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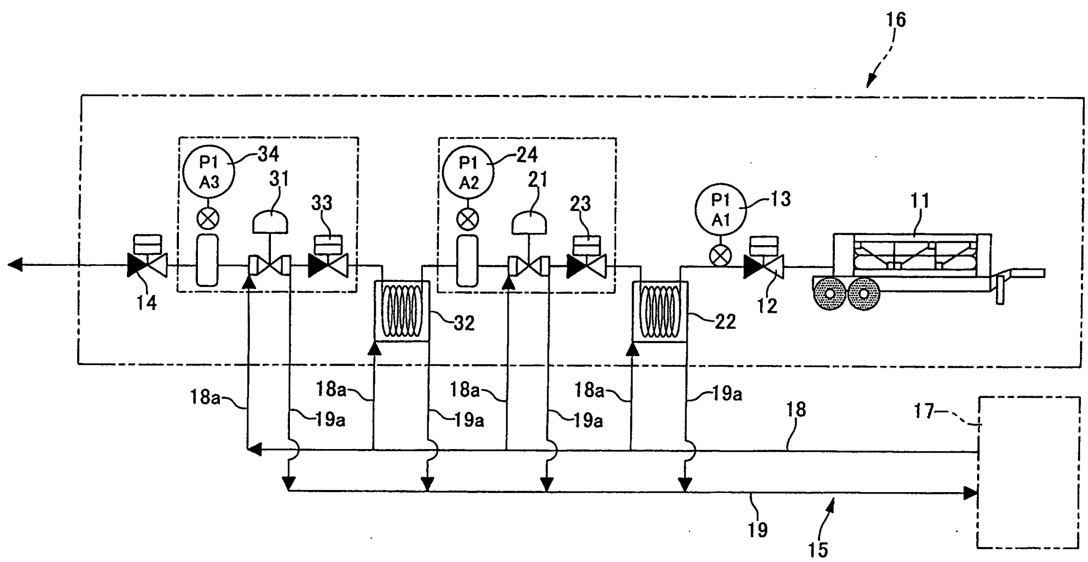
(54) GAS SUPPLY DEVICE

(57) Provided is a gas supply system in which the pressure of a compressed gas can be reduced in a stable state and the resulting gas can be supplied, as well as the system has an excellent economy and safety, wherein the pressure of a gas supplied from a source of a compressed gas (high-pressure gas container 11) is reduced by a pressure reducing means (pressure regulator 21, 31) and the resulting gas is supplied, wherein, on the upstream side, in the gas flow direction, of the pressure reducing means, a heat exchanger 22, 32 which heats the gas by heat exchange of a gas introduced to the pressure reducing means and warm water supplied from a warm water source (warm water circulation unit 15) is provided, as well as, in the pressure reducing means, a warm water flow channel 53 for heating the pressure reducing means by a part of the warm water is provided.

FIG.1



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Description

Technical Field

[0001] The present invention relates to a gas supply system, and specifically to a gas supply system in which the pressure of a compressed gas is reduced and the resulting gas is supplied.

Background Art

[0002] When a compressed gas is supplied from a 47 liter cylinder or a large-sized container, the pressure of the gas is reduced to a specified pressure by a pressure reducing means such as a pressure adjusting equipment, a pressure reducing valve or a control valve, whereby the gas is to be supplied. In this case, since the temperature of the gas whose pressure is reduced by the pressure reducing means is decreased due to adiabatic expansion and Joule-Thomson effect, dew condensation or frost formation occurs on the outer surface of the pressure reducing means, which sometimes makes it difficult to adjust the gas pressure. Accordingly, by heating a pipe on the upstream side of the pressure reducing means (a primary pipe) or by heating the pressure reducing means, decrease in the gas temperature after the pressure is reduced is restrained (for example, see Patent Documents 1 to 3).

