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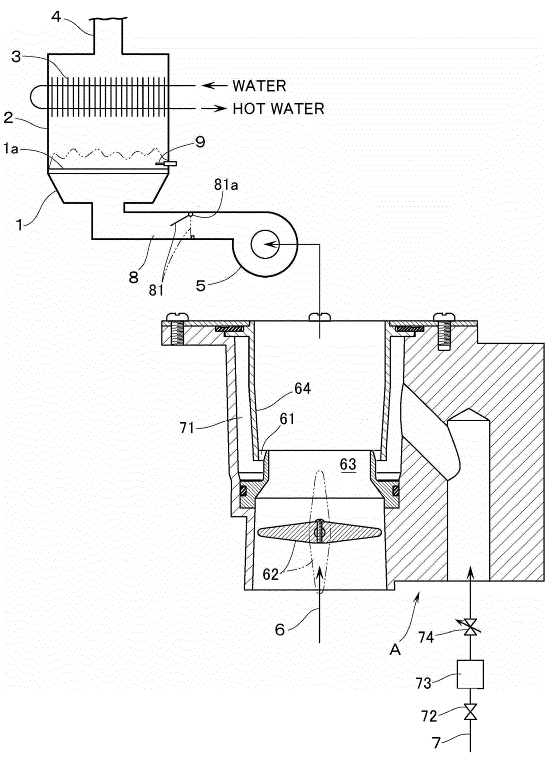
(54) PREMIXING APPARATUS

(57) A premixing apparatus for mixing air with a fuel gas in order to supply a burner (1) with an air-fuel mixture through a fan (5), wherein a downstream end of a gas supply passage (7) is connected to a gas suction part (61) disposed in a portion, on an upstream side of the fan (5), of an air supply passage (6). The gas supply passage (7) has interposed therein a zero governor (73) for adjusting a secondary gas pressure to an atmospheric pressure. Even if the calorific value of the fuel gas may fluctuate, excess air ratio of the air-fuel mixture is arranged to be maintained at a constant value.

The premixing apparatus is provided with: an excess air ratio detection device (9) for detecting an excess air ratio of the air-fuel mixture; and a flow control valve (74) interposed in a portion, on a downstream side of the zero governor, of the gas supply passage (7). The flow control valve (74) is controlled such that the excess air ratio detected by the excess air ratio of the air-fuel mixture detection device (9) becomes constant.

FIG.1



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Description

Technical Field

[0001] The present invention relates to a premixing apparatus for mixing air with a fuel gas in order to supply a burner with an air-fuel mixture through a fan.

Background Art

[0002] Conventionally, as this kind of premixing apparatus, there is known one, e.g. in JP-A-2018-179447, in which a downstream end of a gas supply passage is connected to a gas suction part disposed in a portion, on an upstream side of the fan, of an air supply passage. The gas supply passage has interposed therein a zero governor for adjusting a secondary gas pressure to an atmospheric pressure. It is to be noted here that the supply amount of the fuel gas varies with a differential pressure between the atmospheric pressure which is the secondary gas pressure and a negative pressure inside the air supply passage. Since the negative pressure inside the air supply passage varies with the rotational speed of the fan, the supply amount of the fuel gas varies with the rotational speed of the fan, i.e., with the supply amount of the air. Therefore, by controlling the rotational speed of the fan depending on the required combustion amount, the amount of the air-fuel mixture according to the required combustion amount is supplied to the burner and, as a result, the excess air ratio (amount of primary air / amount of air in theoretical air-fuel ratio) becomes constant.

[0003] By the way, in some countries of the world, there are cases where the calorific value (Wobbe Index) of the fuel gas may fluctuate with the time of the day even if the same kind of gas is being used as the fuel gas. In the above-mentioned conventional example, even if the calorific value of the fuel gas may fluctuate, the ratio of the supply amount of air to the supply amount of the fuel gas remains constant. Therefore, accompanied by the fluctuation of the calorific value of the fuel gas, the excess air ratio of the air-fuel mixture may fluctuate, thereby giving rise to the combustion failure.

SUMMARY OF THE INVENTION

Problems that the Invention is to Solve

[0004] In view of the above points, this invention has a problem of providing a premixing apparatus which is arranged to keep constant the excess air ratio of the air-fuel mixture even if the calorific value of the fuel gas may fluctuate, thereby preventing the combustion failure from taking place.

