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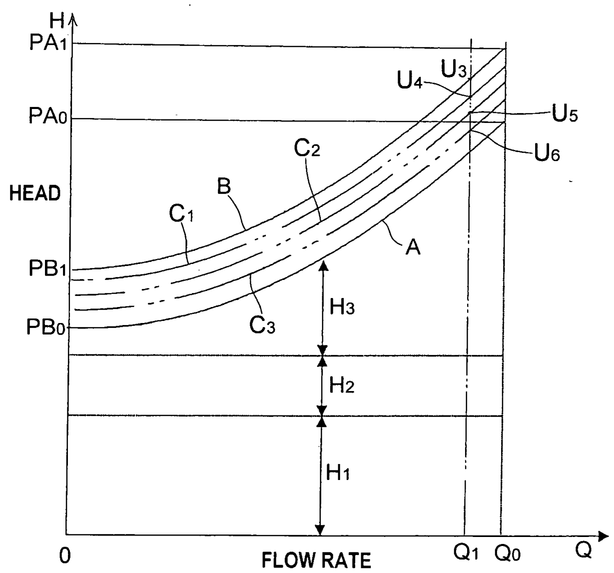
(54) **WATER SUPPLY DEVICE**

(57) A water supply apparatus is configured to meet energy-saving demands by controlling a pump so that the rotational speed of the pump is lowered while keeping a constant flow rate. The water supply apparatus includes a pump for pressurizing and delivering water, a frequency converter for supplying electric power to the pump to operate the pump at a variable rotational speed, a discharge-side pressure sensor for detecting a pressure at a discharge side of the pump, and a controller (15) for controlling the rotational speed of the pump. The controller (15) stores a plurality of control head curves (B, C_1, C_2, C_3) representing different relationships between flow rates (Q) and heads (H), and controls the rotational speed of the pump based on an alternatively selected one of the control head curves (B, C_1, C_2, C_3).

FIG. 4



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Description

Technical Field

[0001] The present invention relates to a water supply apparatus for supplying water such as tap water to collective housing or a building using a pump.

Background Art

[0002] As an apparatus installed in collective housing or a building for supplying water to each of water supply ends, there has been a water supply apparatus. FIG. 1 shows a typical example of such water supply apparatus. The water supply apparatus includes two pumps 1 combined with respective motors M for pressurizing and delivering water, and inverters (frequency converters) 2 for supplying electric power to the motors M for driving the respective pumps 1. The water supply apparatus includes a pressure tank 3 and a discharge-side pressure sensor 4 at the discharge side of the pumps 1, and flow switches (flow rate detecting means) 6 and check valves 7 for the respective pumps 1. A suction-side pipe 8 of the pumps 1 is connected to a water main 9. A suction-side pressure sensor 10 and a backflow prevention device 11 are provided in the suction-side pipe 8. Further, a bypass pipe 12 for supplying water only by the pressure of the water main 9 is provided between the suction-side pipe 8 and a discharge-side pipe 13 for the pumps 1. A check valve 14 is provided in the middle of the bypass pipe 12. A controller 15 for controlling the pumps 1 controls the rotational speeds of the pumps 1 and the number of operating pumps 1 according to the situation, based on signals from these sensors.

[0003] If the water supply apparatus is not a directly connected water supply apparatus whose suction-side pipe of the pump is connected to the water main, but is a receiving tank type water supply apparatus, then the suction-side pipe of the pump is connected to a water receiving tank, and a water level detector provided in the water receiving tank is connected to the controller. The receiving tank type water supply apparatus is free of the backflow prevention device, the suction-side pressure sensor, and the bypass pipe.

[0004] FIG. 2 shows a required head curve A representing the relationship between a usage flow rate and a pump head required for the usage flow rate, and a standard control head curve B established based on the required head curve A, as well as Q-H curves of the pump (rotational speeds N_1, N_2, N_3 of the pump). In FIG. 2, the horizontal axis represents the flow rate Q, and the vertical axis represents the pump head (head) H.

[0005] The required head curve A is determined from the sum ($H_1 + H_2 + H_3$) of the head H_1 of, for example, the building (the height of the highest floor of the building), the pressure H_2 required for the water supply instrument (pressure loss caused by the water supply instrument), and the piping loss H_3 depending on the flow rate. In the illustrated example, the required head curve A is plotted as a curve smoothly interconnecting a head PB_0 required when the usage flow rate is nil and a head PA_0 required when the usage flow rate is of a final point Q_0.

[0006] The required head curve A is determined from the relationship between an ideal pump head and a usage flow rate. For actual designs, it has widely been customary to establish the standard control head curve B which is higher than the required head curve A by a margin of, e.g. a dozen %, and to control the rotational speed of the pump based on the standard control head curve B. The standard control head curve B is plotted as a curve smoothly interconnecting a head (lowest required pressure) PB_1, which is higher than the head PB_0 by a margin of a dozen %, required when the usage flow rate is nil, and a head (highest required pressure) PA_1, which is higher than the head PA_0 by a margin of a dozen %, required when the usage flow rate is of the final point Q_0.

[0007] The standard control head curve B is stored in a memory of the controller 15 of the water supply apparatus shown in FIG. 1. Based on the standard control head curve B, the controller 15 controls the rotational speed of the pump 1 so that when the usage flow rate is Q_1, the intersection U_3 between the flow rate Q_1 and the standard control head curve B will be at the operating point (rotational speed N_1) of the pump 1, as shown in FIG. 2, for example.

[0008] In this manner, the standard control head curve B which is higher than the required head curve A by a margin of a dozen % is set, and the rotational speed of the pump is controlled based on the standard control head curve B. Therefore, for example, in the case where the water pipe is corroded, causing a greater piping loss than the initially designed piping loss, the water supply apparatus is prevented from failing to exercise the required performance in use and is able to meet the demand for an increase in the flow rate that the user may want to achieve for some reason.

