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54 **NATURAL CIRCULATION-TYPE HOT WATER STORAGE HEATER.**

57 A natural circulation-type hot water storage heater for storing hot water obtained from a water storage tank (as water or hot water) at the bottom through a first circulation pipe, a heat exchanger and a second circulation pipe into a tank. A thermovalve is mounted within the second circulation pipe on the downstream side of the heat exchanger to vary its opening area in response to the hot water temperature to thereby substantially maintain constant the temperature of the hot water from the heat exchanger. As a result, the temperature distribution at the time the water is boiling in the water storage tank is rendered substantially constant instantaneously so as to increase the effective hot water storage amount. In addition, the hot water temperature is held constant without fluctuation regardless of the repetitive ON and OFF operation of a burner, and will not fluctuate even if the burner is turned ON when hot water is supplied. Instead, the time during which the hot water is continuously supplied at constant temperature is prolonged to provide an effective hot water storage amount which is greater than the inside volume of the water storage tank.

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FIG. 4

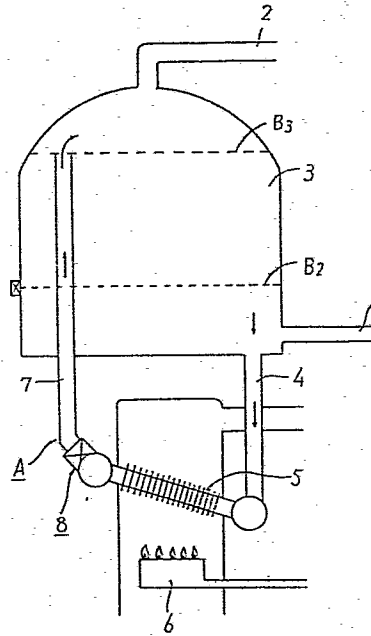
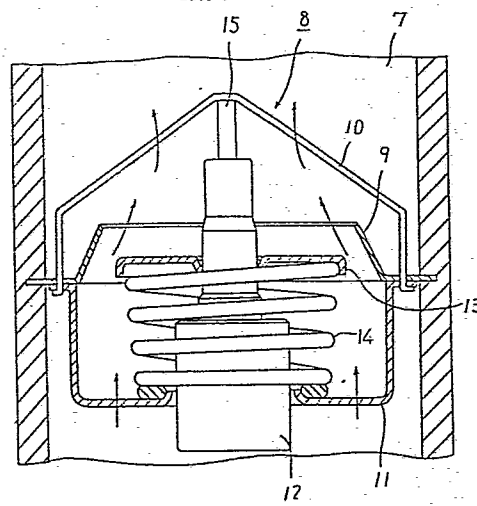


FIG. 6



TITLE MODIFIED
see front page

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Title of the Invention

A Hot-Water Storage Type Hot-Water Supply Apparatus
Operating Under a Natural Circulation Principle

Technical Field of the Invention

The present invention relates to an improvement in a hot-water storage type hot-water supply apparatus operating under a natural circulation principle.

5

Background Art

Now a hitherto known hot-water storage type hot-water supply apparatus operating under the natural circulation principle will be explained in reference to Figure 1 of the attached drawings. As shown in the drawing, water contained within a hot-water storage tank (3) provided with a water feed orifice (1) and a hot-water supply orifice (2) is fed through a first circulation pipe (4) connected to the bottom of tank (3) to a heat exchanger (5) to be heated by a burner or a combustor (6), the water thus heated being supplied through a second circulation pipe (7) to the upper portion within tank (3).

20 In this case, assuming that the mean density of water flowing through first circulation pipe (4) is $\bar{r}_1$, the mean density of hot-water flowing through second circulation pipe (7) is $\bar{r}_2$, and the height from the mid-

dle position of heat exchanger (5) to the boundary surface between the hot-water and the cold-water within hot-water storage tank (3) is $\underline{H}_1$, the natural circulation force $\underline{F}$ is formulated as follows :

$$5 \quad F = (\bar{r}_1 - \bar{r}_2) \cdot H_1 \quad (1)$$

It has also been known that the flow rate $\underline{w}$ of the cold- or hot-water passing through a circulation passage $\underline{A}$ comprising first circulation pipe (4), heat exchanger (5) and second circulation pipe (7) is related to the natural circulation force $\underline{F}$ by the following equation :

$$w \propto F^n \quad (n \geq 1) \quad (2)$$

15 Further, assuming that the heat quantity given to the water in heat exchanger (5) by the heat from combustor (6) is $\underline{Q}$, the specific heat at constant pressure is $\underline{C}_p$, and each of the temperatures of the cold- and hot-water at the entrance and the exit of heat exchanger (5) are $\underline{T}_{in}$ and $\underline{T}_{out}$, respectively, the next equation is given :

$$w = Q / C_p \quad (\underline{T}_{out} - \underline{T}_{in}) \quad (3)$$

Therefore, the equations (2) and (3) become as follows:

$$25 \quad \frac{1}{(\underline{T}_{out} - \underline{T}_{in})} \propto F^n \quad (4)$$

Thus, it will be appreciated that the smaller the natural circulation force $\underline{F}$, the larger the temperature difference $(\underline{T}_{out} - \underline{T}_{in})$ becomes.