Means of Solving the Problems

[0005] In order to solve the above problem, this invention is a premixing apparatus for mixing air with a fuel gas in order to supply a burner with an air-fuel mixture through a fan, wherein a downstream end of a gas supply passage is connected to a gas suction part disposed in a portion, on an upstream side of the fan, of an air supply passage. The gas supply passage has interposed therein a zero governor for adjusting a secondary gas pressure to an atmospheric pressure. The premixing apparatus includes: an excess air ratio detection device for detecting an excess air ratio of the air-fuel mixture; and a flow control valve interposed in a portion, on a downstream side of the zero governor, of the gas supply passage. The flow control valve is controlled such that the excess air ratio of the air-fuel mixture detected by the excess air ratio detection device becomes constant.

[0006] According to this invention, even if the calorific value of the fuel gas may fluctuate, the excess air ratio of the air-fuel mixture can be kept constant by the control of the flow control valve, thereby preventing the combustion failure from taking place.

[0007] By the way, in order not to cause exhausting failure to take place due to entry of wind into an exhaust tube, i.e., in order to secure wind resistance performance, the lower-limit rotational speed of the fan will have to be set relatively high. However, this arrangement brings about also a relatively higher minimum combustion amount that is the combustion amount obtainable at the time when the rotational speed of the fan is reduced to the lower-limit rotational speed. As a result, a turndown ratio will become small.

[0008] As a solution, the premixing apparatus according to this invention preferably further comprises a swing valve provided in an air-fuel mixture supply passage between the burner and the fan. The swing valve is capable of swinging from a closed posture of being hung down with an upper end shaft serving as a fulcrum to a bottom-up open side against a self-weight thereof. According to this arrangement, when the rotational speed of the fan is made to exceed a predetermined rotational speed, the swing valve may be swung to the bottom-up open side, into a fully-opened state against the self-weight of the swing valve due to a wind pressure from the fan. On the other hand, if the rotational speed of the fan is below the predetermined rotational speed, the swing valve will gradually be swung downward from the fully-opened state. As a result, accompanied by the lowering of the rotational speed of the fan, the passage area of the air-fuel mixture supply passage will gradually be reduced. Accordingly, even if the lower-limit rotational speed is relatively high, the supply amount of the air-fuel mixture becomes relatively small due to a decrease in the passage area of the air-fuel mixture supply passage, i.e., the minimum combustion amount becomes relatively lower. As a consequence, the turndown ratio can be made large.

[0009] Further, according to this invention, even in case the kind of gas of the fuel gas has been changed, the excess air ratio of the air-fuel mixture can be made constant by the control of the flow control valve. In this case, in order to cope with the change to the kind of gas with a largely different calorific value, it becomes necessary to largely change the flow resistance in a portion, on a downstream side of the zero governor, of the gas supply passage, i.e., to considerably widen the range of change in opening degree of the flow control valve. However, such an arrangement will deteriorate the controllability of the flow control valve.

[0010] As a solution, according to this invention, the premixing apparatus preferably further comprises a bypass passage having interposed therein an on-off valve, the bypass passage being disposed in parallel with the flow control valve and in a portion, on the downstream side of the zero governor, of the gas supply passage. According to this arrangement, even if the range of change in opening degree of the flow control valve is not considerably wide, the flow resistance in a portion, on the downstream side of the zero governor, of the gas supply passage can be varied over a wide range: by the change in opening degree of the flow control valve in a state in which the on-off valve is closed so that the fuel gas does not flow into the bypass passage; and by the change in opening degree of the flow control valve in a state in which the on-off valve is opened so that the fuel gas can flow into the bypass passage. Accordingly, there can be evaded deterioration in controllability as a result of enlarging the opening degree of the flow control valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is an explanation diagram showing the premixing apparatus according to a first embodiment of this invention.

FIG. 2 is an explanation diagram showing the premixing apparatus according to a second embodiment of this invention.

FIG. 3 is a graph showing the relationship between the rotational speed of the fan and the supply amount of the air-fuel mixture.