[0009] There has been proposed a method of inputting a flow rate determined from the pipe resistance and the pump performance curve and automatically controlling the rotational speed of the pump in order to achieve the desired flow rate (see Patent document 1). According to the proposed method, when the flow rate is initially measured, if the flow rate is high, then the rotational speed of the pump is automatically lowered. If the flow rate is still high regardless of the reduction in the rotational speed of the pump, then the rotational speed of the pump is further automatically lowered so as to meet the flow rate. In this manner, the rotational speed of the pump is automatically adjusted sequentially until a target flow rate is reached.

Citation List

Patent Literature

[0010] Patent document 1: Japanese laid-open patent publication No. 59-51193

Summary of Invention

Technical Problem

[0011] However, when the standard control head curve B which is higher than the required head curve A by a margin of a dozen % is set, and the rotational speed of the pump is controlled based only on the standard control head curve B, no flexible solution has been found to meet energy-saving demands. For example, as shown in FIG. 2, when the rotational speed of the pump is controlled based only on the standard control head curve B to achieve the flow rate Q_1 required by the user, the rotational speed of the pump is adjusted to N_1 so that the intersection U_3 between the flow rate Q_1 and the standard control head curve B will be at the operating point. Therefore, the operating point cannot be changed as required.

[0012] However, if the flow rate Q_1 required by the user is ensured, then there are instances where the rotational speed of the pump may be adjusted to N_2 so that the intersection U_2, whose head is higher than the head at the intersection (rotational speed N_3) U_1 between the flow rate Q_1 and the required head curve A and lower than the head at the intersection U_3, as shown in FIG. 2, will be at the operating point. In such a case, if the pump is operated at the intersection U_3 whose head is higher, the rotational speed of the pump is higher compared to the case where the pump is operated at the intersection U_2 whose head is lower, and hence the pump consumes more electric power. Such a mode of operation goes against today's stricter needs for energy saving.

[0013] Occasionally, the user may find it unnecessary to control the rotational speed of the pump based on the standard control head curve which has a sufficient margin. In such a case, demands for energy saving can be met by controlling the rotational speed of the pump based on a control head curve which has a minimum margin required.

[0014] However, the invention disclosed in Patent document 1 is not intended to achieve such energy saving.

[0015] The present invention has been made in view of the above circumstances. It is therefore an object of the present invention to provide a water supply apparatus which is capable of controlling the rotational speed of a pump so as to lower the rotational speed of the pump while keeping a constant flow rate, thereby meeting demands for energy saving.

Solution to Problem

[0016] The present invention recited in claim 1 relates to a water supply apparatus comprising: a pump configured to pressurize and deliver water; a frequency converter configured to supply electric power to the pump to operate the pump at a desired rotational speed; a discharge-side pressure sensor configured to detect a pressure at a discharge side of the pump; and a controller configured to control the rotational speed of the pump; wherein the controller stores a plurality of control head curves representing different relationships between flow rates and heads, and controls the rotational speed of the pump based on an alternatively selected one of the control head curves.

[0017] For example, a first control head curve and a second control head curve whose pressure (head) is set to be lower than that of the first control curve are stored in the controller. Then, normally, the controller controls the rotational speed of the pump based on the first control head curve, and as required, the controller controls the rotational speed of the pump based on the second control head curve. Thus, the water supply apparatus can save more energy by operating the pump at a lower rotational speed while maintaining the usage flow rate of water, compared to the case where the rotational speed of the pump is controlled based only on the first control head curve.

[0018] The present invention recited in claim 2 relates to the water supply apparatus according to claim 1 which further comprises an operation panel having a selector button configured to successively switch the plural control head curves stored in the controller and an energy-saving indicator configured to indicate energy-saving levels corresponding to the control head curves used to control the rotational speed of the pump.

[0019] Therefore, the user of the water supply apparatus can easily select one of the control head curves used for control by using the selector button, and can confirm the selected state on the energy-saving indicator.

[0020] The present invention recited in claim 3 relates to the water supply apparatus according to claim 1 or 2, wherein the plural control head curves include a standard control head curve and a small-flow-rate-range energy-saving control head curve whose head is lower than that of the standard control head curve in a small flow rate range.

[0021] The present invention recited in claim 4 relates to the water supply apparatus according to claims 1 to 3, wherein the plural control head curves include a standard control head curve and a medium-flow-rate-range energy-saving control head curve whose head is lower than that of the standard control head curve in a medium flow rate range.

[0022] The present invention recited in claim 5 relates to the water supply apparatus according to any one of claims 1 to 4, wherein the plural control head curves include a standard control head curve and a large-flow-rate-range energy-saving control head curve whose head is lower than that of the standard control head curve in a large flow rate range.
[0023] The present invention recited in claim 6 relates to the water supply apparatus according to any one of claims 1 to 5, wherein the plural control head curves include a standard control head curve and a full-flow-rate-range energy-saving control head curve which extends substantially parallel to the standard control head curve and whose head is lower than that of the standard control head curve in a full flow rate range.

Advantageous Effects of Invention

[0024] According to the water supply apparatus of the present invention, even if the usage flow rate remains the same, the pump can be operated at an operating point having a lower rotational speed, as required. Consequently, the amount of electric power consumed for the water supply can be reduced to achieve energy saving, leading to CO_2 reduction.