In short, as shown in Figure 1, if the hot-water accumulates as high within hot-water storage tank (3) as a level denoted by the dot-and-dash line $\underline{B}_1$, height $\underline{H}$ decreases to as low as $\underline{H}_1$, while $(\bar{r}_1 - \bar{r}_2)$ increases

a bit, but, since the degree of decrease in $\underline{H}$ is larger than the degree of increase in $(\bar{r}_1 - \bar{r}_2)$, the natural circulation force $\underline{F}$ as represented by formula (1) decreases so that the temperature difference

5 ($\underline{T}_{out} - \underline{T}_{in}$) in the temperature of the water before and after the heat exchanger becomes large. This means that the larger the hot-water volume accumulated in the upper part of hot-water tank (3), the larger

the temperature difference ($\underline{T}_{out} - \underline{T}_{in}$) becomes.

10 From the above reasons, the temperature distribution of the hot-water in hot-water storage tank (3) of the conventional hot-water supply apparatus at the time of the boiling of the hot-water can be expressed by the diagram shown in Figure 2, revealing a temperature

15 gradient wherein the low temperature water exists at the bottom of the tank in the initial stage of the hot-water storage, and the higher the level of the hot-water from the bottom of tank 3, the higher the temperature of the hot-water becomes. Therefore, it has

20 such defect that the volume of the high temperature hot-water available for practical use, i.e. the effective hot-water storage volume is less than the actual inner volume of the tank.

25 And, at the time of the supply of the hot-water, since, with the supply of hot-water, the circulation force $\underline{F}$, i.e. the discharge volume from second circulation pipe (7), varies, the boundary surface between the hot-water and the cold-water varies so that the actuation

30 and the shutting off of combustor (6) are repeated. In this case, since at the time of the actuation of the combustor the volume of the hot-water accumulated in the hot-water storage tank is small, the natural circulation force $\underline{F}$ becomes large, and the temperature of

35 the hot-water flowing out of second circulation pipe (7) becomes low, so the temperature of the hot-water

to be supplied too becomes low. Inversely, since at the time of the shutting off of the combustor the volume of the hot-water accumulated in the hot-water storage tank is large, the natural circulation force
5 F is small, so the high temperature hot-water is supplied. Thus, as shown in Figure 3 the variation in temperature of the hot-water at the time of its supply is large. Therefore, the conventional hot-water supply apparatus is not suited for use with, for exam-
10 ple, a shower bath, etc.

Summary of the Invention

It is an object of the present invention to eliminate such defects in the conventional hot-water supply ap-
15 paratus and provide a hot-water supply apparatus in which a thermal valve is mounted to a circulation pipe downstream of a heat exchanger, which thermal valve operates such that when the temperature of the hot-water becomes high its opening area is enlarged, whe-
20 reas when the temperature of the hot-water becomes low its opening area is narrowed, so that the temperature distribution of the boiled hot-water within the hot-water storage tank is kept nearly constant throughout the tank, thereby increasing the effective
25 hot-water storage volume and eliminating the variation in temperature at the time of hot-water supply.

Brief Explanation of the Drawings

Figures 1 to 3 show a conventional hot-water supply
30 apparatus wherein Figure 1 is a diagrammatical vertical sectional view of the apparatus as a whole, Figure 2 is a diagram showing the temperature distribution in the tank at the time of the boiling of the hot-water and Figure 3 is a diagram showing the varia-
35 tion in hot-water temperature at the time of its sup-

ply.

Figures 4 to 8 show one embodiment of a hot-water supply apparatus in accordance with the present invention in which Figure 4 is a diagrammatical vertical sectional view of the apparatus as a whole, Figure 5 is a vertical sectional view of the thermal valve in its closed state, Figure 6 is a vertical sectional view of the thermal valve in its opened state, Figure 7 is a diagram showing the temperature distribution in the tank at the time of the boiling of hot-water, and Figure 8 is a diagram showing the variation in hot-water temperature during its supply.

Figure 9 is a graph showing changes in the hot-water temperature during its supply for the conventional hot-water supply apparatus and the apparatus in accordance with the present invention.

Detailed Description

Now the present invention will be explained fully in connection with its one example in reference to the attached drawings.

