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(54) **CONTROL METHOD FOR WATER HEATING SYSTEM**

(57) Provided is a control method for a water heating system. The water heating system includes a gas heating module and a heat-pump heating module. The gas heating module and the heat-pump heating module are selectively activatable. The control method for a water heating system includes acquiring a recommended heating mode according to electric power information and gas information; in response to the recommended heating mode being a heat-pump heating mode, acquiring an inlet water temperature at an inlet end of the heat-pump heating module; and in response to the inlet water temperature being lower than a preset water temperature, activating the heat-pump heating module. Operation costs of the heat-pump heating module and the gas heating module are compared to acquire the recommended heating mode. If the recommended heating mode is the heat-pump heating mode, the inlet water temperature is compared with the preset water temperature to determine whether an activating condition of the heat-pump heating module is satisfied, thereby improving the economical performance of the water heating system, and avoiding the heat pump from the high-temperature alarm.

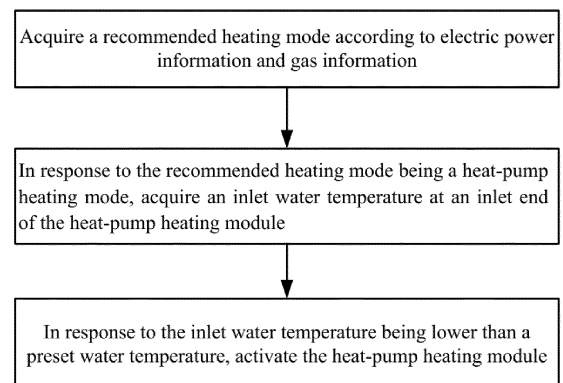


FIG. 1

Description

[0001] This application claims priority to Chinese Patent Application No. 202110992954.5 filed Aug. 27, 2021, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present application relates to the field of household appliances, for example, a control method for a water heating system.

BACKGROUND

[0003] Water heaters are household appliances commonly used in people's daily life and can be divided into gas water heaters, electric water heaters, solar water heaters, and air energy water heaters according to different energy sources. Water heaters in the existing art only use a single energy source and cannot well satisfy the user requirements.

[0004] With the development of economy and production technologies, hot water supply systems that combine gas heating with heat pump water heaters are not rare. However, most of the water heating systems of this type use one energy source as the main energy source and another energy source as the auxiliary energy source, thereby switching the heating mode only from the perspective of supplementary heating but fail to consider how to make the hot water supply system most economical from the perspective of how to save operation costs. Moreover, it is prone to cause the heat pump module to fail without sufficiently considering the activating condition of the heat pump.

SUMMARY

[0005] The present application provides a control method for a water heating system that can solve the problems that when the heating mode is switched economic costs need to be considered and the heat pump is prone to fail in the related art.

[0006] An embodiment provides a control method for a water heating system. The water heating system includes a gas heating module and a heat-pump heating module, where the gas heating module and the heat-pump heating module are selectively activatable. The control method for a water heating system includes acquiring a recommended heating mode according to electric power information and gas information; in response to the recommended heating mode being a heat-pump heating mode, acquiring an inlet water temperature at an inlet end of the heat-pump heating module; and in response to the inlet water temperature being lower than a preset water temperature, activating the heat-pump heating module.

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. 1 is a flowchart of a control method for a water heating system according to embodiment one of the present application.

DETAILED DESCRIPTION

[0008] In the description of the present application, unless otherwise expressly specified and limited, a term such as "assembly", "connected to each other", "connected" or "fixed" is to be construed in a broad sense, for example, as permanently connected, detachably connected, or integrated; mechanically connected, electrically connected or communication; directly connected to each other or indirectly connected to each other via an intermediary; or internally connected or interactional between two components. For those of ordinary skill in the art, specific meanings of the preceding terms in the present application may be understood based on specific situations.

[0009] In the present application, unless otherwise expressly specified and limited, when a first feature is described as "on" or "below" a second feature, the first feature and the second feature may be in direct contact, or be in contact via another feature between the two features instead of being in direct contact. Moreover, when the first feature is described as "on", "above", or "over" the second feature, the first feature is right on, above, or over the second feature or the first feature is obliquely on, above, or over the second feature, or the first feature is simply at a higher level than the second feature. When the first feature is described as "under", "below", or "underneath" the second feature, the first feature is right under, below, or underneath the second feature or the first feature is obliquely under, below, or underneath the second feature, or the first feature is simply at a lower level than the second feature.