Brief Description of Drawings

[0025]

FIG. 1 is a view showing a structural example of a conventional water supply apparatus;
FIG. 2 is a graph showing a required head curve of a water supply apparatus, a standard control head curve of a conventional water supply apparatus, and Q-H curves of a pump;
FIG. 3 is a view showing a structural example of a water supply apparatus according to an embodiment of the present invention;
FIG. 4 is a graph showing a plurality of control head curves as well as a required head curve which are stored in a controller of the water supply apparatus according to the embodiment of the present invention;
FIG. 5 is a plan view of an operation panel provided in the water supply apparatus according to the embodiment of the present invention;
FIG. 6 is a graph showing a full-flow-rate-range energy-saving control head curve for use as a control head curve according to the present invention, as well as a required head curve and a standard control head curve;
FIG. 7 is a graph showing a medium-flow-rate-range energy-saving control head curve for use as a control head curve according to the present invention, as well as a required head curve and a standard control head curve;
FIG. 8 is a graph showing a large-flow-rate-range energy-saving control head curve for use as a control head curve according to the present invention, as well as a required head curve and a standard control head curve;
FIG. 9 is a graph showing a small-flow-rate-range energy-saving control head curve for use as a control head curve according to the present invention, as well as a required head curve and a standard control head curve; and
FIG. 10 is a graph showing the relationship between an amount of supplied water (flow rate) and time when the water supply apparatus operates throughout the day.

Description of Embodiments

[0026] An embodiment of the present invention will be described in detail below with reference to FIGS. 3 through 5. In FIGS. 1 through 5, identical or corresponding parts are denoted by identical reference numerals, and will not be described in duplication.
[0027] FIG. 3 is a view showing a structural example of a water supply apparatus according to an embodiment of the present invention. As shown in FIG. 3, the water supply apparatus includes a controller 15 having a setting unit 16, a memory 17, a processor 18, a display unit 19, and an I/O unit 20. The setting unit 16 and the display unit 19 are incorporated in an operation panel 21 of the water supply apparatus. Details of the parts other than the controller 15 are essentially the same as those of the conventional water supply apparatus shown in FIG. 1.
[0028] The setting unit 16 is used to establish various settings such as a plurality of control head curves, etc. which represent the different relationships between flow rates and heads, by external operation. The various settings such as a plurality of control head curves, etc. that are established by the setting unit 16 are stored in the memory 17. For example, the above-mentioned head (lowest required pressure) PB_1 required when the usage flow rate is nil, and the above-mentioned head (highest required pressure) PA_1 required when the usage flow rate is of the final point Q_0, are inputted as settings to the memory 17 and stored therein. The I/O unit 20 receives signals from various sensors installed in the water supply apparatus, such as an output signal from the discharge-side pressure sensor 4 and a signal from the flow switch 6, and sends the received signals to the processor 18. Further, the I/O unit 20 and the inverters 2 are connected to each other by communication means such as RS485. The controller 15 sends various settings, frequency command values, and control signals including start and stop signals to the inverters 2, and the inverters 2 sequentially

send operational details including actual frequency values and current values to the controller 15.

[0029] FIG. 4 shows a plurality of control head curves established by the setting unit 16 and stored in the memory 17. The illustrated example uses a required head curve A that is determined from the sum (H_1 + H_2 + H_3) of, for example, the head H_1 of the building (the height of the highest floor of the building), the pressure H_2 required for the water supply instrument (the pressure loss caused by the water supply instrument), and the piping loss H_3 depending on the flow rate, and a total of four control head curves including a standard control head curve B which is higher than the required head curve A by a margin of, e.g. a dozen %, and three full-flow-rate-range energy-saving control head curves C_1, C_2, C_3.

[0030] The full-flow-rate-range energy-saving control head curves C_1, C_2, C_3 extend substantially parallel to the standard control head curve B and have heads lower than that of the standard control head curve B and higher than that of the required head curve A over the full flow rate range. The heads of the full-flow-rate-range energy-saving control head curves C_1, C_2, C_3 are successively lower in the order named. Then, one of the four control head curves B, C_1, C_2, C_3 is selected, and the rotational speed of the pump 1 is controlled based on the selected one of the four control head curves B, C_1, C_2, C_3.

[0031] FIG. 5 is a plan view of the operation panel 21 of the water supply apparatus. As shown in FIG. 5, the operation panel 21 has a selector button 22 for successively selecting the four control head curves B, C_1, C_2, C_3 that are stored in the controller 17, and an energy-saving indicator 23 for indicating energy-saving levels corresponding to the control head curves that are used to control the rotational speed of the pump 1.

[0032] When the selector button 22 is not pressed, any lamps of the energy-saving indicator 23 are not turned on, and the standard control head curve B is used to control the rotational speed of the pump 1. When the selector button 22 is pressed once, a lamp corresponding to "L" on the energy-saving indicator 23 is turned on, and the full-flow-rate-range energy-saving control head curve C_1 is used to control the rotational speed of the pump 1. When the selector button 22 is pressed twice, a lamp corresponding to "M" on the energy-saving indicator 23 is turned on, and the full-flow-rate-range energy-saving control head curve C_2 is used to control the rotational speed of the pump 1. Further, when the selector button 22 is pressed three times, a lamp corresponding to "H" on the energy-saving indicator 23 is turned on, and the full-flow-rate-range energy-saving control head curve C_3 is used to control the rotational speed of the pump 1. When the selector button 22 is pressed four times, the energy-saving indicator 23 goes back to the original state.

[0033] Therefore, the user can easily select one of the control head curves B, C_1, C_2, C_3 used for control by pressing the selector button 22, and can confirm the selected state on the energy-saving indicator 23.

[0034] Operation of the water supply apparatus for controlling the rotational speed of the pump to achieve the flow rate Q_1 required by the user will be described below with reference to FIG. 4. First, when the user does not press the selector button 22, the rotational speed of the pump 1 is controlled based on the standard control head curve B, so that the intersection U_3 between the standard control head curve B and the flow rate Q_1 will be at the operating point of the pump 1. At this time, any lamps of the energy-saving indicator 23 are not turned on.