In Figure 4, the reference numeral (1) shows a water inlet orifice, (2) a hot-water supply orifice, (3) a hot-water storage tank, (4) a first circulation pipe, (5) a heat exchanger, (6) a burner or combustor, and (7) a second circulation pipe. The present invention is characterized in the provision of a thermal valve (8) interposed in a circulation passage A at second circulation pipe (7) downstream of heat exchanger (5), thermal valve (8) operating such that when the temperature of the hot-water becomes high its opening area is enlarged and when the temperature of the hot-water becomes low its opening area is narrowed.

As shown in Figure 5 thermal valve (8) comprises an orifice plate (9) fixedly mounted to the inner wall of second circulation pipe (7) near the exit of the heat exchanger and having generally a hollow truncated conical shape, a pin abutting plate (10) fixedly secured to orifice plate (9), a coil spring seating plate (11) fixedly secured to orifice plate (9), a coil spring (14) laid on spring fixing plate (11) centrally thereof, a movable circular disc (13) secured to coil spring (14) at its top, a temperature feeler (12) fixedly secured to disc (13) and having thermal wax sealingly filled therein, and pin (15) protruded through temperature feeler (12) centrally thereof so as to be freely axially movable and having its upper end abutted against pin abutting plate (10).

The thermal wax sealed within temperature feeler (12) changes its state from the solid phase to the liquid phase or vice versa depending on the temperature of the hot-water, to expand or contract so that pin (15) is projected or withdrawn from or into temperature feeler (12) due to the equilibration of the force acting on movable plate (13) from spring (14) on the one hand and from temperature feeler (12) on the other hand. Therefore, in the state where the thermal wax is contracted owing to the low temperature of the surrounding hot-water, temperature feeler (12) is urged upwards relative to spring abutting plate (11) as viewed in Figure 5 so that the area for the passage of the hot-water formed between the opening of conical-shaped orifice plate (9) and circular movable disc (13) is made small, whereby the circulation flow rate w is made small. Inversely, when the temperature of the hot-water becomes high the thermal wax expands, so movable disc (3) moves downwards against the action of spring (14) as viewed in Figure 5 in the man-

ner contrary to that abovesaid. Therefore, the flow passage formed between the opening of orifice plate (9) and movable disc (13) is made large as shown in Figure 6, whereby the circulation flow rate $\underline{w}$ is made
5 large.

Now the operation of the hot-water supply apparatus provided with the thermal valve according to the present invention will be explained below.

10

In Figures 4 to 6, when the apparatus is to be operated for the storage hot-water within the storage tank, combustor (6) is ignited so that the hot-water flowing from heat exchanger (5) begins to accumulate in
15 the upper part of hot-water tank (3) through second circulation pipe (7). At this time, in the conventional hot-water supply apparatus, if a small quantity of hot-water has been already accumulated in the upper part of tank (3), since the natural circulation force
20 $\underline{F}$ is large, the circulation flow rate $\underline{w}$ is large so that the temperature of the hot-water at the exit of heat exchanger (5) becomes low. Contrarily, in the present invention, when the hot-water temperature at the exit of heat exchanger (5) has a tendency to be
25 lowered, temperature feeler (12) of thermal valve (8) detects this tendency and operates so as to cause the flow area to be made small, thereby lowering the flow rate. Further, in the conventional hot-water supply apparatus, when a volume of the hot-water is accumula-
30 ted within tank (3), since the natural circulation force $\underline{F}$ is small, the flow rate $\underline{w}$ is made small so that the hot-water temperature at the exit of heat exchanger (5) becomes high, but, in the present invention, when the hot-water temperature at the exit of
35 the heat exchanger has a tendency to be increased, thermal valve (8) detects this tendency and operates

to cause the flow rate of the hot-water to be increased. Therefore, in the present invention, the circulation flow rate w is maintained always substantially constant regardless of the hot-water volume accumulated within tank (3). Thus, in the present invention,
5 hot-water temperature T_{out} at the exit of heat exchanger (5) is controlled so as to be substantially constant by such operation of thermal valve (8).

10 Therefore, the temperature distribution of the hot-water within the hot-water storage tank at the time of boiling is made to be substantially constant over the total height of the tank as shown in Figure 7, resulting in the hot-water accumulation within the storage tank being as effective as possible relative to
15 its inner volume.

At the time of supplying hot-water in the apparatus according to the present invention, when the supply
20 volume of the hot-water becomes less than the circulation flow rate w , even though combustor (6) repeats ignition and extinguishing, since hot-water at a substantially constant temperature is fed through second circulation pipe (7), continuous hot-water
25 supply can be carried out while being kept at a stable temperature irrespective of whether the combustor is ignited or not, as shown in Figure 8.