Prior Art Documents

Patent Documents

[0003]

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2006-283812
Patent Document 2: Patent Document 3592446
Patent Document 3: Japanese Examined Patent Application Publication No. 06-33858

Summary of the Invention

Problems to be Solved by the Invention

[0004] However, an electric heater is not preferred to be used as a heat source for heating a pipe of a system which supplies a flammable gas or a pressure reducing means since there is a risk of ignition if a gas leak should occur. Winding a pipe for heating in which a fluid for heating flows around a gas pipe causes a rise in the equipment cost or the operation cost since, in order to raise the temperature of the gas in the gas pipe, it is necessary to make an area for heat transfer extremely large or to make the temperature of fluid flowing in the pipe for heating high.

[0005] On the other hand, since Monosilane (SiH_4) or Nitrogen trifluoride (NF_3) has a critical pressure very close to the filling pressure, and the critical temperature thereof is also relatively close to room temperature, it is supplied in a state of being filled at the vicinity of the critical point. In addition, since the normal boiling point thereof is high, decrease in the gas temperature due to adiabatic expansion is large and the gas is likely to be liquefied, whereby dew condensation or frost formation frequently occurs on the pressure reducing means. Further, since Monosilane has combustibility and self-combustibility and Nitrogen trifluoride also has a combustion supporting ability, the use of an electric heater is desired to be avoided.

[0006] Accordingly, an object of the present invention is to provide a gas supply system in which the pressure of a compressed gas can be reduced in a stable state and the resulting gas can be supplied, as well as the system has an excellent economy and safety.

Means for Solving the Problems

[0007] In order to attain the above-mentioned object, the gas supply system in the present invention is a gas supply system in which the pressure of a gas supplied from a source of a compressed gas is reduced by a pressure reducing means and the resulting gas is supplied, wherein, on the upstream side, in the gas flow direction, of the pressure reducing means, a heat exchanger which heats the gas by heat exchange of a gas introduced to the pressure reducing means and warm water supplied from a warm water source is provided, as well as, in the pressure reducing means, a warm water flow channel for heating the pressure reducing means by a part of the warm water was provided.

[0008] Further, the gas supply system of the present invention is provided with a warm water circulation means in which the warm water is heated to a temperature of 30 to 40°C and the resulting water is supplied to the heat exchanger and a warm water flow channel of the pressure reducing means. A plurality of the pressure reducing means are arranged in series or in parallel and, on the upstream side, in the gas flow direction, of each of the pressure reducing means, the heat exchanger is arranged. Further, the gas is Monosilane or Nitrogen trifluoride.

Effects of the Invention

[0009] In the gas supply system of the present invention, since a gas is heated by a heat exchanger using warm water as a heat source, a gas flowing in a pipe can be effectively and surely heated, and by heating the pressure reducing means by warm water, a gas after the pressure thereof is reduced can be prevented to be liquefied. By using warm water as a heat source, the safety can be improved as compared with an electric heater. Further, by setting the warm water temperature to not higher than 40°C, the gas temperature does not become too high and energy required for heating can be made small. By providing a plurality of pressure reducing means in series or in parallel, the degree of reduced pressure in each of the pressure reducing means can be optimally configured, and therefore, without generating dew condensation or frost formation on the pressure reducing means or piping systems, a gas whose pressure is reduced can be more effectively supplied, and in particular, a gas such as monosilane or Nitrogen trifluoride can be supplied safely and in a stable state. Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a block diagram illustrating one embodiment of a gas supply system of the present invention.

[Fig. 2] Fig. 2 is a cross-sectional view illustrating one example of a heat exchanger used for a gas supply system of the present invention.

[Fig. 3] Fig. 3 is a cross-sectional view illustrating one example of a pressure regulator used for a gas supply system of the present invention.