[0035] When the user presses the selector button 22 once, the rotational speed of the pump 1 is controlled based on the full-flow-rate-range energy-saving control head curve C_1, so that the intersection U_4 between the full-flow-rate-range energy-saving control head curve C_1 and the flow rate Q_1 will be at the operating point of the pump 1. At this time, the lamp corresponding to "L" on the energy-saving indicator 23 is turned on. When the user presses the selector button 22 twice, the rotational speed of the pump 1 is controlled based on the full-flow-rate-range energy-saving control head curve C_2, so that the intersection U_5 between the full-flow-rate-range energy-saving control head curve C_2 and the flow rate Q_1 will be at the operating point of the pump 1. At this time, the lamp corresponding to "M" on the energy-saving indicator 23 is turned on. Then, when the user presses the selector button 22 three times, the rotational speed of the pump 1 is controlled based on the full-flow-rate-range energy-saving control head curve C_3, so that the intersection U_6 between the full-flow-rate-range energy-saving control head curve C_3 and the flow rate Q_1 will be at the operating point of the pump 1. At this time, the lamp corresponding to "H" on the energy-saving indicator 23 is turned on.

[0036] In this manner, even if the usage flow rate remains the same, the pump 1 can be operated at a selected operating point having a lower rotational speed, as required. Consequently, the amount of electric power consumed for the water supply can be reduced to achieve energy saving, leading to CO_2 reduction.

[0037] In the above example, as shown in FIG. 6, a plurality of (three in the example) full-flow-rate-range energy-saving control head curves C that extend substantially parallel to the standard control head curve B and have heads lower than that of the standard control head curve B and higher than that of the required head curve A over the full flow rate range are used to achieve a substantially constant level of energy saving over the full flow rate range.

[0038] As shown in FIG. 7, a medium-flow-rate range energy-saving control head curve D that has a head lower than that of the standard control head curve B in a medium flow rate range may be used to achieve energy saving primarily in the medium flow rate range. In this case, a plurality of medium-flow-rate range energy-saving control head curves D having respective heads different from the standard control head curve B in the medium flow rate range may be used to achieve stepwise energy saving.

[0039] Further, as shown in FIG. 8, a large-flow-rate range energy-saving control head curve E that has a head lower than that of the standard control head curve B in a large flow rate range may be used to achieve energy saving primarily in the large flow rate range. In this case, a plurality of large-flow-rate range energy-saving control head curves E having respective heads different from the standard control head curve B in the large flow rate range may be used to achieve stepwise energy saving.

[0040] Furthermore, as shown in FIG. 9, a small-flow-rate range energy-saving control head curve F that has a head lower than that of the standard control head curve B in a small flow rate range may be used to achieve energy saving primarily in the small flow rate range. In this case, a plurality of small-flow-rate range energy-saving control head curves F having respective heads different from the standard control head curve B in the small flow rate range may be used to achieve stepwise energy saving.

[0041] The full-flow-rate-range energy-saving control head curve C shown in FIG. 6, the medium-flow-rate range energy-saving control head curve D shown in FIG. 7, the large-flow-rate range energy-saving control head curve E shown in FIG. 8, and the small-flow-rate range energy-saving control head curve F shown in FIG. 9 may be combined in any desired combinations to control the rotational speed of the pump, thereby achieving a desired flow rate and a desired head while maintaining an energy-saving effect.

[0042] The water supply apparatus was operated throughout the day to supply water at hourly rates (flow rates) kept as shown in FIG. 10 under a head (water supply pressure) of 40 m and then 36 m. The relationship between hours, water supply ratios, amounts of supplied water, and amounts of consumed electric power (hourly consumed electric power) under the head of 36 m is shown in Table 1 below, and the relationship between hours, water supply ratios, amounts of supplied water, and amounts of consumed electric power (hourly consumed electric power) under the head of 40 m is shown in Table 2 below.

[0043]

Table 1

Hour	Water supply ratio %	Amount of supplied water L/min	Amount of consumed electric power kWh
0 ~ 1	30	8.3	0.51
1 ~ 2	10	2.8	0.50
2 ~ 3	10	2.8	0.50
3 ~ 4	10	2.8	0.50
4 ~ 5	12	3.3	0.50
5 ~ 6	41	11.4	0.52
6 ~ 7	85	23.6	0.56
7 ~ 8	138	38.3	0.62
8 ~ 9	247	68.6	0.77
9 ~ 10	215	59.7	0.72
10 ~ 11	164	45.6	0.65
11 ~ 12	124	34.4	0.60
12 ~ 13	114	31.7	0.59
13 ~ 14	95	26.4	0.57
14 ~ 15	95	26.4	0.57
15 ~ 16	96	26.7	0.57
16 ~ 17	110	30.6	0.59
17 ~ 18	125	34.7	0.60
18 ~ 19	153	42.5	0.64
19 ~ 20	143	39.7	0.62
20 ~ 21	129	35.8	0.61
21 ~ 22	111	30.8	0.59
22 ~ 23	88	24.4	0.56

(continued)

Hour	Water supply ratio %	Amount of supplied water L/min	Amount of consumed electric power kWh
23 ~ 24	55	15.3	0.53
Hourly-averaged amount of supplied water	100	27.8	Total 13.99

The water supply ratio represents an hourly ratio with respect to the hourly-averaged amount of supplied water which is 100.

[0044]

Table 2

Hour	Water supply ratio %	Amount of supplied water L/min	Amount of consumed electric power kWh
0 ~ 1	30	8.3	0.60
1 ~ 2	10	2.8	0.59
2 ~ 3	10	2.8	0.59
3 ~ 4	10	2.8	0.59
4 ~ 5	12	3.3	0.59
5 ~ 6	41	11.4	0.61
6 ~ 7	85	23.6	0.66
7 ~ 8	138	38.3	0.72
8 ~ 9	247	68.6	0.90
9 ~ 10	215	59.7	0.84
10 ~ 11	164	45.6	0.76
11 ~ 12	124	34.4	0.70
12 ~ 13	114	31.7	0.69
13 ~ 14	95	26.4	0.67
14 ~ 15	95	26.4	0.67
15 ~ 16	96	26.7	0.67
16 ~ 17	110	30.6	0.69
17 ~ 18	125	34.7	0.71
18 ~ 19	153	42.5	0.74
19 ~ 20	143	39.7	0.73
20 ~ 21	129	35.8	0.71
21 ~ 22	111	30.8	0.69
22 ~ 23	88	24.4	0.66
23 ~ 24	55	15.3	0.63
Hourly-averaged amount of supplied water	100	27.8	Total 16.41

The water supply ratio represents an hourly ratio with respect to the hourly-averaged amount of supplied water which is 100.