MODES FOR CARRYING OUT THE INVENTION

[0012] The combustion apparatus represented in FIG. 1 is a heat source apparatus comprising: a totally aerated combustion burner 1; a combustion box 2 enclosing a combustion space of an air-fuel mixture to be ejected from a combustion surface 1a of the burner 1; and a heat exchanger 3 disposed inside the combustion box 2. The combustion gas generated by the combustion of the air-fuel mixture is exhausted outside, after having heated the heat exchanger 3, through an exhaust tube 4 that is connected to an end part of the combustion tube 2. By means of the premixing apparatus A according to an embodiment of this invention, air is mixed with a fuel gas, and the resultant air-fuel mixture is supplied to the burner 1 through a fan 5.

[0013] The premixing apparatus A is provided with: an air supply passage 6 on an upstream side of the fan 5; a gas supply passage 7 for supplying the fuel gas; and an air-fuel mixture supply passage 8 between the burner 1 on the downstream side of the fan 5. The downstream end of the gas supply passage 7 is connected to a gas suction part 61 which is disposed in the air supply passage 6. In such a portion of the air supply passage 6 as is adjacent to the upstream side of the gas suction part 61, there is disposed a venturi part 63 of a smaller diameter than the portion in which is disposed a butterfly valve 62, which will be described in detail hereinafter. The portion of the air supply passage 6, adjacent to the downstream side of the venture part 63, is enclosed by a tubular part 64 that is larger in diameter than the venturi part 63. The downstream end of the venturi part 63 is thus inserted, while leaving an annular clearance, into the upstream end of the tubular part 64, thereby constituting a gas suction part 61 by this clearance. The downstream end of the gas supply passage 7 is provided with a gas chamber 71 which is in communication with the gas suction part 61 in a manner to enclose the tubular part 64. In addition, the gas supply passage 7 has interposed therein, from the upstream side downward in sequence, a main valve 72, a zero governor 73 which adjusts the secondary gas pressure to atmospheric pressure, and a flow control valve 74.

[0014] The amount of the fuel gas to be supplied through the gas suction part 61 varies with the differential pressure between the atmospheric pressure that is the secondary pressure and the negative pressure in the air supply passage 6. It is to be noted here that the negative pressure in the air supply passage 6 varies with the rotational speed of the fan 5. Therefore, the supply amount of the fuel gas varies in proportion to the rotational speed of the fan 5, i.e., in proportion to the supply amount of air. Further, the ratio of supply amount of the fuel gas to the supply amount of air varies with the opening degree of the flow control valve 74. By making the opening degree of the flow control valve 74 to a predetermined standard opening degree according to the kind of gas to be used, the excess air ratio of the air-fuel mixture will become an appropriate value (e.g., 1.3). Then, by controlling the rotational speed of the fan 5 according to the required combustion amount (the amount of combustion required to supply hot water at a set hot water temperature), the air-fuel mixture can be supplied to the burner 1 in an amount according to the required combustion amount at the appropriate value in the excess air ratio.

[0015] By the way, in order to prevent exhausting failure due to entry of the wind into the exhaust tube 4, i.e., in order to secure the wind resistance performance, the lower-limit rotational speed of the fan 5 cannot be set to a considerably lower value. In addition, in case the required combustion amount has fallen below the predetermined value that corresponds to the lower-limit rotational speed of the fan 5, the air corresponding to the required combustion amount can no longer be supplied.