Modes for Carrying out the Invention

[0011] A gas supply system illustrated in the present embodiment is provided with two pressure regulators 21, 31 in series as pressure reducing means which reduces the pressure of a gas supplied from a high-pressure gas container 11 which is a source of the compressed gas filled with a compressed gas in a prescribed high pressure state, and is formed such that, at a first pressure regulator 21 on the upstream side of the gas flow direction, the pressure of a high-pressure gas is reduced at a preset degree of reduced pressure to obtain a middle-pressure gas, and, at a second pressure regulator 31 on the downstream side of the gas flow direction, the pressure of the middle-pressure gas is reduced at a preset degree of reduced pressure to supply a low-pressure gas having a pressure according to the demand of a supply destination. For example, in cases where the pressure of a compressed gas whose filling pressure is 9 MPa (absolute pressure, the same hereinafter) is reduced to near the atmospheric pressure and the resulting gas is supplied, the pressure of the gas is reduced to a middle-pressure which is about 4 MPa by a first pressure regulator 21, and then, the pressure of the resulting gas is reduced to a supply pressure which is near the atmospheric pressure from 4 MPa by a second pressure regulator 31, whereby the resulting gas is supplied.

[0012] Between the gas supply system and the high-pressure gas container 11, a high-pressure valve 12 and a pressure detector 13 are provided, and between the gas supply system and the supply destination, a low-pressure valve 14 is provided. On the upstream side (on the primary side), in the gas flow direction, of each of the pressure regulator 21, 31, heat exchangers 22, 32 and shutoff valves 23, 33 are provided, and on the downstream side (on the secondary side), in the gas flow direction, of each of pressure regulators 21, 31, pressure detectors 24, 34 are provided, respectively. In the gas supply system illustrated in the present embodiment, a warm water circulation unit 15 which supplies warm water for heating in a circulating manner to the pressure regulators 21, 31 and the heat exchangers 22, 32 is provided in a state in which the unit is separated from a body part 16 on which the pressure regulators 21, 31 or heat exchangers 22, 32 are arranged.

[0013] As illustrated in Fig. 2, for the heat exchangers 22, 32, those having a structure in which a coil pipe 42 made of metal is stored in a top-opened container 41 with a bottom (shell-and-coil structure) are used. On the top-opening of the container 41, a lid 43 through which an entrance pipe 42a and an exit pipe 42b of coil pipe 42 are inserted is detachably attached. On one of opposing sidewalls of the container 41, a warm water introduction port 44 is provided, and on the other side of the sidewalls, a warm water discharge port 45 is provided, as well as, inside the container 41, a plurality of baffles (baffle boards) 46 by which warm water which has flowed into the container 41 from the warm water introduction port 44 is efficiently allowed to be in contact with a coil pipe 42 are provided in such a manner that the baffles are not interfered with the coil pipe 42. Warm water which has been flowed into the container 41 from the warm water introduction port 44 flows inside the container 41 while meandering by the effect of the baffles 46 to be evenly in contact with the outer surface of the coil pipe 42, and then the gas is heated by heat exchange with a gas flowing inside the coil pipe 42 through the pipe wall of the coil pipe 42 to be discharged from a warm water discharge port 45.

[0014] As illustrated in Fig. 3, for the pressure regulators 21, 31, those having a warming function in which a warm water flow channel 53 is provided in such a manner that the channel 53 surrounds gas flow channels 51, 52 at the center are used. On one end of the warm water flow channel 53, a warm water introduction port 54, and on the other end of the warm water flow channel 53, a warm water discharge port 55 are provided respectively. Warm water which has flowed in the warm water flow channel 53 from the warm water introduction port 54 passes an entrance side ring-shaped flow channel 53a formed on the periphery of the gas flow channel 51, flows into an exit side ring-shaped flow channel 53c from the entrance side ring-shaped flow channel 53a by way of a valve box periphery flow channel 53b provided on the periphery of the valve box portion. When warm water flows in each of the flow channels above, it heats the pressure regulators 21, 31, then is discharged from warm water discharge port 55.