[0045] It will be seen from Table 1 and Table 2 that when the water supply apparatus operates throughout the day to supply water under a head (water supply pressure) reduced from 40 m to 36 m, the total amount of consumed electric power is reduced from 16.41 kWh to 13.99 kWh. Therefore, the amount of saved energy per day is 2.42 kWh, and the amount of saved energy per year is 883 kWh, which is converted into 358 kg of CO_2 (CO_2 conversion coefficient recommended by Tokyo Electric Power Company, Incorporated: 1 kWh = 0.43 kg). Since one cedar tree can absorb 14.5 kg of CO_2 per year (because 11000 cedar trees absorb 160 t of CO_2 per year according to Workshop of Iron Nutrition Enhancement in Plants), CO_2 reduction equivalent to about 25 cedar trees can be achieved.

[0046] A plurality of control head curves may be used, and when the user feels that the head is low, the user may select one of the control head curves which has a higher head. Specifically, according to the above embodiment, the standard control head curve B and several control head curves whose heads are lower than that of the standard control head curve B fully or partly over the flow rate range thereof are stored in the controller, and one of the several control head curves is selected. However, the standard control head curve B and several control head curves whose heads are higher than that of the standard control head curve B fully or partly over the flow rate range thereof may be stored in the controller, and one of the several control head curves may be selected.

[0047] Although the embodiment of present invention has been described above, the present invention is not limited to the above embodiment, but may be reduced to practice in various different manners within the scope of the technical concept thereof. The water supply apparatus according to the present invention allows the user to select one of the control head curves for the purpose of energy saving, i.e. for reducing the amount of electric power used to operate the pump. However, the present invention is not limited to such purpose, but is also applicable to a water supply apparatus which allows the user to select one of control head curves for the purpose of saving water.

Industrial Applicability

[0048] The present invention is applicable to a water supply apparatus for supplying water such as tap water to collective housing or a building using a pump.

Reference Signs List

[0049]

1	pump
2	inverter (frequency converter)
3	pressure tank
4	discharge-side pressure sensor
8	suction-side pipe
9	water main
10	suction-side pressure sensor
12	bypass pipe
13	discharge-side pipe
15	controller
16	setting unit
17	memory
18	processor
19	display unit
20	I/O unit
21	operation panel
22	selector button
23	energy-saving indicator
A	required head curve
B	standard control head curve
C	full-flow-rate-range energy-saving control head curve
D	medium-flow-rate-range energy-saving control head curve
E	large-flow-rate-range energy-saving control head curve
F	small-flow-rate-range energy-saving control head curve

Claims

1. A water supply apparatus comprising:

a pump configured to pressurize and deliver water;
a frequency converter configured to supply electric power to the pump to operate the pump at a desired rotational speed;
a discharge-side pressure sensor configured to detect a pressure at a discharge side of the pump; and
a controller configured to control the rotational speed of the pump;
wherein the controller stores a plurality of control head curves representing different relationships between flow rates and heads, and controls the rotational speed of the pump based on an alternatively selected one of the control head curves.

2. A water supply apparatus according to claim 1, further comprising:

an operation panel having a selector button configured to successively switch the plural control head curves stored in the controller and an energy-saving indicator configured to indicate energy-saving levels corresponding to the control head curves used to control the rotational speed of the pump.

3. A water supply apparatus according to claim 1 or 2, wherein the plural control head curves include a standard control head curve and a small-flow-rate-range energy-saving control head curve whose head is lower than that of the standard control head curve in a small flow rate range.

4. A water supply apparatus according to any one of claims 1 to 3, wherein the plural control head curves include a standard control head curve and a medium-flow-rate-range energy-saving control head curve whose head is lower than that of the standard control head curve in a medium flow rate range.

5. A water supply apparatus according to any one of claims 1 to 4, wherein the plural control head curves include a standard control head curve and a large-flow-rate-range energy-saving control head curve whose head is lower than that of the standard control head curve in a large flow rate range.

6. A water supply apparatus according to any one of claims 1 to 5, wherein the plural control head curves include a standard control head curve and a full-flow-rate-range energy-saving control head curve which extends substantially parallel to the standard control head curve and whose head is lower than that of the standard control head curve in a full flow rate range.