[0016] Then, in a portion of the air supply passage 6, on the upstream side of the gas suction part 61, in order to switch the flow resistance at the portion in question between two stages of large one and small one, there is disposed a butterfly valve 62 that can be switched, by a motor (not illustrated), between a closed posture as illustrated in solid lines in FIG. 1 and an open posture as illustrated in imaginary lines. In this arrangement, in case the required combustion amount has fallen below the above-mentioned predetermined value, the butterfly valve 62 is made into the closed posture in order to increase the flow resistance in the air supply passage 6. According to this arrangement, it is possible to supply air in an amount that corresponds to the predetermined required combustion amount below the required amount without making the rotational speed of the fan 5 below the lower-limit rotational speed. It is to be noted here that by simply making the butterfly valve 62 into the closed posture to thereby increase the flow resistance in the air supply passage 6, the negative pressure inside the air supply passage 6 will increase and the supply amount of the fuel gas will become excessive. As a result, the excess air ratio of the air-fuel mixture to be supplied to the burner 1 will fall below the appropriate value. As a solution, in case the required combustion amount is relatively small, the butterfly valve 62 is made into the closed posture in order to make the flow resistance in the air supply passage 6 larger and, at the same time, the flow control valve 74 is throttled by an amount corresponding to the predetermined opening degree from the standard opening degree, thereby attaining a small-capacity state in which the flow resistance in a portion, on the downstream side of the zero governor 73, of the gas supply passage 7 is made larger. In this manner, it is thus so arranged that the air-fuel mixture can be supplied to the burner 1 in an amount that corresponds to a relatively small required combustion amount at the appropriate value in the excess air ratio. In case the required combustion amount is relatively large, the butterfly valve 62 is made into an open posture in order to make the flow resistance in the air supply passage 6 smaller and, at the same time, the flow control valve 74 is opened up to the standard opening degree in order to attain a large-capacity state in which the flow resistance in a portion, on the downstream side of the zero governor 73, of the gas supply passage 7 is made small. According to this arrangement, the burner 1 can be supplied with the air-fuel mixture in an amount that corresponds to a relatively large required combustion amount at the appropriate value in the excess air ratio.

[0017] Further, in the air-fuel mixture supply passage 8 there is disposed a swing valve 81 that is capable of swinging from a closed posture (the posture illustrated in imaginary lines in FIG. 1) of being hung down with an upper end shaft 81a serving as a fulcrum to a bottom-up open side against a self-weight thereof. When the rotational speed of the fan 5 exceeds a predetermined rotational speed, the swing valve 81 will be swung upward by the wind pressure from the fan 5 against its self-weight, thereby attaining a fully-opened state. When the rotational speed falls below the predetermined rotational speed, the swing valve 81 comes to be swung gradually downward from the fully-opened state accompanied by the lowering of the rotational speed of the fan 5 and, as a result, the passage area of the air-fuel mixture supply passage 8 gradually decreases.

[0018] The relationship between the rotational speed of the fan 5 and the supply amount of the air-fuel mixture is as illustrated by a characteristic line L in FIG. 3 in the small-capacity state, and is as illustrated by a characteristic line H in FIG. 3 in the large-capacity state. By providing the swing valve 81 as in the embodiment of this invention, these characteristic curves L, H will become those in which the supply amounts of the air-fuel mixture are made smaller than those of the proportional lines illustrated in FIG. 3 by dotted lines. Therefore, it is possible to secure a large turndown ratio (maximum amount of combustion / minimum amount of combustion) that is the ratio between: the amount Qmax of supply of the air-fuel mixture at the time when the rotational speed of the fan 5 is made the upper limit rotational speed Nmax in the state of large capacity, i.e., the maximum amount of combustion by the burner 1; and the amount Qmin of supply of the air-fuel mixture at the time when the rotational speed of the fan 5 is made the lower limit rotational speed Nmin in the state of small capacity, i.e., the minimum amount of combustion by the burner 1.

[0019] By the way, even if the same kind of gas is used as the fuel gas, there are cases where the calorific values (Wobbe Index) may fluctuate with the time of the day. In this case, when the ratio of the supply amount of fuel gas relative to the supply amount of air is constant, the excess air ratio of the air-fuel mixture will fluctuate due to the fluctuation in the calorific value of the fuel gas, thereby resulting in combustion failure.

[0020] As a solution, there is provided an excess air ratio detection means 9 for detecting the excess air ratio of the air-fuel mixture. In this embodiment, a flame rod provided in a manner to face the combustion surface 1a of the burner

1 constitutes the excess air ratio detection means 9 so that the excess air ratio of the air-fuel mixture can be detected by flame current that flows through the flame rod. By the way, since the flame moves toward or away from the combustion surface 1a depending on the excess air ratio of the air-fuel mixture, the rear-surface temperature of the combustion surface 1a varies with the excess air ratio of the air-fuel mixture. Therefore, it is also possible to constitute the excess air ratio detection means 9 by the temperature sensor for detecting the rear-surface temperature of the combustion surface 1a.