[0015] The warm water circulation unit 15 is provided with a warm water generator 17 which generates warm water having a preset temperature by using an arbitrary heat energy and a warm water supply pipe 18 and a warm water return pipe 19 each of which connects the warm water generator 17 and objects to be heated in the body part 16. The warm water generator 17 is those in which warm water heated to, for example, a temperature of 30 to 40°C by an electric heater is generated and supplied by a pump, and is formed such that warm water generated in the warm water generator 17 passes the warm water supply pipe 18 to branch off into introduction side branched pipes 18a corresponding to heat exchangers 22, 32 or pressure regulators 21, 31, and warm water discharged from the heat exchangers 22, 32 or pressure regulators 21, 31 join into a warm water return pipe 19 from each of the discharge side branched pipes 19a to circulate in the warm water generator 17 to be recycled.

[0016] The temperature of warm water supplied from the warm water generator 17 can be arbitrarily set depending on conditions such as the supplied gas flow rate, the heat exchange efficiencies of the heat exchangers 22, 32 and the heating efficiencies of the pressure regulators 21, 31, and preferably not higher than 40°C in view of the safety in the case of leakage, and, in view of the heating effect of the gas, preferably not lower than 30°C, and particularly, most suitably not lower than 35°C. The warm water flow rate can also be appropriately set depending on the gas flow rates or the heat exchange efficiencies of the heat exchangers 22, 32, and can be set such that, for example, the temperature of warm water which is decreased by performing heat exchange in a counter flow with respect to the gas flow in the coil pipe 42, that is, the warm water temperature at the warm water discharge port 45 is lower than the warm water temperature at the warm water introduction port 44 by less than 5°C, and preferably 2°C.

[0017] On the other hand, for the coil pipe 42, a pipe having a diameter or thickness depending on a gas flow rate which the supply destination demands and the pressure of the gases passing the coil pipe 42 is used. Although, by increasing the length of the coil pipe 42, the gas temperature after performing heat exchange can be made close to the warm water temperature, since a sufficient effect corresponding to the increase in the cost of the pipe to be used cannot be expected, the gas temperature which has been raised by heat exchange with warm water is preferably set to be lower than the warm water temperature by 5°C, and preferably by 3°C.

[0018] In this case, heat exchange between a gas flowing in the coil pipe 42 and warm water flowing on the periphery of the coil pipe 42 is performed through the pipe wall of the coil pipe 42. Since this case is not the case of a conventional gas pipe around which a warm water pipe is wound in which two pipes are in line contact with each other on outer surfaces thereof and in which there is an air layer intervening between the pipes, the gas temperature or the like after heat exchange can be easily determined by calculation by setting conditions such as surface areas of the inside and the outside of the coil pipe 42, the thickness of the pipe wall, the temperature difference between the inside and the outside of the pipe or the specific heat. Accordingly, unlike the conventional case in which the gas temperature cannot be sufficiently raised or in which the gas temperature becomes unstable, gas which flows into the pressure regulator 21, 31 provided on the downstream side can be surely heated.

[0019] In the pressure regulators 21, 31, the degrees of reduced pressure in the pressure regulators 21, 31 are preferably set individually in view of the gas temperature after reducing the pressure and in view of heating effect of warm water. The warm water flow rate, the structure or the shape of the warm water flow channel 53 may be set such that dew condensation does not occur on the outer surface of the pressure regulators 21, 31 at the temperature of warm water supplied to the heat exchangers 22, 32 and such that the outer surface of the pressure regulators 21, 31 can be heated.

[0020] Further, although the warm water temperature, the warm water supply capacity of the warm water circulation unit 15, the heat exchange capacities of heat exchangers 22, 32 and the heating capacities of the pressure regulators 21, 31 are generally set corresponding to the maximum flow rate of the supplied gas, when the duration of the maximum flow rate is short and the amounts of dew condensation on the pressure regulators 21, 31 are negligible, each capacity can be set corresponding to a gas flow rate lower than the maximum flow rate.