FIG. 1

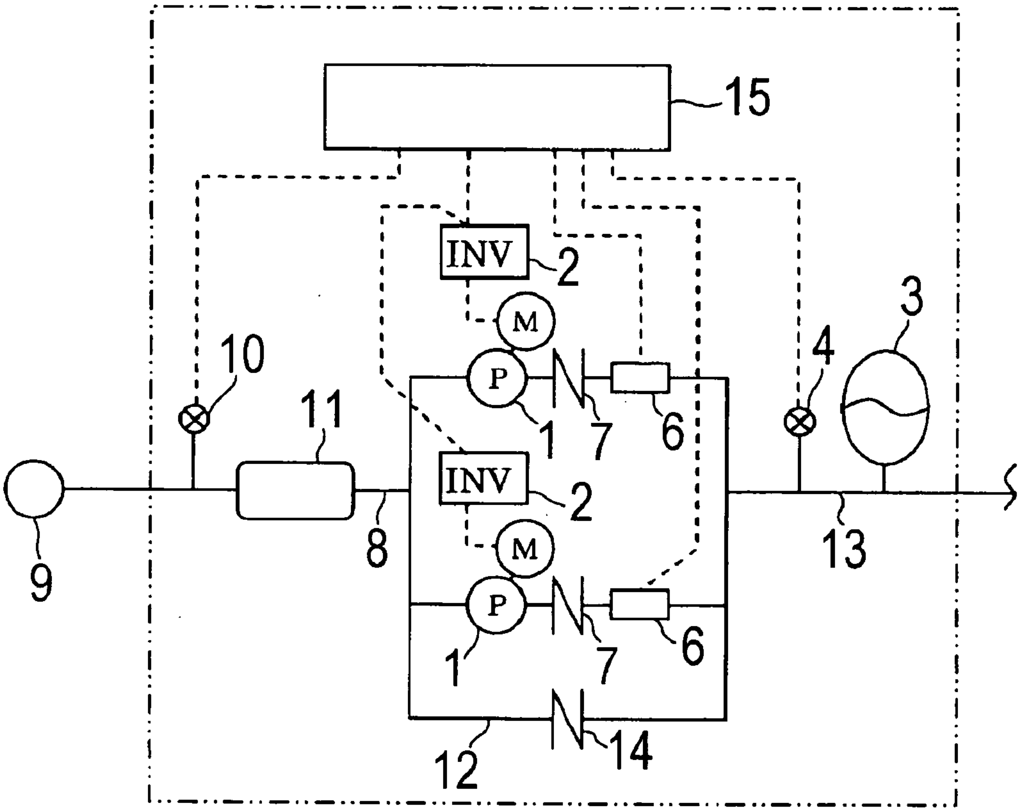
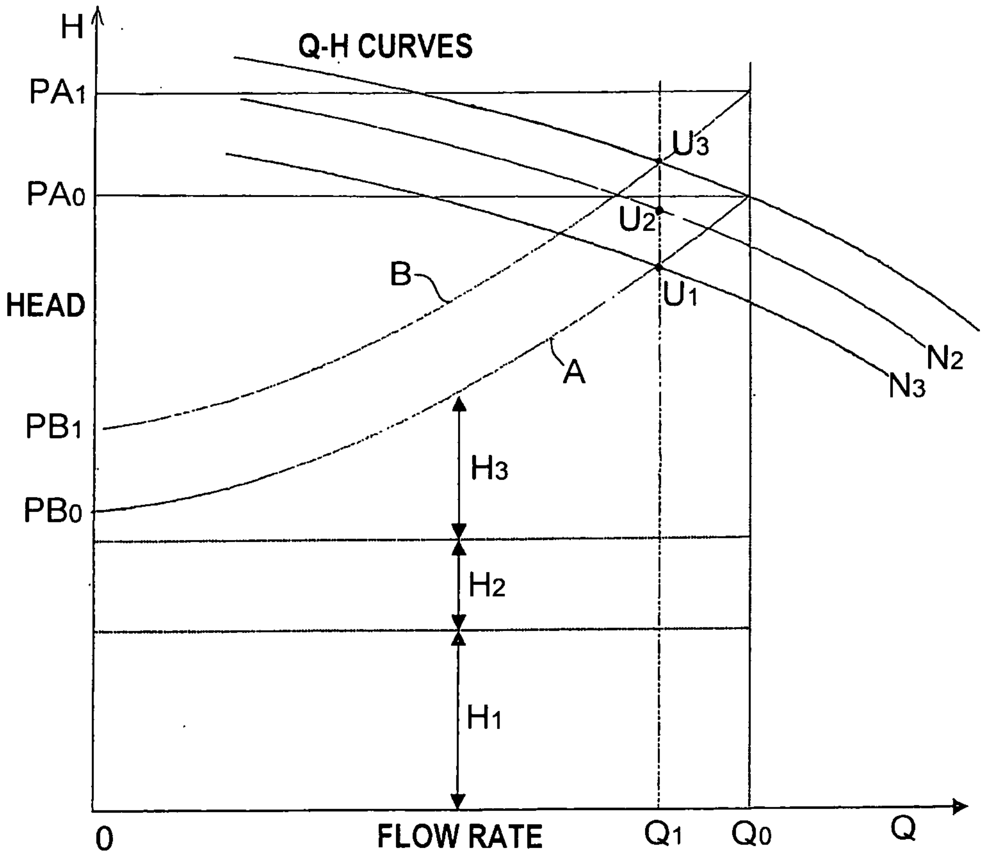