[0021] Then, the flow control valve 74 is feed-back controlled so that the excess air ratio of the air-fuel mixture to be detected by the excess air ratio detection means 9 becomes constant, i.e., in order to keep the excess air ratio to a predetermined appropriate value. Specifically, when the excess air ratio in the air-fuel mixture is reduced by an increase in the calorific value of the fuel gas, the opening degree of the flow control valve 74 is reduced so that the ratio of the supply amount of the fuel gas relative to the supply amount of air is decreased so as to attain the appropriate value in the excess air ratio. Further, when the excess air ratio of the air-fuel mixture is increased due to a decrease in the calorific value of the fuel gas, the opening degree of the flow control valve 74 is increased so that the ratio of the supply amount of the fuel gas relative to the supply amount of air is increased so as to attain the appropriate value in the excess air ratio. According to this arrangement, even if the calorific value of the fuel gas fluctuates, the excess air ratio of the air-fuel mixture can be maintained at the appropriate value, thereby preventing the combustion failure from taking place.

[0022] Next, a description will be made of a second embodiment as shown in FIG. 2. The basic construction of the second embodiment is not particularly different from that of the above-mentioned first embodiment. The members and parts that are the same as those of the first embodiment have been assigned thereto the same reference marks. The difference of the second embodiment from the first embodiment is that a bypass passage 75 is provided in parallel with the flow control valve 74 in a portion, on a downstream side of the zero governor 73, of the gas supply passage 7, and that an on-off valve 76 is interposed in this bypass passage 75.

[0023] Even in case the kind of gas of the fuel gas is changed, the excess air ratio of the air-fuel mixture can be made to the appropriate value by the control of the flow control valve 74. It is to be noted however that, in order to cope with the change to a gas with a largely different calorific value, it becomes necessary to largely change the flow resistance in a portion, on a downstream side of the zero governor 73, of the gas supply passage 7. In the arrangement of the first embodiment, it becomes necessary to make relatively wider the range of opening degree change of the flow control valve 74. For that purpose, the amount of change in opening degree per unit operation amount of the flow control valve 74 will be obliged to be made larger. As a consequence, the allowable error in the operation amount becomes slight, thereby deteriorating the controllability of the flow control valve 74.

[0024] On the other hand, according to the second embodiment, even if the change width of opening degree of the flow control valve 74 is not so large, the flow resistance in a portion, on the downstream side of the zero governor 73, of the gas supply passage 7 can be varied over a wide range: by the opening degree change in the state in which the fuel gas does not flow through the bypass passage 75 as a result of closing the on-off valve 76; and by the opening degree change of the flow control valve 74 in a state in which the fuel gas flows through the bypass passage 75 as a result of opening the on-off valve 76. Therefore, the deterioration in the controllability of the flow control valve 74 due to enlargement of the range in opening degree change can be avoided.

[0025] Descriptions have so far been made of the embodiments of this invention with reference to the figures, but this invention shall not be limited to the above. For example, in the above-mentioned embodiments, in order to switch the capacity, the flow resistance in the air supply passage 6 is switched between large and small by means of the butterfly valve 62 and, accompanied by the operation, the flow resistance in a portion, on the downstream side of the zero governor 73, of the gas supply passage 7 is switched between large and small by means of the flow control valve. However, it is also possible to interpose, in series with the flow control valve 74, a switching valve for switching the flow resistance between large and small, in a portion, on the downstream side of the zero governor 73, of the gas supply passage 7. The switching of the capacity can thus be made without controlling the flow control valve 74. Further, it is also possible to do away with the butterfly valve 62 so that the capacity switching is not performed.

Explanation of Reference Characters

A	premixing apparatus	1	burner
5	fan	6	air supply passage
61	gas suction part	7	gas supply passage
73	zero governor	74	flow control valve
75	bypass passage	76	on-off valve
8	air-fuel mixture supply passage	81	swing valve
81a	shaft	9	excess air ratio detection means

Claims

1. A premixing apparatus for mixing air with a fuel gas in order to supply a burner with an air-fuel mixture through a fan, wherein a downstream end of a gas supply passage is connected to a gas suction part disposed in a portion, on an upstream side of the fan, of an air supply passage, the gas supply passage having interposed therein a zero governor for adjusting a secondary gas pressure to an atmospheric pressure,
the premixing apparatus comprising:

    an excess air ratio detection device for detecting an excess air ratio of the air-fuel mixture; and
    a flow control valve interposed in a portion, on a downstream side of the zero governor, of the gas supply passage, wherein the flow control valve is controlled such that the excess air ratio of the air-fuel mixture detected by the excess air ratio detection device becomes constant.