[0010] In the description of this embodiment, orientations or position relations indicated by terms such as "upper", "lower" and "right" are based on orientations or position relations shown in the drawings. These orientations or position relations are intended only to facilitate description and simplify operations and not to indicate or imply that a device or element referred to must have such specific orientations or must be configured or operated in such specific orientations. Thus, these orientations or position relations are not to be construed as limiting the present application. In addition, the terms "first" and "second" are used only to distinguish between descriptions and have no special meaning.

Embodiment one

[0011] This embodiment provides a control method for a water heating system that can be used in a water heating system having a gas heating module and a heat-pump heating module. The control method for a water heating

system can integrate the operation costs of the water heating system and provide users with an economical and stable hot water heating mode to reduce the operation costs and the failure rate of the water heating system.

[0012] The control method for a water heating system includes: acquiring a recommended heating mode according to electric power information and gas information; in response to the recommended heating mode being a heat-pump heating mode, acquiring an inlet water temperature at an inlet end of the heat-pump heating module; and in response to the inlet water temperature being lower than a preset water temperature, activating the heat-pump heating module.

[0013] In one embodiment, as shown in FIG. 1, after the water heating system is activated, the recommended heating mode is acquired according to the electric power information and the gas information. It is possible to acquire a more economical heating mode by comprehensively considering the power information and the gas information. If the operation cost of the gas heating module is lower than the operation cost of the heat-pump heating module, the recommended heating mode is the gas heating mode, and the water heating system activates the gas heating module. On the contrary, if the operation cost of the gas heating module is higher than the operation cost of the heat-pump heating module, the recommended heating mode is the heat-pump heating mode, and the water heating system activates the heat-pump heating module.

[0014] The efficiency of the heat pump is related to the water temperature at the inlet end of the heat-pump heating module. Therefore, when the water temperature at the inlet end is relatively high, the efficiency of the heat-pump heating module is relatively low; and when the water temperature at the inlet end is relatively low, the efficiency of the heat-pump heating module is relatively high. To ensure the heat-pump heating module to work at a relatively high efficiency, if the recommended heating mode is the heat-pump heating mode, the water heating system, before activating, also acquires the inlet water temperature at the inlet end of the heat-pump heating module. If the inlet water temperature is lower than the preset water temperature, the heat-pump heating module is activated. On the contrary, if the inlet water temperature is higher than the preset water temperature, the water heating system activates the gas heating module to heat the water in the gas heating mode.

[0015] The inlet water temperature is compared with the preset water temperature to ensure the heat-pump heating module to have a relatively high efficiency when activated, thereby increasing the heating rate. Moreover, when the inlet water temperature is lower than the preset water temperature, the heat-pump heating module is activated, avoiding the high-temperature alarm of the heat-pump heating module caused by the excess temperature at the water inlet end, thereby avoiding the failure of the heat-pump heating module, and improving the stability of the water heating system.

[0016] In one embodiment, the preset water temperature can be set according to actual requirements. In one embodiment, the preset water temperature may be 50 °C to 60 °C.

[0017] The step in which the recommended heating mode is acquired according to the electric power information and the gas information includes the steps below.

[0018] A critical energy efficiency η_{critical} is acquired.

[0019] A current energy efficiency η of the heat-pump heating module is acquired. If the current energy efficiency η is not less than the critical energy efficiency η_{critical} , the recommended heating mode is determined as the heat-pump heating mode.

$$\eta_{\text{critical}} = \frac{Q_{\text{gas}} \times M_{\text{electricity}}}{Q_{\text{electricity}} \times M_{\text{gas}}}$$
, Q_{gas} is a calorific value of gas, $Q_{\text{electricity}}$ is a calorific value of electric power, M_{gas} is a gas price per unit, and $M_{\text{electricity}}$ is an electric power price per unit.