FIG. 2



H
Q-H CURVES
PA1
PA0
HEAD
PB1
PB0
U3
U2
U1
B
A
N1
N2
N3
H3
H2
H1
0
FLOW RATE
Q1
Q0
Q

FIG. 3

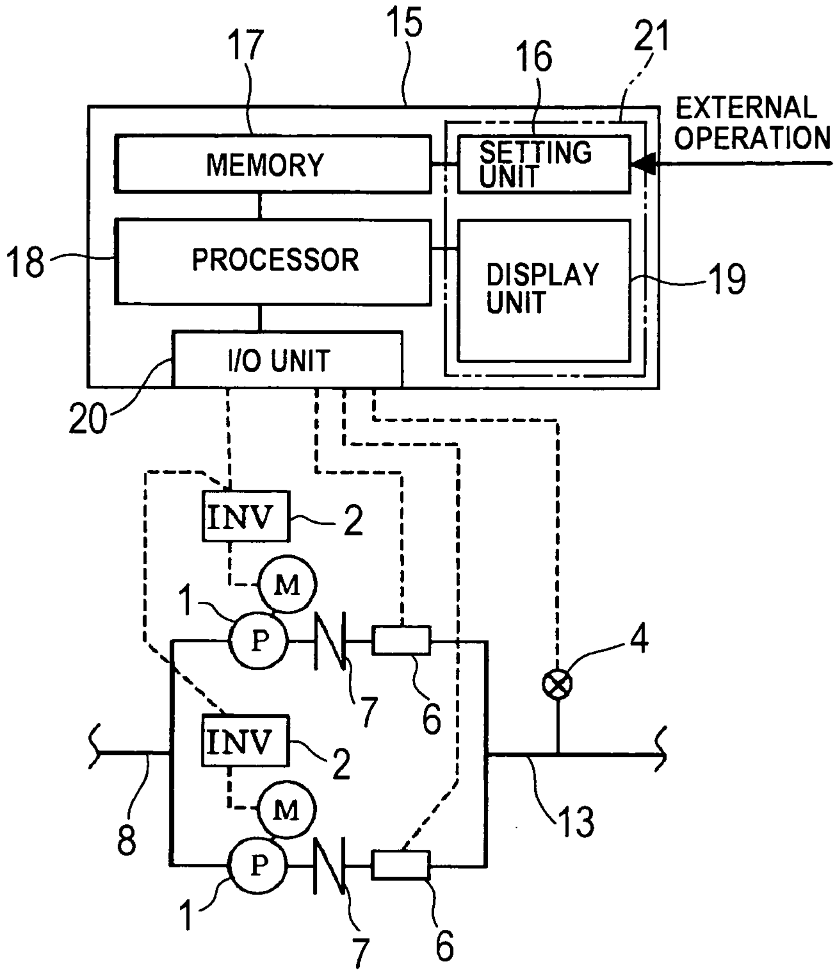

15
17
16
21
EXTERNAL OPERATION
MEMORY
SETTING UNIT
18
PROCESSOR
DISPLAY UNIT
19
I/O UNIT
20
INV
2
M
1
P
4
7
6
INV
2
8
M
13
P
1
7
6