2. The premixing apparatus according to claim 1, further comprising a swing valve provided in an air-fuel mixture supply passage between the burner and the fan, the swing valve being capable of swinging from a closed posture of being hung down with an upper end shaft serving as a fulcrum to a bottom-up open side against a self-weight thereof.

3. The premixing apparatus according to claim 1 or 2, further comprising a bypass passage having interposed therein an on-off valve, the bypass passage being disposed in parallel with the flow control valve and in a portion, on the downstream side of the zero governor, of the gas supply passage.

FIG.1

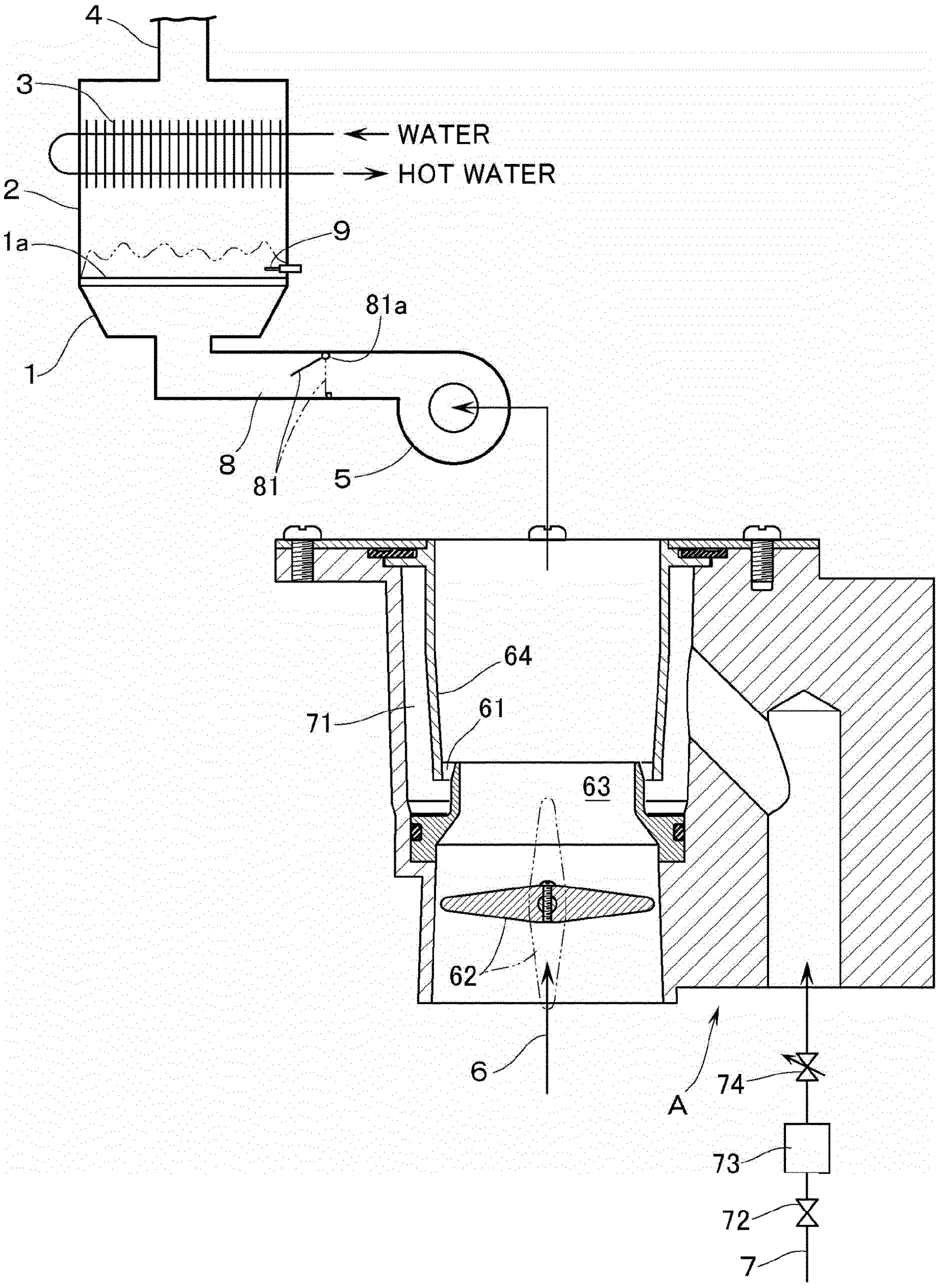
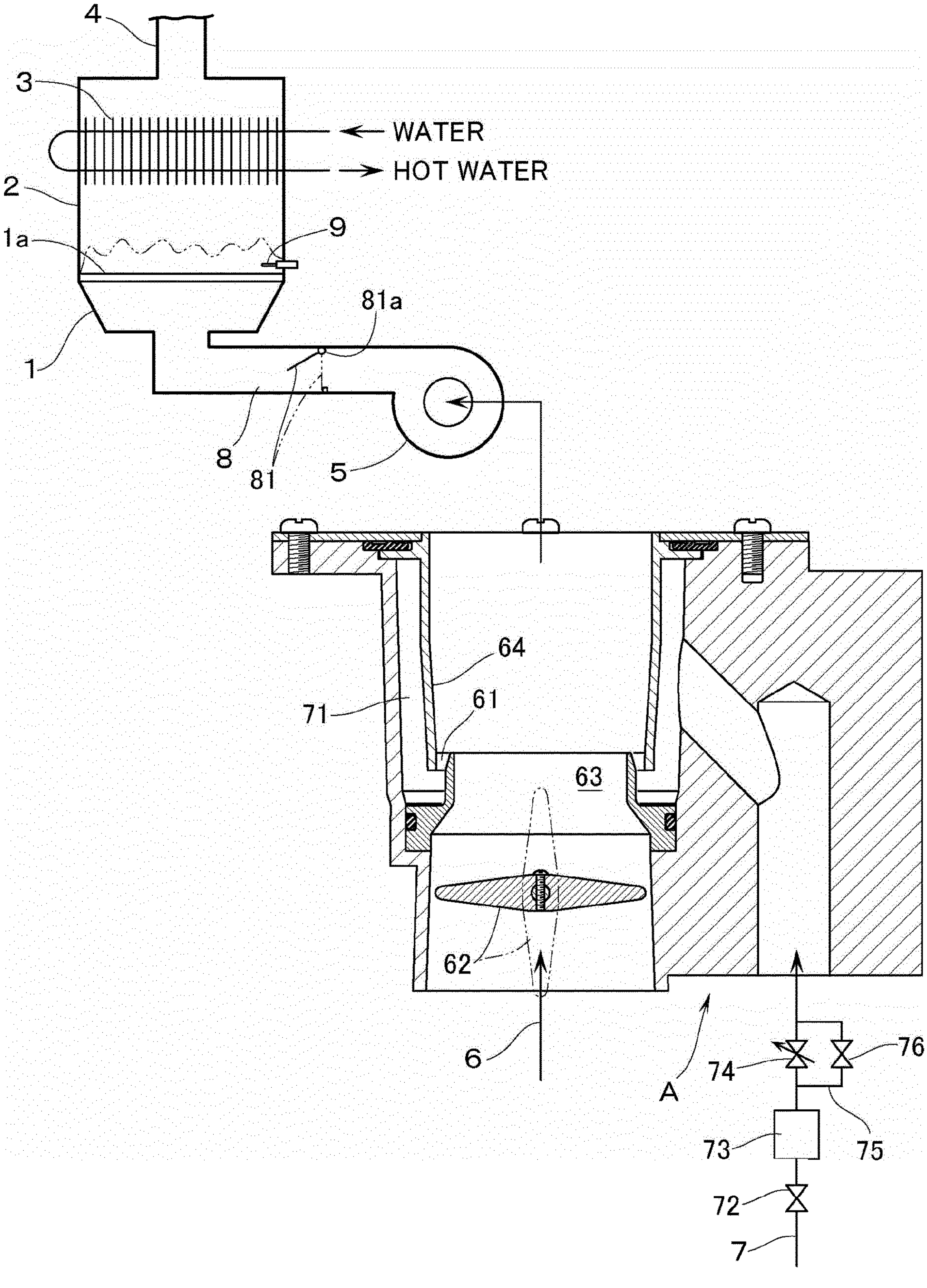


