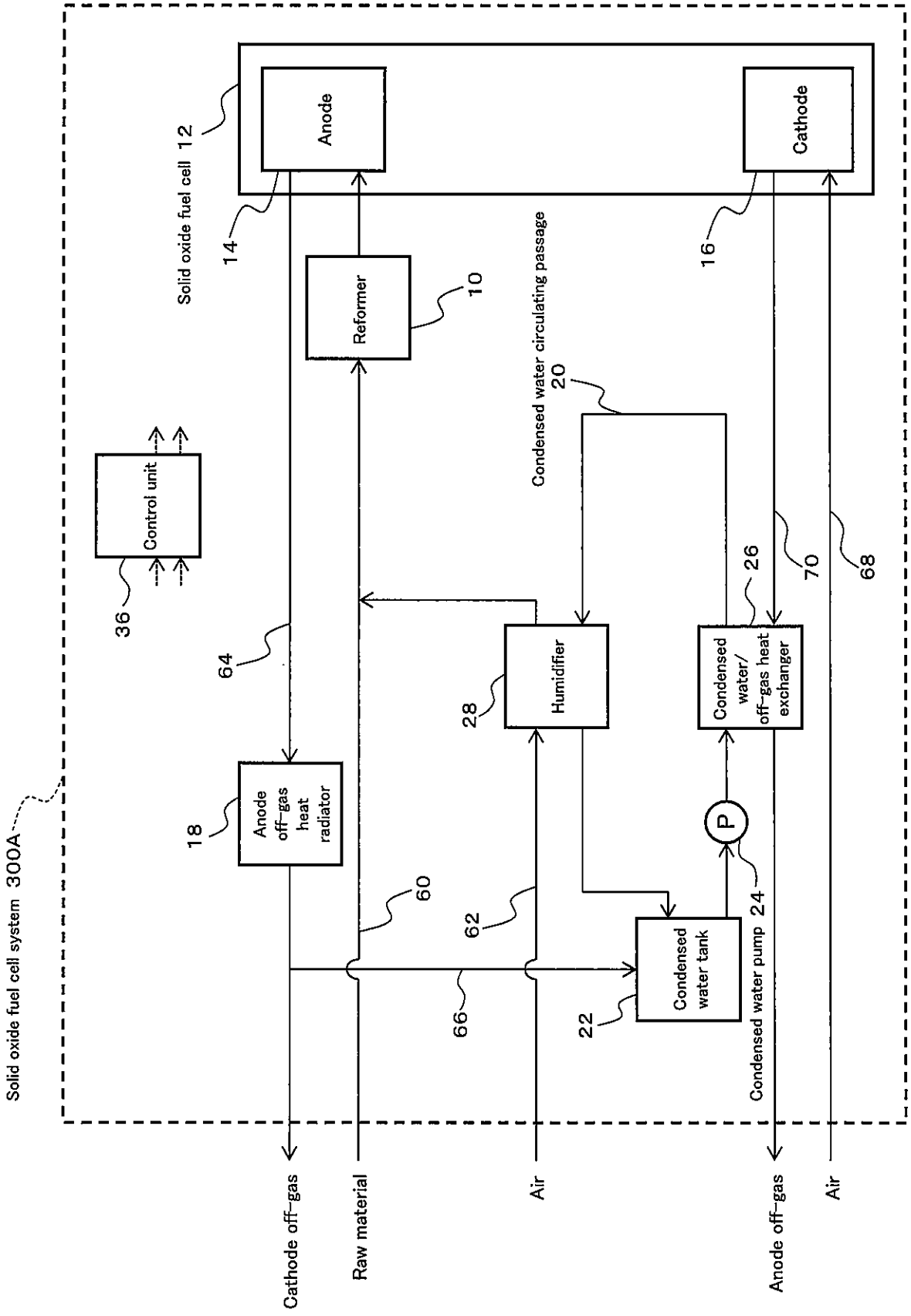
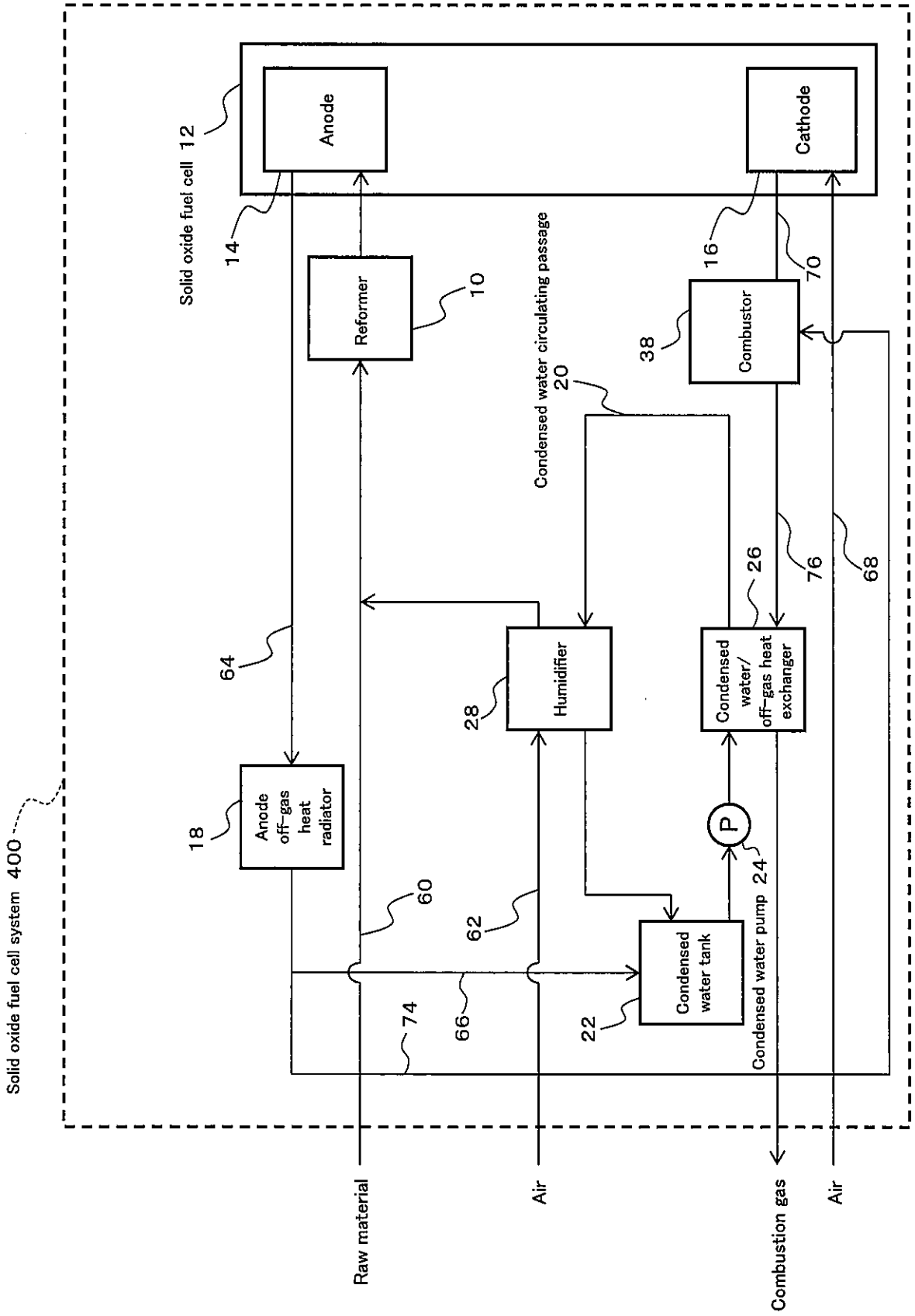

Solid oxide fuel cell system 300A
Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
Control unit
36
64
Humidifier
28
Condensed water/ off-gas heat exchanger
26
70
68
Anode off-gas heat radiator
18
60
62
66
22
Condensed water tank
P
24
Condensed water pump
Cathode off-gas
Raw material
Air
Anode off-gas
Air