In the case where the volume of the hot-water supply
30 is larger than the circulation flow rate w , with the assumption that combustor (6) is to be ignited when the water has been supplied to as high a level as B_2 shown by the dot-and-dash line in Figure 4 and the hot-water supply volume is W , and that the hot-water accumulation volume from level B_2 to the position of
35 the exit opening of second circulation pipe (7) (the

dot-and-dash line B3) is represented by V_o and the natural circulation flow rate is represented by w, the change in hot-water temperature is shown in Figure 9. In the conventional hot-water supply apparatus, as shown by the dot-and-dash line x, the change in hot-water temperature occurs simultaneously with the start of the ignition of the combustor (point C). Contrarily, in the hot-water supply apparatus according to the present invention, since temperature T_{out} of the hot-water flowing through second circulation pipe (7) by natural circulation is kept substantially constant, the hot-water supply volume becomes (W - w) in substance. Therefore, as shown by the solid line Y in Figure 9, after the start of ignition (point c), it is possible to supply hot-water at a constant temperature for a longer period of time as formulated by the following equation :

$$V_o / (W - w) - V_o / W \quad (5)$$

This means that the present invention has an effective hot-water accumulation volume larger than the inner volume of the hot-water storage tank.

Patent claims

1. A hot-water storage type hot-water supply apparatus operating under a natural circulation principle having a hot-water storage tank and a hot-water circulation pipe having one end thereof connected to the
5 bottom of said tank with the other end thereof being located at an upper position within said tank and with a heat exchanger disposed between said one end and said other end, whereby hot-water heated by said heat exchanger is stored in said tank from its upper portion, characterized in that said circulation pipe is
10 provided with a thermal valve downstream of said heat exchanger such that it operates to increase its opening area when the temperature of said hot-water becomes high, whereas it operates to decrease its opening area when the temperature of said hot-water becomes low, whereby the temperature of said hot-water
15 flowing out from said heat exchanger is kept substantially constant.
- 20 2. A hot-water storage type hot-water supply apparatus operating under a natural circulation principle as claimed in claim 1 wherein said heat exchanger is adapted to be heated by a combustor.

A schematic diagram of a gas analysis apparatus. It features a large spherical chamber (3) with two horizontal dashed lines indicating internal levels or zones labeled B_I. A vertical tube (7) enters from the top left, passes through the upper zone, and has an upward arrow. Another vertical tube (4) enters from the right, passes through the lower zone, and has a downward arrow. These tubes are connected at their bases by a horizontal assembly containing a coiled spring-like element (5). This assembly is positioned above a rectangular burner unit (6) which contains four lit flames. The entire setup is mounted on a base. Labels include 1, 2, 3, B_I, 4, 5, 6, 7, and dimension lines I and II.