FIG.2


4
3
WATER
HOT WATER
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9
81a
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61
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74
76
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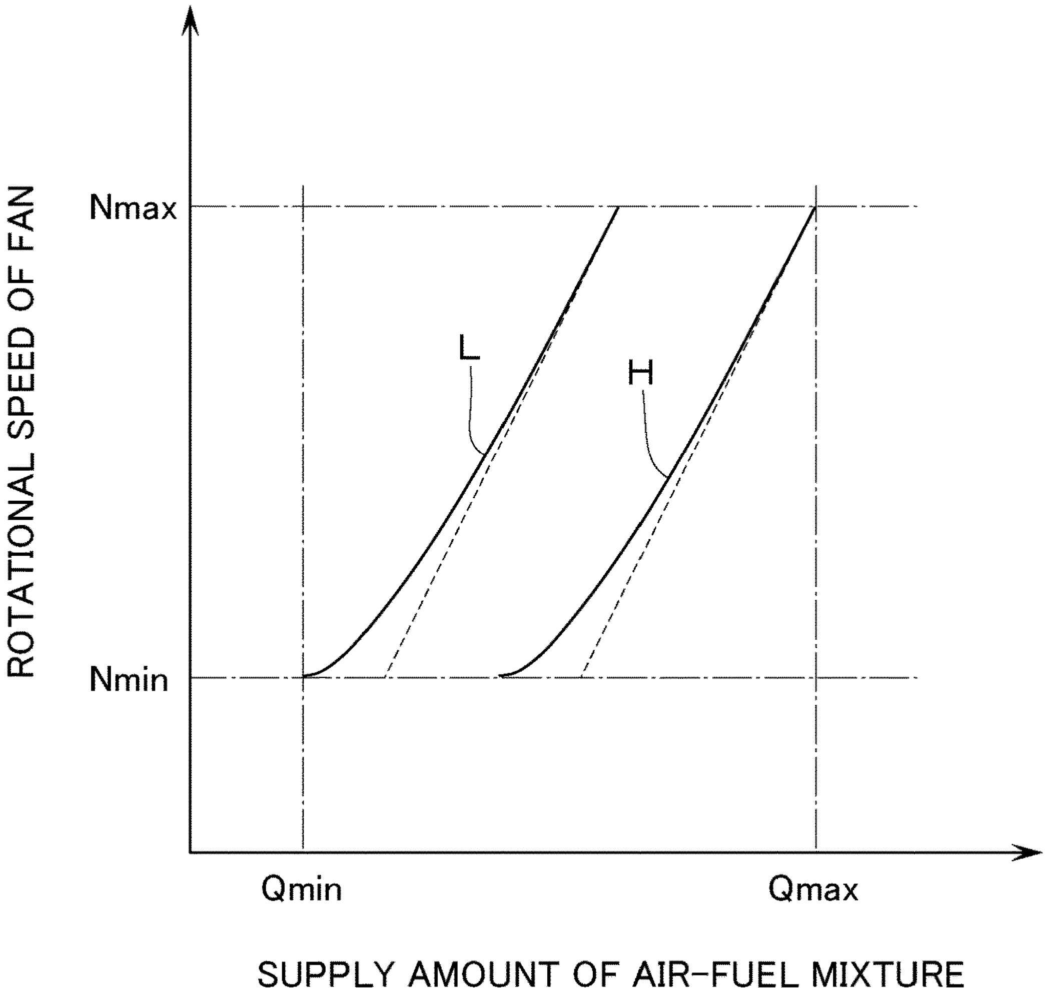
72
7

FIG.3


ROTATIONAL SPEED OF FAN
Nmax
Nmin
L
H
Qmin
Qmax
SUPPLY AMOUNT OF AIR-FUEL MIXTURE

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EUROPEAN SEARCH REPORT

Application Number
EP 20 18 5491

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TECHNICAL FIELDS SEARCHED (IPC)
F23N

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	27 November 2020	Theis, Gilbert

CATEGORY OF CITED DOCUMENTS

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