[0021] As illustrated in the present embodiment, by reducing the pressure of the compressed gas in a plurality of steps, the degree of reduced pressure at each step of reducing the pressure can be made small, as well as it becomes not necessary to heat a compressed gas which is to be introduced into a pressure reducing means (pressure regulators 21, 31) to a high temperature. By heating the gas by the heat exchangers 22, 32 using warm water having a temperature of not higher than 40°C, liquefaction of the gas in the pressure reducing means and dew condensation on the outer surface of the pressure reducing means can be prevented. In particular, by heating the gas with warm water witha heat exchanger, the gas can be efficiently heated to a prescribed temperature, and by using warm water having a temperature of not higher than 40°C, the safety can be more secured than in cases where a pipe is heated by an electric heater. By placing a body part 16 provided with piping system in which compressed gas flows and a warm water generator 17 which generates warm water in a state in which they are separated from each other by a separator or the like, even when an electric heater is used for a heat source of the warm water generator 17, the safety can be considerably improved since the compressed gas and the electric heater are separated. By using warm water, energy required for heating can be reduced as compared with the case in which hot water or steam is used, and heat loss in the piping system becomes small, and if warm water should leak, there is no risk of scald.

[0022] When a low-pressure gas after the pressure thereof is reduced is serially supplied to a supply destination, a plurality of gas supply systems provided with the body part 16 and the warm water circulation unit 15 may be placed, and one warm water circulation unit 15 can relate to a plurality of body parts 16. When decrease in gas temperature by adiabatic expansion is relatively small, and the pressure of a compressed gas whose degree of reduced pressure is small is reduced and the resulting gas is supplied, only one pressure reducing means and only one heat exchanger can be provided individually.

Description of Symbols

[0023] 11 ... high-pressure gas container, 12 ... high-pressure valve, 13 ... pressure detector, 14 ... low-pressure valve, 15 ... warm water circulation unit, 16 ... body part, 17 ... warm water generator, 18 ... warm water supply pipe, 18a ... introduction side branched pipe, 19 ... warm water return pipe, 19a ... discharge side branched pipe, 21, 31 ... pressure regulator, 22, 32 ... heat exchanger, 23, 33 ... shutoff valve, 24, 34 ... pressure detector, 41 ... container, 42 ... coil pipe, 42a ... entrance pipe, 42b ... exit pipe, 43 ... lid, 44 ... warm water introduction port, 45 ... warm water discharge port, 46 ... baffle, 51, 52 ... gas flow channel, 53 ... warm water flow channel, 53a ... entrance side ring-shaped flow channel, 53b ... valve box periphery flow channel, 53c ... exit side ring-shaped flow channel, 54 ... warm water introduction port, 55 ... warm water discharge port

Claims

1. A gas supply system in which the pressure of a gas supplied from a source of a compressed gas is reduced by a pressure reducing means and the resulting gas is supplied, wherein, on the upstream side, in the gas flow direction, of the pressure reducing means, a heat exchanger which heats the gas by heat exchange of a gas introduced to the pressure reducing means and warm water supplied from a warm water source is provided, as well as, in the pressure reducing means, a warm water flow channel for heating the pressure reducing means by a part of the warm water was provided.

2. The gas supply system according to claim 1, wherein the system is provided with a warm water circulation means in which the warm water is heated to a temperature of 30 to 40°C and the resulting water is supplied to the heat exchanger and a warm water flow channel of the pressure reducing means.

3. The gas supply system according to claim 1 or 2, wherein a plurality of the pressure reducing means are arranged in series or in parallel and, on the upstream side, in the gas flow direction, of each of the pressure reducing means, the heat exchanger is arranged.