FIG. 2

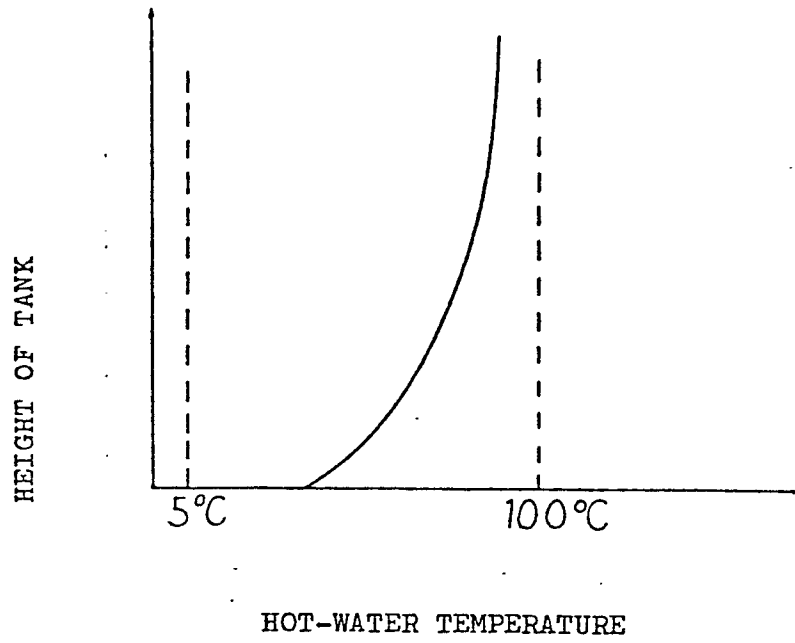


FIG. 3

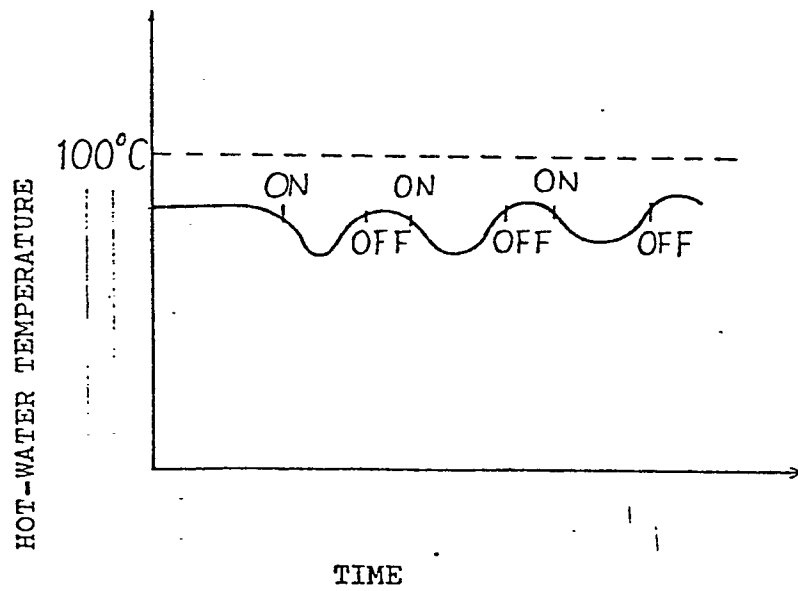


FIG. 4

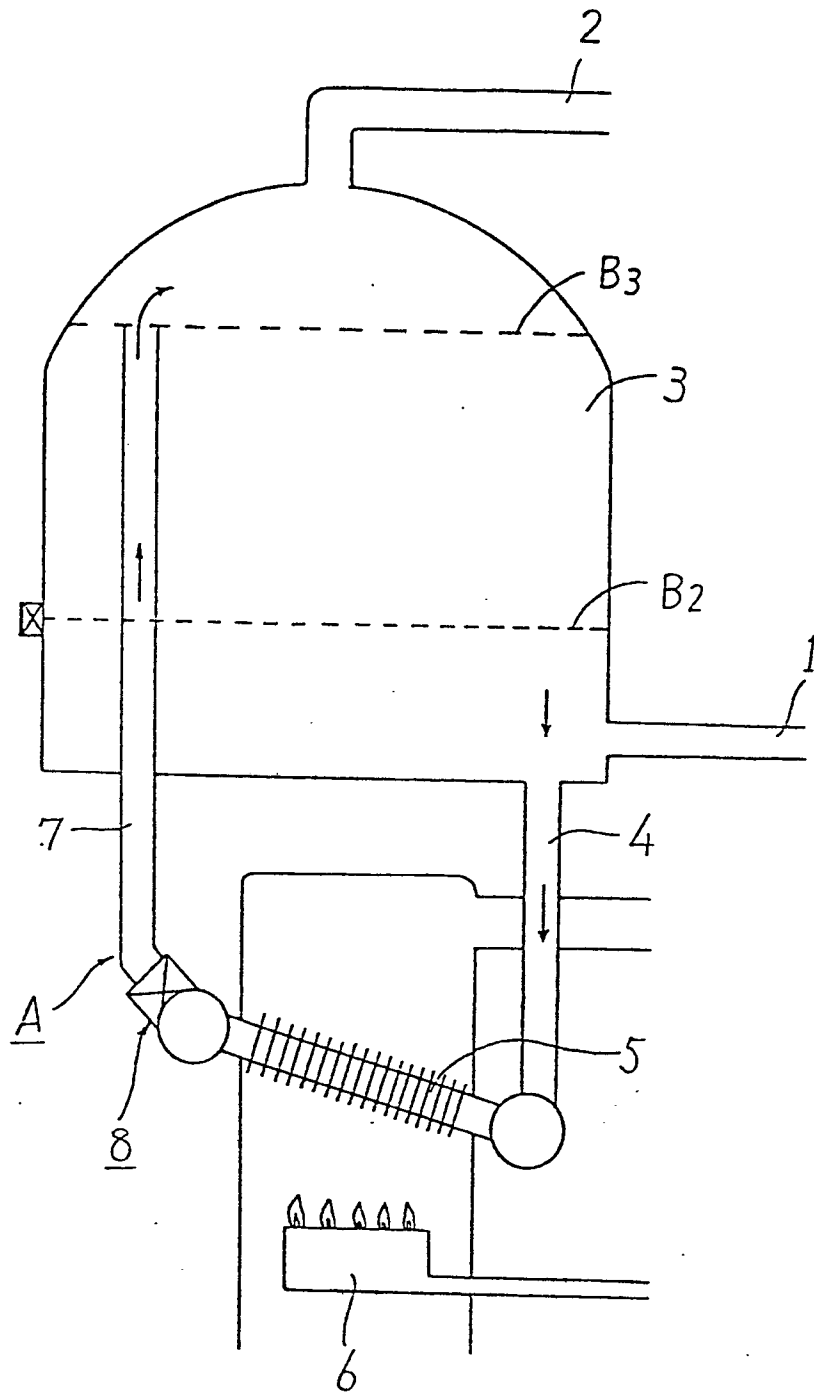


FIG. 5

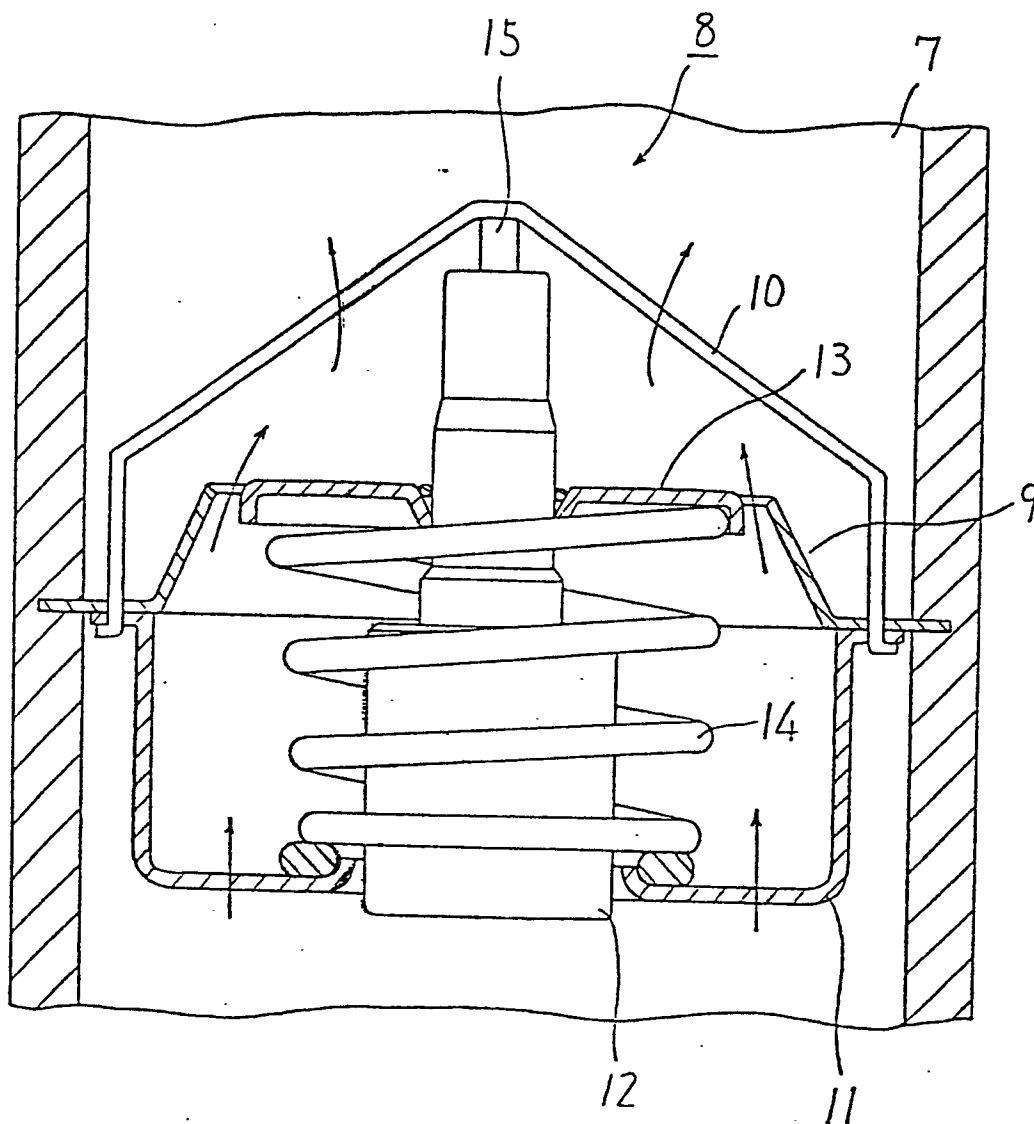


FIG. 6

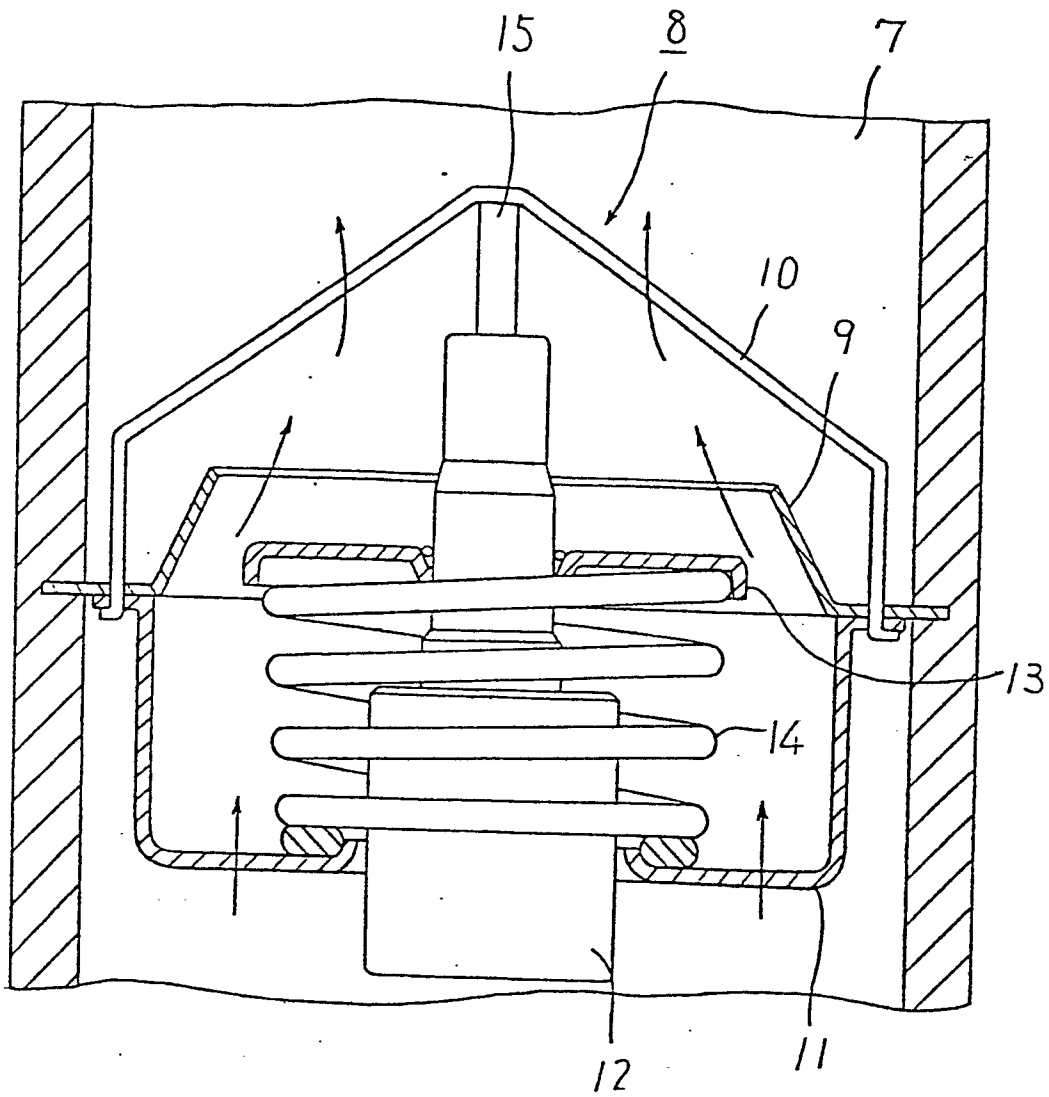


FIG. 7

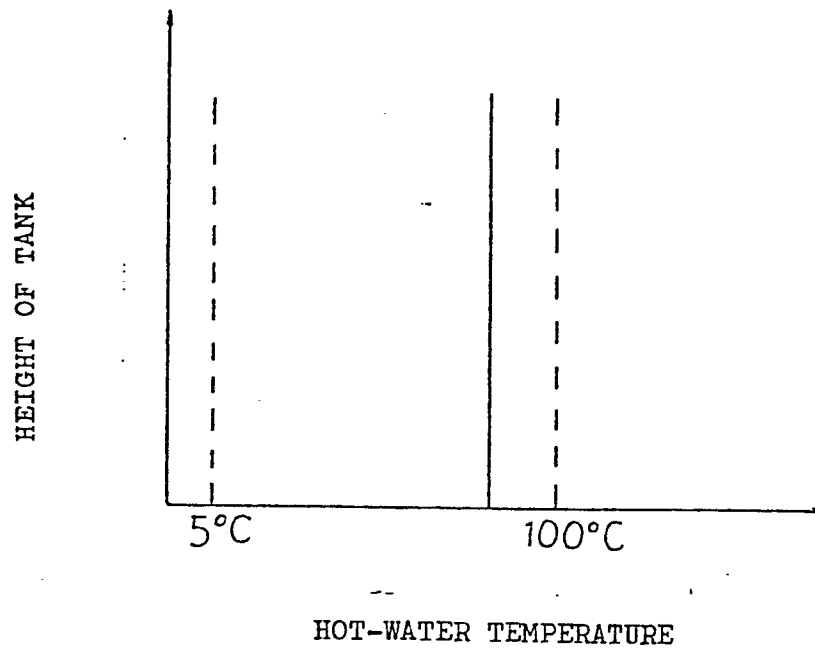