[0020] In this embodiment, the current energy efficiency of the heat-pump heating module is compared with the critical energy efficiency to select the recommended heating mode so that the control logic is simple and the recommendation result is accurate. In one embodiment, the calculation formula of the power consumption cost corresponding to per unit of heat is as follows:

$$G_{\text{electricity}} = \frac{M_{\text{electricity}}}{Q_{\text{electricity}} \times \eta}.$$

[0021] The calculation formula of the gas consumption cost corresponding to per unit of heat is as follows:

$$G_{\text{gas}} = \frac{M_{\text{gas}}}{Q_{\text{gas}}}.$$

[0022] If the power consumption cost corresponding to per unit of heat is larger than the gas consumption cost corresponding to per unit of heat, the following formula

$$\text{can be derived: } \eta < \frac{Q_{\text{gas}} \times M_{\text{electricity}}}{Q_{\text{electricity}} \times M_{\text{gas}}}.$$

[0023] That is, $\eta < \eta_{\text{critical}}$.

[0024] It can be seen from the above analysis that, in this embodiment, a more economical heating mode can be recommended for the users by comparing the current energy efficiency η with the critical energy efficiency η_{critical} .

[0025] To improve the accuracy of the recommended heating mode, the current energy efficiency η of the heat-pump heating module can be obtained by integrating a current outdoor temperature and a required temperature of water consumption of a user.

[0026] The step in which the current energy efficiency η of the heat-pump heating module is acquired includes the steps below: a current outdoor temperature is acquired; a required temperature of water consumption of a user is acquired; and an energy efficiency value corre-

sponding to the current outdoor temperature in a pre-stored heat-pump energy efficiency curve corresponding to the required temperature is acquired.

[0027] In one embodiment, heat-pump energy efficiency curves are stored in the water heating system, and different required temperatures correspond to different heat-pump energy efficiency curves. After the current outdoor temperature and the required temperature of water consumption of the user are acquired, an energy efficiency value corresponding to the current outdoor temperature is searched in the heat-pump energy efficiency curve corresponding to the required temperature, where this energy efficiency value is the current energy efficiency η of the heat-pump heating module. The heat-pump energy efficiency curve is pre-stored so that the acquired current energy efficiency is more accurate, facilitating improving the determination accuracy.

[0028] In one embodiment, in the activation process of the water heating system, the control method also includes the step below: the inlet water temperature at the inlet end of the heat-pump heating module is monitored when the heat-pump heating module is in an activated state. If the inlet water temperature is not lower than the preset water temperature, the heat-pump heating module is turned off. The inlet water temperature at the inlet end of the heat-pump heating module is monitored in real time so that the heat-pump heating module can be turned off after the heat-pump heating module efficiency decreases, thereby ensuring the economical performance of the water heating system in the working process.

[0029] In one embodiment, when it is detected that the inlet water temperature is not lower than the preset water temperature, the heat-pump heating module is turned off and the gas heating module is turned on. The gas heating mode is switched, not only ensuring the economical performance of the water heating system, but also satisfying the requirements of the water consumption of the user.

[0030] In the control method for a water heating system provided in the present application, the operation costs of the heat-pump heating module and the gas heating module are compared to acquire the recommended heating mode. If the recommended heating mode is the heat-pump heating mode, the inlet water temperature is compared with the preset water temperature to determine whether an activating condition of the heat-pump heating module is satisfied, thereby improving the economical performance of the water heating system, and avoiding the heat pump from the high-temperature alarm.

Embodiment two

[0031] This embodiment provides a control method for a water heating system. This control method is improved on the basis of embodiment one. In one embodiment, the water heating system, before acquiring the recommended heating mode, also acquires the required temperature of water consumption of the user, and acquires the recommended heating mode according to the re-

quired temperature, current electric power information, and current gas information. It is possible to better select an appropriate heating mode and improve the economical performance of the water heating system by comprehensively considering the required temperature, the current electric power information, and the current gas information.

[0032] The step of acquiring the recommended heating mode according to the required temperature, the current electric power information, and the current gas information includes the steps below: a heating time required for heating a water temperature to the required temperature in the heat-pump heating mode is acquired; time-of-use pricing information within the heating time is acquired to acquire a critical energy efficiency η_{critical} of the heat-pump heating module at a different electricity price; and a current energy efficiency η of the heat-pump heating module is compared with the critical energy efficiency η_{critical} of the heat-pump heating module in different electricity price periods, separately, and if the current energy efficiency η is not less than the critical energy efficiency η_{critical} , the recommended heating mode is determined as the heat-pump heating mode in a corresponding period.