4. The gas supply system according to any one of claims 1 to 3, wherein the gas is Monosilane or Nitrogen trifluoride.

FIG.1

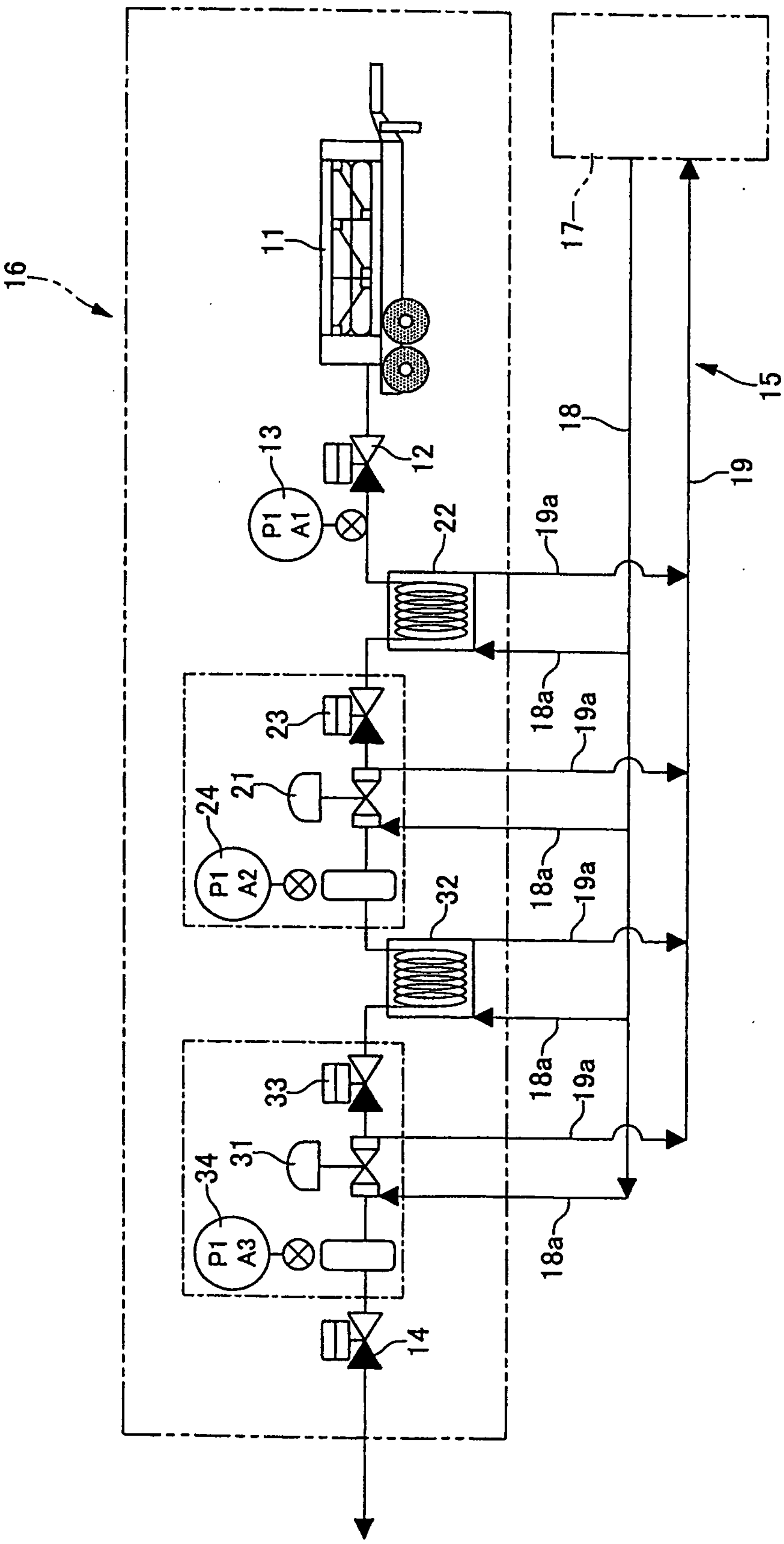
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FIG.2