FIG. 8

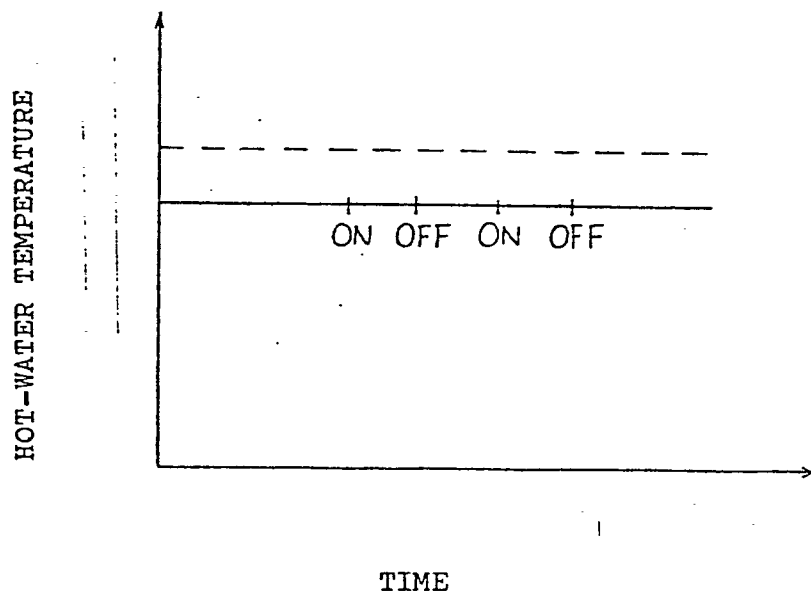
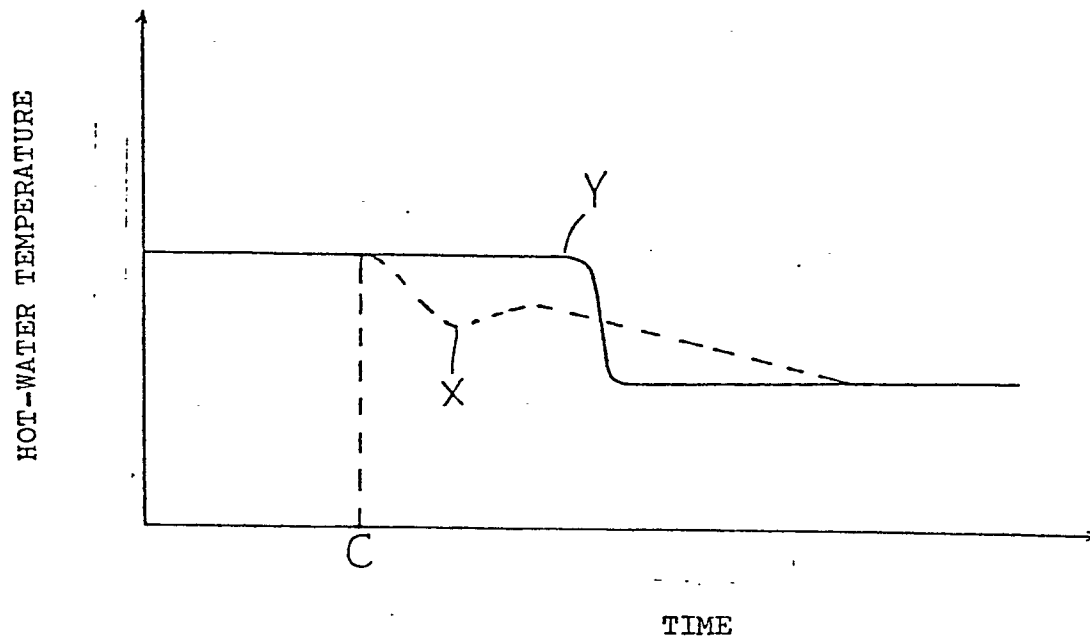


FIG. 9



INTERNATIONAL SEARCH REPORT

0034186

International Application No PCT/JP80/00113

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl. ³ F24H 9/20		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
I P C	F24H 1/18 - 20	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
Kokai Jitsuyo Shinan Koho 1972 - 1977		
Jitsuyo Shinan Koho 1960 - 1977		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	JP, U52-158951 1977-12-2 Specification appended Application Document of Utility Model Application No. 68181/1976 and microfilm photographed contents of Drawing (1977-12-2) See page 4, lines 2 to 10	1, 2
X	JP, U52-6847 1977-1-18 See right column, lines 2 to 6	1, 2
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IV. CERTIFICATION		
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