[0033] In one embodiment, the heating time required for heating the water temperature to the required temperature in the heat-pump heating mode is acquired according to the required temperature. Some areas or users adopt time-of-use prices, i.e. a charging mode of different electricity prices at different times, so to more accurately compare the economical performance of the heat-pump heating mode and the economical performance of the gas heating mode, the time-of-use pricing information within the heating time is acquired to acquire the critical energy efficiency η_{critical} of the heat-pump heating module at a different electricity price. Then, the current energy efficiency η of the heat-pump heating module is compared with the critical energy efficiency η_{critical} of the heat-pump heating module in different electricity price periods, separately. If the current energy efficiency η is not less than the critical energy efficiency η_{critical} , the recommended heating mode is determined as the heat-pump heating mode in the corresponding period.

[0034] In the embodiment, by comparing the economic performance of the heat-pump heating mode with that of the gas heating mode in different time periods, the accuracy of the comparison results can be improved, and switching the corresponding heating mode according to the comparison results in different time periods is benefit to reduce the use cost.

[0035] In this embodiment, the calculation formula of the critical energy efficiency η_{critical} is as follows:

$$\eta_{\text{critical}} = \frac{Q_{\text{gas}} \times M_{\text{electricity}}}{Q_{\text{electricity}} \times M_{\text{gas}}}$$

[0036] Q_{gas} is a calorific value of gas, $Q_{\text{electricity}}$ is a calorific value of electric power, M_{gas} is a gas price per unit, and $M_{\text{electricity}}$ is an electric power price per unit.

[0037] In one embodiment, the control method also includes the steps below: after the water heating system is activated, parameters are updated every preset time; and the recommended heating mode is re-acquired according to the updated parameters, the parameters include the electric power information, the gas information, and the inlet water temperature. The parameters are updated so that the heating mode can be adjusted in time to ensure the water heating system to operate in the most economical mode.

[0038] In one embodiment, if the water heating system activates the heat-pump heating module for heating, the control method also includes the step below: a temperature rise rate of water heating and a preset temperature rise rate are acquired and compared to determine whether the heat-pump heating module works normally. If the temperature rise rate of water heating is less than the preset temperature rise rate, the heat-pump heating module is turned off, and the gas heating module is activated.

[0039] When the temperature rise rate of water heating is less than the preset temperature rise rate, it indicates that the heat-pump heating module works abnormally, resulting in unsatisfactory final heating results. To satisfy the user requirements and reduce the energy efficiency, in this case, the heat-pump heating module is turned off in time and switched to the gas heating mode, reducing the loss.

[0040] In one embodiment, the preset temperature rise rate may be calculated according to the current energy efficiency η of the heat-pump heating module, power of the heat-pump heating module, and the current outdoor temperature.

[0041] In some embodiments, after it is detected that the temperature rise rate of water heating is less than the preset temperature rise rate, the heat-pump heating module is turned off and a repair is reported to eliminate potential safety hazards.

Claims

1. A control method for a water heating system, wherein the water heating system comprises a gas heating module and a heat-pump heating module, wherein the gas heating module and the heat-pump heating module are selectively activatable; the control method for a water heating system comprises:

acquiring a recommended heating mode according to electric power information and gas information;
in response to the recommended heating mode being a heat-pump heating mode, acquiring an inlet water temperature at an inlet end of the heat-pump heating module; and
in response to the inlet water temperature being

lower than a preset water temperature, activating the heat-pump heating module.

2. The control method for a water heating system of claim 1, wherein the acquiring a recommended heating mode according to electric power information and gas information comprises:

acquiring a critical energy efficiency η_{critical} ;
acquiring a current energy efficiency η of the heat-pump heating module, and in response to the current energy efficiency η being not less than the critical energy efficiency η_{critical} , determining the recommended heating mode as the heat-pump heating mode,

wherein
$$\eta_{\text{critical}} = \frac{Q_{\text{gas}} \times M_{\text{electricity}}}{Q_{\text{electricity}} \times M_{\text{gas}}},$$

 Q_{gas} is a calorific value of gas, $Q_{\text{electricity}}$ is a calorific value of electric power, M_{gas} is a gas price per unit, and $M_{\text{electricity}}$ is an electric power price per unit.

3. The control method for a water heating system of claim 2, wherein the acquiring a current energy efficiency η of the heat-pump heating module comprises:

acquiring a current outdoor temperature;
acquiring a required temperature of water consumption of a user; and
acquiring an energy efficiency value corresponding to the current outdoor temperature in a pre-stored heat-pump energy efficiency curve corresponding to the required temperature.