Fig. 6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Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
Combustor
38
70
64
Humidifier
28
Condensed water/ off-gas heat exchanger
26
76
68
Anode off-gas heat radiator
18
P
Condensed water pump 24
60
62
Condensed water tank
22
74
66
Raw material
Air
Combustion gas
Air

Fig. 7

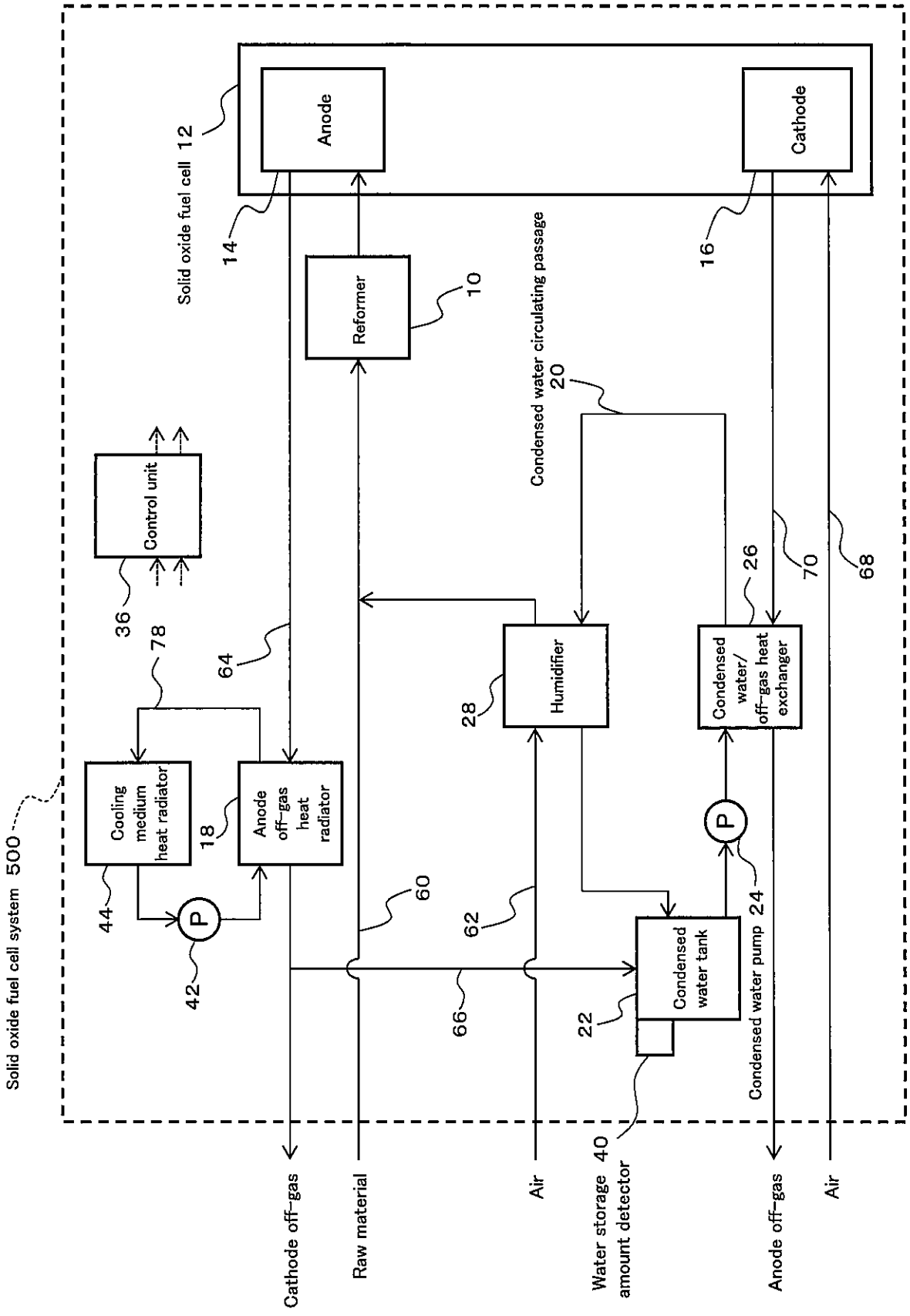