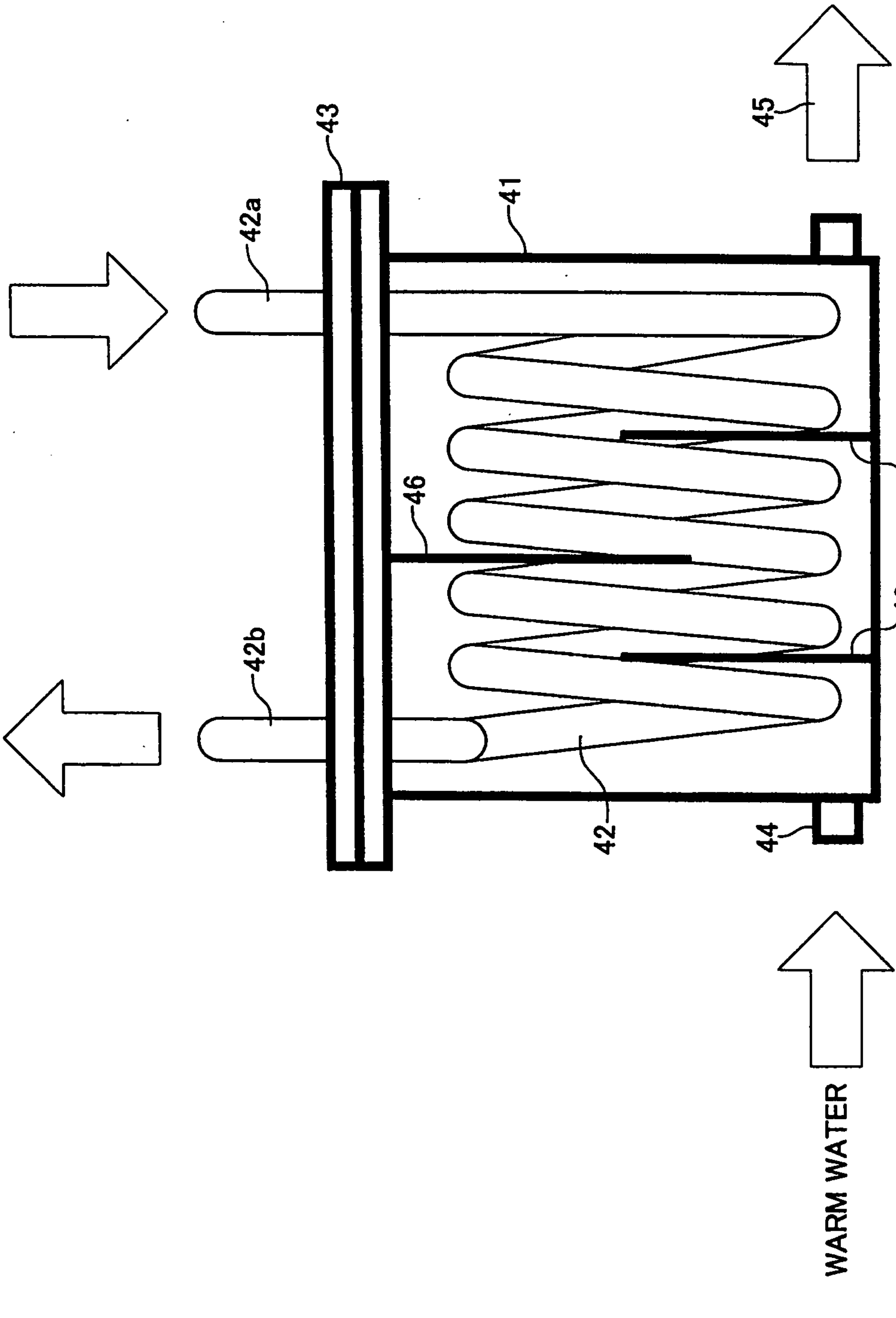
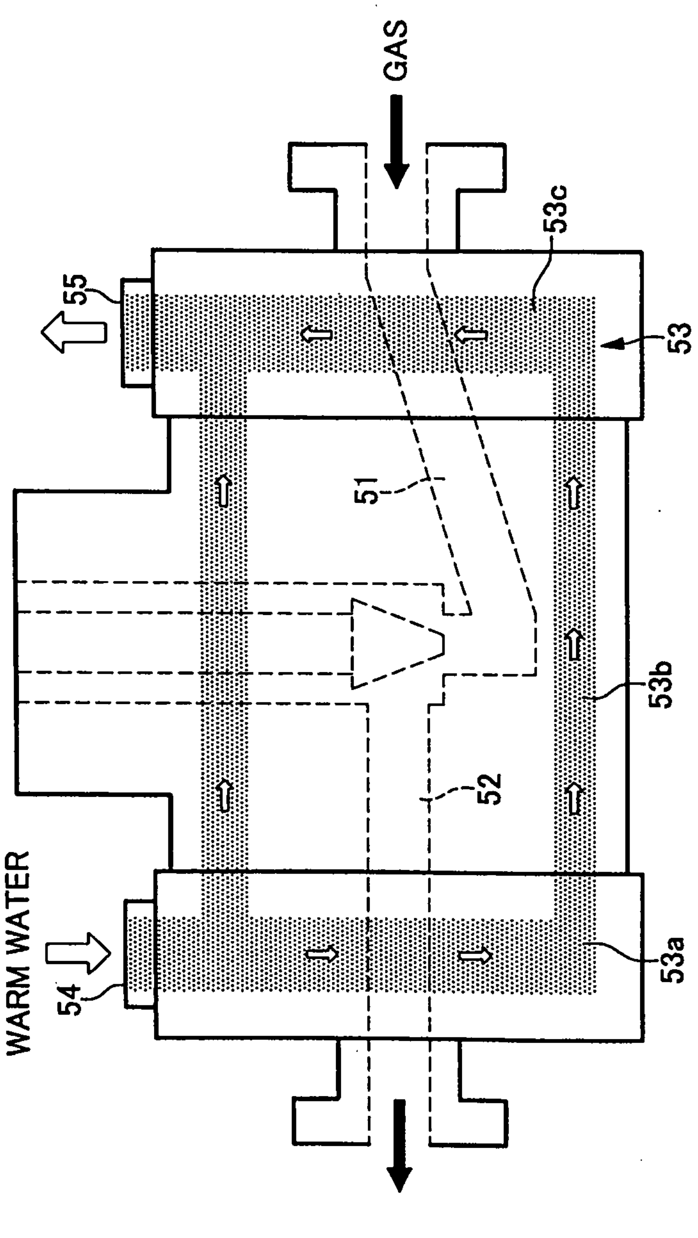


FIG.3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/070525

A. CLASSIFICATION OF SUBJECT MATTER
F17C7/00(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)
F17C7/00

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 094893/1987(Laid-open No. 000798/1989) (Kobe Steel, Ltd.), 05 January 1989 (05.01.1989), page 4, line 1 to page 7, line 20 (Family: none)	1-4
A	JP 10-105853 A (Tokyo Gas Co., Ltd.), 24 April 1998 (24.04.1998), paragraphs [0015] to [0016]; fig. 2 (Family: none)	1-4

☒ 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	Date of mailing of the international search report
03 December, 2010 (03.12.10)	14 December, 2010 (14.12.10)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/070525

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2003/0070432 A1 (Nalin WALPITA), 17 April 2003 (17.04.2003), entire text; all drawings (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006283812 A **[0003]**
- JP 3592446 B **[0003]**
- JP 6033858 A **[0003]**