4. The control method for a water heating system of claim 1, further comprising:

acquiring a required temperature of water consumption of a user; and
acquiring the recommended heating mode according to the required temperature, current electric power information, and current gas information.

5. The control method for a water heating system of claim 4, wherein the acquiring a recommended heating mode according to the required temperature, current electric power information, and current gas information comprises:

acquiring a heating time required for heating a water temperature to the required temperature in the heat-pump heating mode;
acquiring time-of-use pricing information within the heating time to acquire a critical energy ef-

efficiency η_{critical} of the heat-pump heating module
 at a different electricity price; and
 comparing a current energy efficiency η of the
 heat-pump heating module and the critical en-
 ergy efficiency η_{critical} of the heat-pump heating
 module in different electricity price periods, sep-
 arately; and in response to the current energy
 efficiency η being not less than the critical en-
 ergy efficiency η_{critical} , determining the recom-
 mended heating mode as the heat-pump heat-
 ing mode in a corresponding period,

wherein $\eta_{\text{critical}} = \frac{Q_{\text{gas}} \times M_{\text{electricity}}}{Q_{\text{electricity}} \times M_{\text{gas}}}$, Q_{gas}
 is a calorific value of gas, $Q_{\text{electricity}}$ is a calorific
 value of electric power, M_{gas} is a gas price per
 unit, and $M_{\text{electricity}}$ is an electric power price per
 unit.

6. The control method for a water heating system of
 any one of claims 1 to 5, further comprising:

monitoring the inlet water temperature at the in-
 let end of the heat-pump heating module when
 the heat-pump heating module is in an activated
 state; and

in response to the inlet water temperature not
 being lower than the preset water temperature,
 turning off the heat-pump heating module.

7. The control method for a water heating system of
 any one of claims 1 to 5, further comprising:

updating parameters every preset time after the
 water heating system is activated, and
 re-acquiring the recommended heating mode
 according to the updated parameters, wherein
 the parameters comprise the electric power in-
 formation, the gas information, and the inlet wa-
 ter temperature.

8. The control method for a water heating system of
 any one of claims 1 to 5, after the activating the heat-
 pump heating module, further comprising:

acquiring a temperature rise rate of water heat-
 ing and a preset temperature rise rate; and
 in response to the temperature rise rate of water
 heating being less than the preset temperature
 rise rate, turning off the heat-pump heating mod-
 ule, and activating the gas heating module.

9. The control method for a water heating system of
 claim 8, wherein the acquiring a preset temperature
 rise rate comprises:

calculating the preset temperature rise rate accord-
 ing to the current energy efficiency η of the heat-

pump heating module, power of the heat-pump heat-
 ing module, and the current outdoor temperature.

10. The control method for a water heating system of
 claim 1, after the activating the heat-pump heating
 module, further comprising:

acquiring a temperature rise rate of water heat-
 ing and a preset temperature rise rate; and
 in response to the temperature rise rate of water
 heating being less than the preset temperature
 rise rate, turning off the heat-pump heating mod-
 ule and reporting a repair.