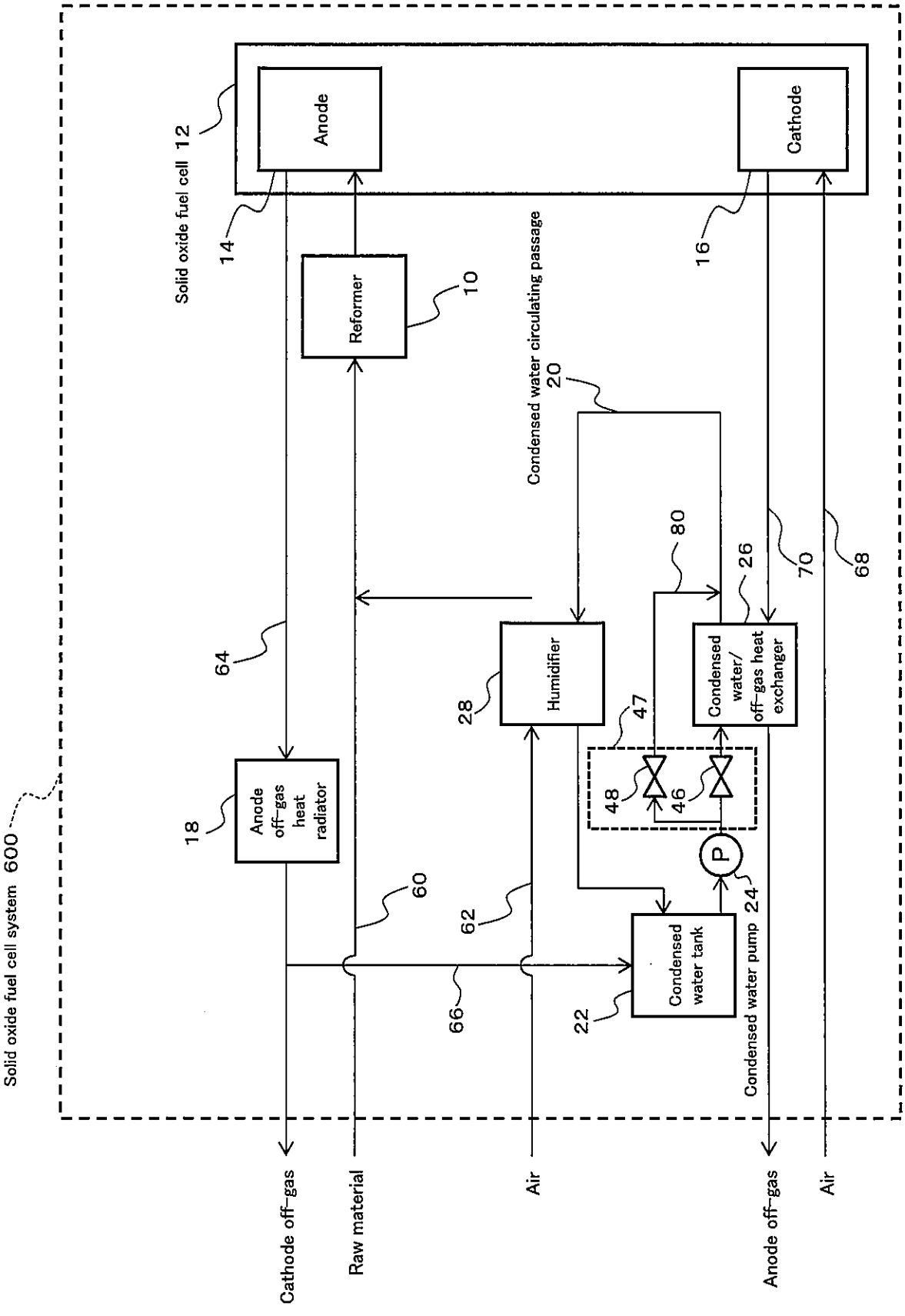

Solid oxide fuel cell system 500
Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
Control unit
36
78
64
Humidifier
28
Condensed water/ off-gas heat exchanger
26
70
68
Cooling medium heat radiator
44
Anode off-gas heat radiator
18
P
42
60
62
66
Condensed water tank
22
P
24
Condensed water pump
Cathode off-gas
Raw material
Air
Water storage amount detector
40
Anode off-gas
Air

Fig. 8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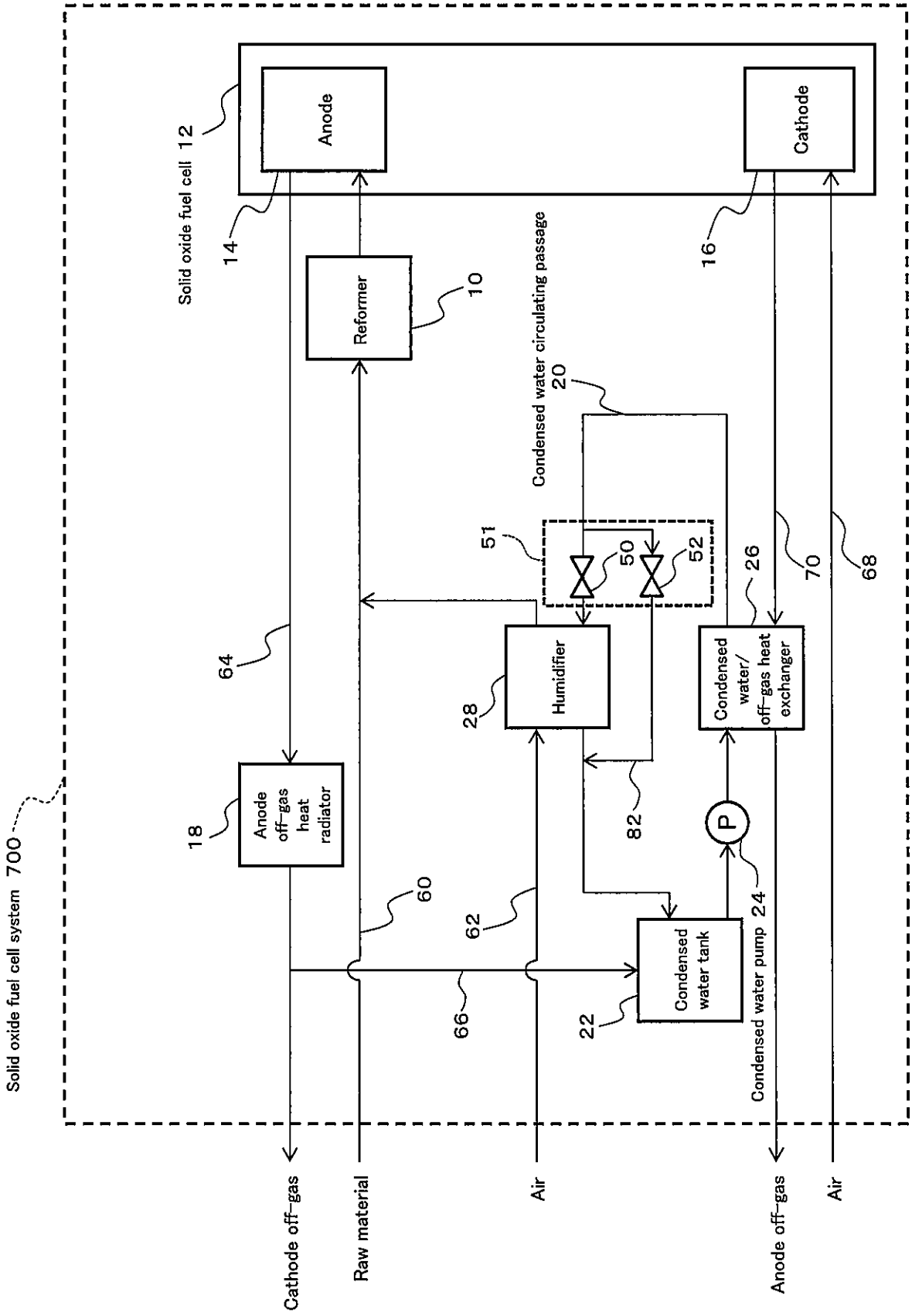
Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
80
26
70
68
64
Humidifier
28
Condensed water/ off-gas heat exchanger
47
48
46
18
Anode off-gas heat radiator
P
24
60
62
66
22
Condensed water tank
Condensed water pump
Cathode off-gas
Raw material
Air
Anode off-gas
Air