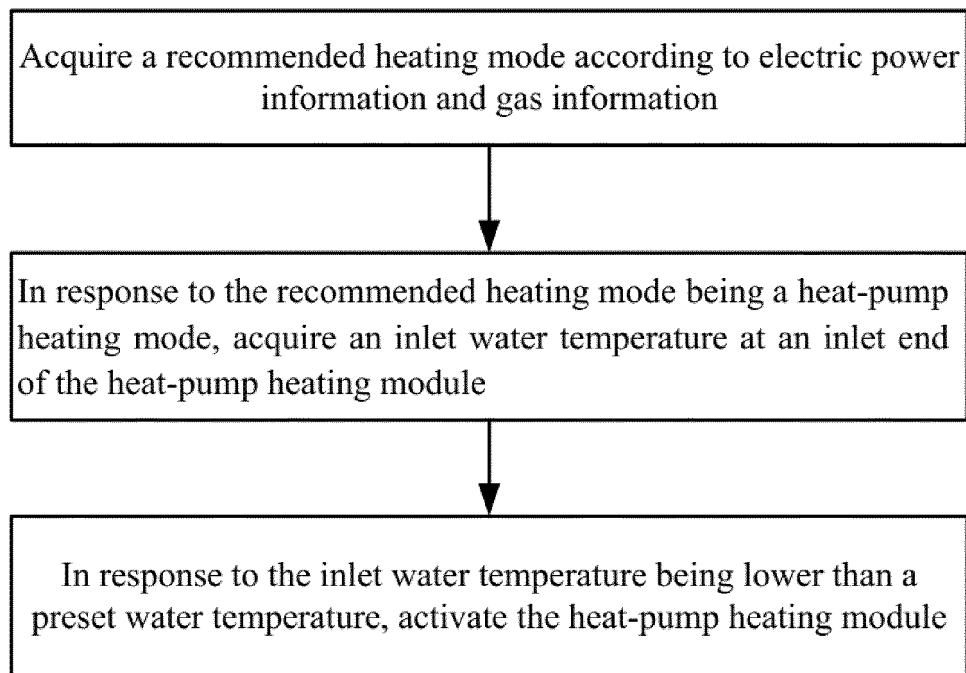


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/110748

A. CLASSIFICATION OF SUBJECT MATTER F24H 9/20(2022.01)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) F24H9/-,F24H4/-,F24H1/-																				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNABS, CNTXT, CNKI, DWPI, VEN, EPTXT, USTXT, WOTXT: 热水系统, 热水器, 热水装置, 燃气, 热泵, 加热, 选择, 推荐, 入水水温, 入口水温, 进水温度, 进水温, 进口水温, 进口温度, 电价, 单价, 能效, 热值, 上限温度, 需求温度, 温升率, 温升速率, 故障, 报修, 经济, 费用, hot water, water heater?, fuel gas, heat pump?, choice, choos+, select+, recommend+, inlet temperature, electric+ price, efficienc+, heat value, ris+ ratio+, fault+, econom+, cost+																				
C. DOCUMENTS CONSIDERED TO BE RELEVANT																				
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>PX</td> <td>CN 113758015 A (QINGDAO ECONOMIC & TECHNOLOGY DEVELOPMENT ZONE HAIER WATER HEATER CO., LTD. et al.) 07 December 2021 (2021-12-07) claims 1-10</td> <td>1-10</td> </tr> <tr> <td>Y</td> <td>CN 102444986 A (A.O. SMITH CORPORATION) 09 May 2012 (2012-05-09) description, paragraphs 0004-0031, and figures 1-5</td> <td>1-10</td> </tr> <tr> <td>Y</td> <td>CN 104101088 A (FUZHOU AQUAPOWER ELECTRIC WATER HEATER CO., LTD.) 15 October 2014 (2014-10-15) description, paragraphs 0028-0047, and figures 1-2</td> <td>1-10</td> </tr> <tr> <td>Y</td> <td>CN 102997443 A (SHUNDE POLYTECHNIC) 27 March 2013 (2013-03-27) description, paragraphs 0004-0014</td> <td>4-5</td> </tr> <tr> <td>A</td> <td>CN 112556165 A (QINGDAO ECONOMIC & TECHNOLOGY DEVELOPMENT ZONE HAIER WATER HEATER CO., LTD. et al.) 26 March 2021 (2021-03-26) entire document</td> <td>1-10</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	PX	CN 113758015 A (QINGDAO ECONOMIC & TECHNOLOGY DEVELOPMENT ZONE HAIER WATER HEATER CO., LTD. et al.) 07 December 2021 (2021-12-07) claims 1-10	1-10	Y	CN 102444986 A (A.O. SMITH CORPORATION) 09 May 2012 (2012-05-09) description, paragraphs 0004-0031, and figures 1-5	1-10	Y	CN 104101088 A (FUZHOU AQUAPOWER ELECTRIC WATER HEATER CO., LTD.) 15 October 2014 (2014-10-15) description, paragraphs 0028-0047, and figures 1-2	1-10	Y	CN 102997443 A (SHUNDE POLYTECHNIC) 27 March 2013 (2013-03-27) description, paragraphs 0004-0014	4-5	A	CN 112556165 A (QINGDAO ECONOMIC & TECHNOLOGY DEVELOPMENT ZONE HAIER WATER HEATER CO., LTD. et al.) 26 March 2021 (2021-03-26) entire document	1-10		
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Date of the actual completion of the international search 24 October 2022	Date of mailing of the international search report 16 November 2022																			
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China Facsimile No. (86-10)62019451	Authorized officer Telephone No.																			

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INTERNATIONAL SEARCH REPORT

International application No.
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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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