Fig. 9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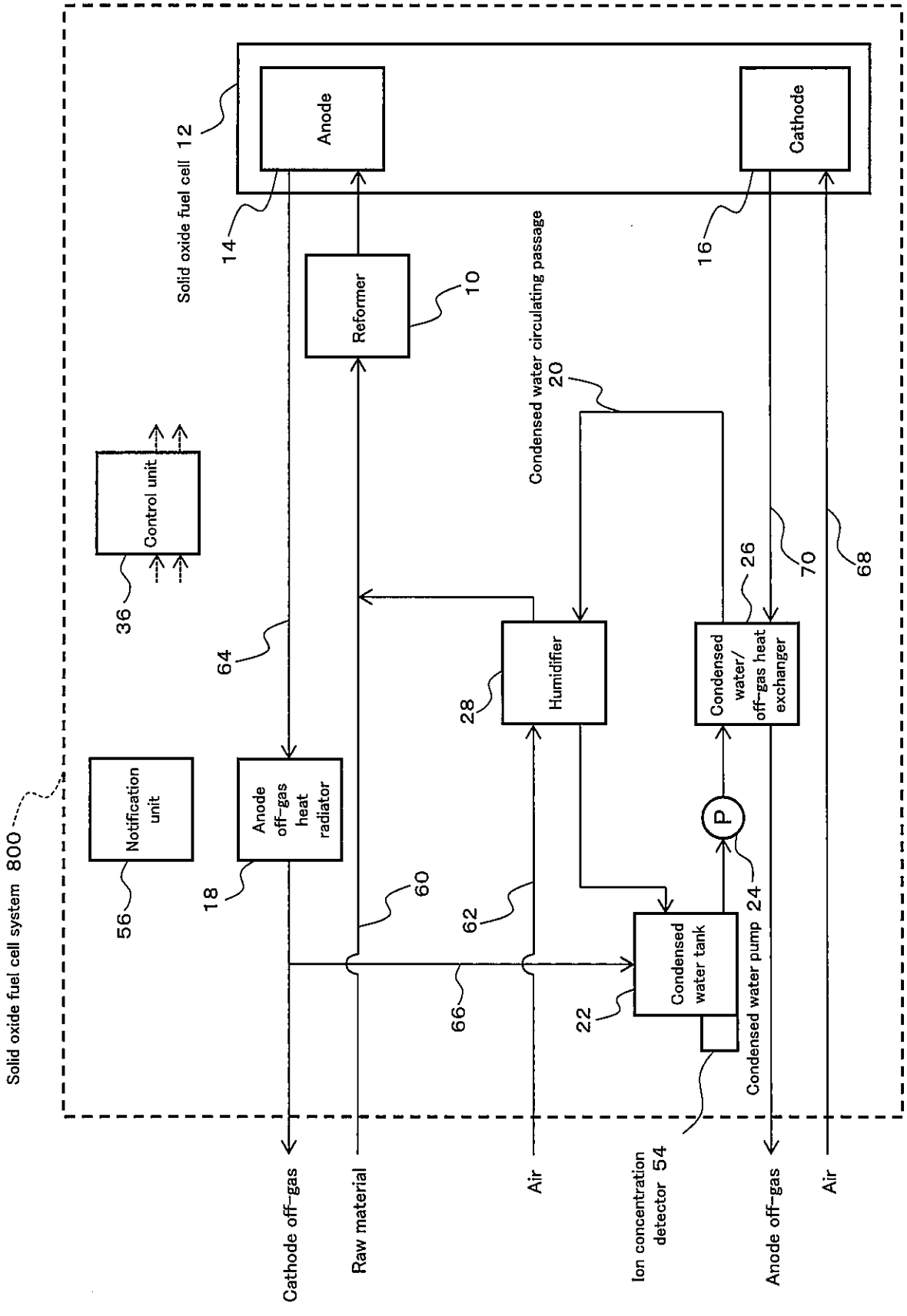
Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
51
50
52
26
70
68
64
Humidifier
28
Condensed water/ off-gas heat exchanger
Anode off-gas heat radiator
18
82
P
24
60
62
Condensed water tank
22
66
Cathode off-gas
Raw material
Air
Anode off-gas
Air

Fig. 10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Solid oxide fuel cell 12
Anode
Cathode
14
16
Reformer
10
Condensed water circulating passage
20
Control unit
36
64
Humidifier
28
Condensed water/ off-gas heat exchanger
26
70
68
Notification unit
56
Anode off-gas heat radiator
18
60
62
66
22
Condensed water tank
P
24
Condensed water pump
Cathode off-gas
Raw material
Air
Ion concentration detector 54
Anode off-gas
Air

Fig. 11