FIG. 4

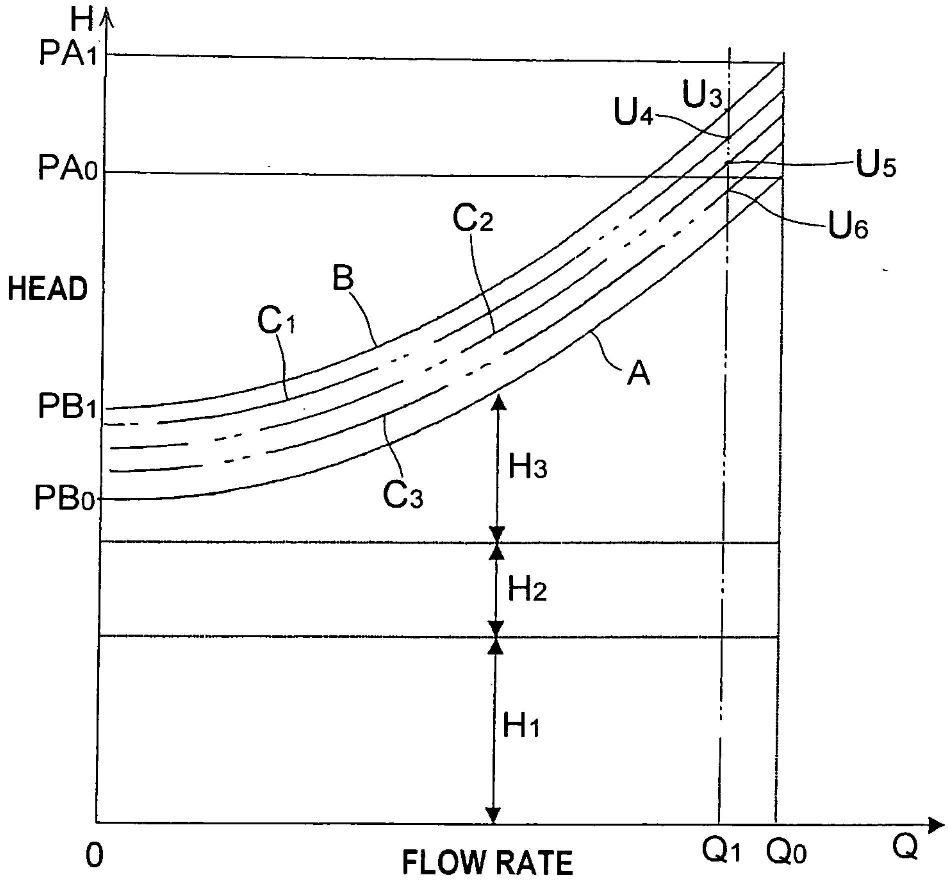

H
PA1
PA0
HEAD
PB1
PB0
U3
U4
U5
U6
C2
B
C1
A
C3
H3
H2
H1
0
FLOW RATE
Q1
Q0
Q

FIG. 5

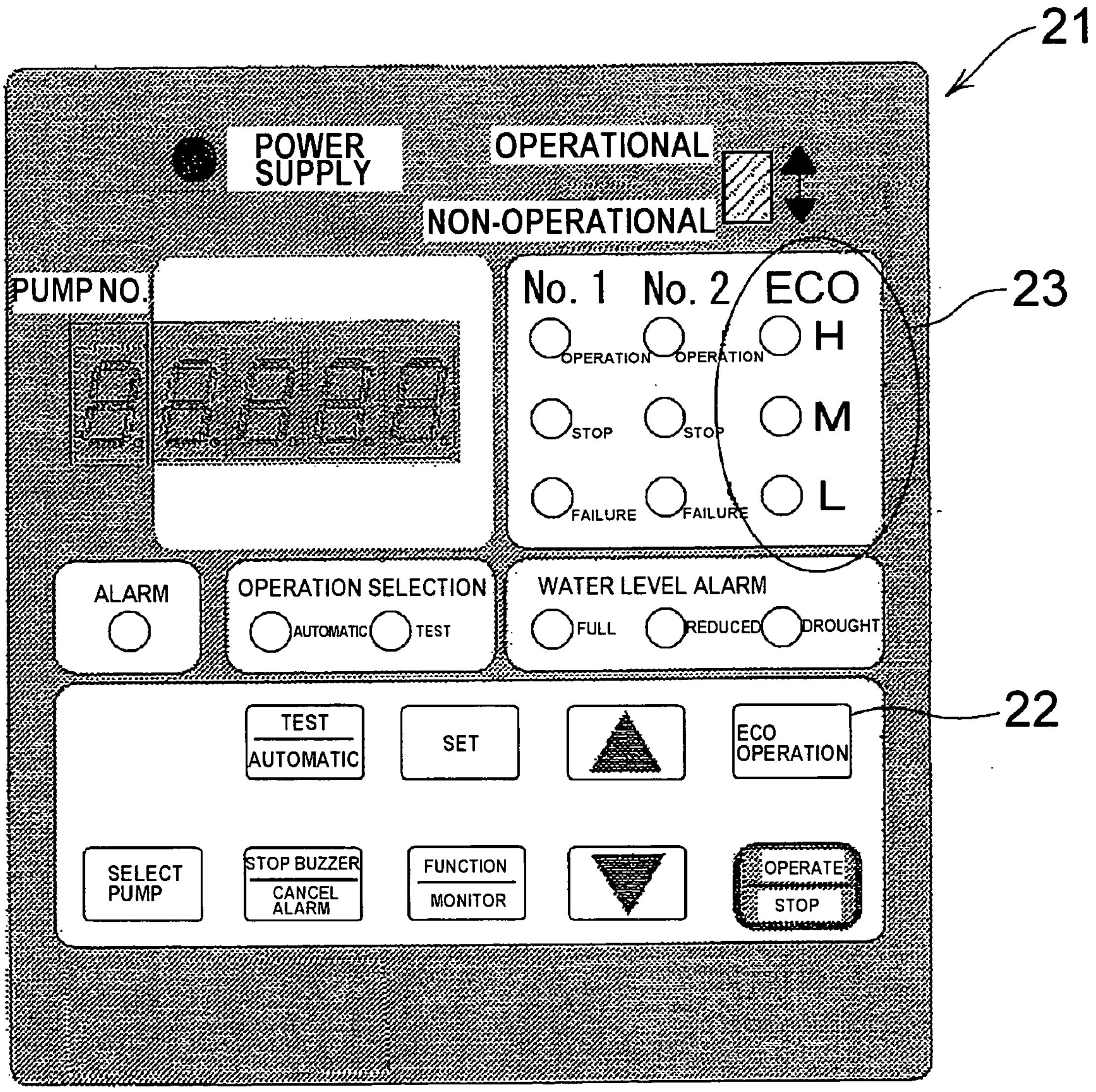

21
POWER SUPPLY
OPERATIONAL
NON-OPERATIONAL
PUMP NO.
No. 1
No. 2
ECO
H
M
L
OPERATION
OPERATION
STOP
STOP
FAILURE
FAILURE
23
ALARM
OPERATION SELECTION
AUTOMATIC
TEST
WATER LEVEL ALARM
FULL
REDUCED
DROUGHT
TEST
AUTOMATIC
SET
ECO OPERATION
22
SELECT PUMP
STOP BUZZER
CANCEL ALARM
FUNCTION
MONITOR
OPERATE
STOP

FIG. 6

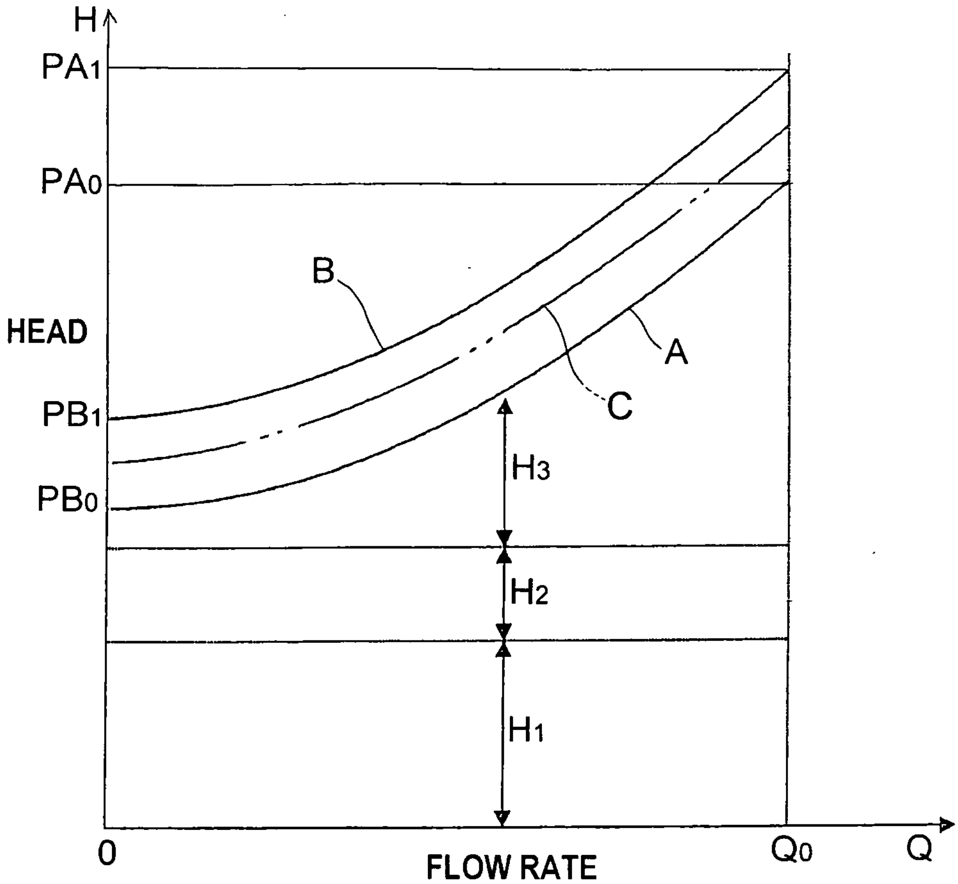


FIG. 7

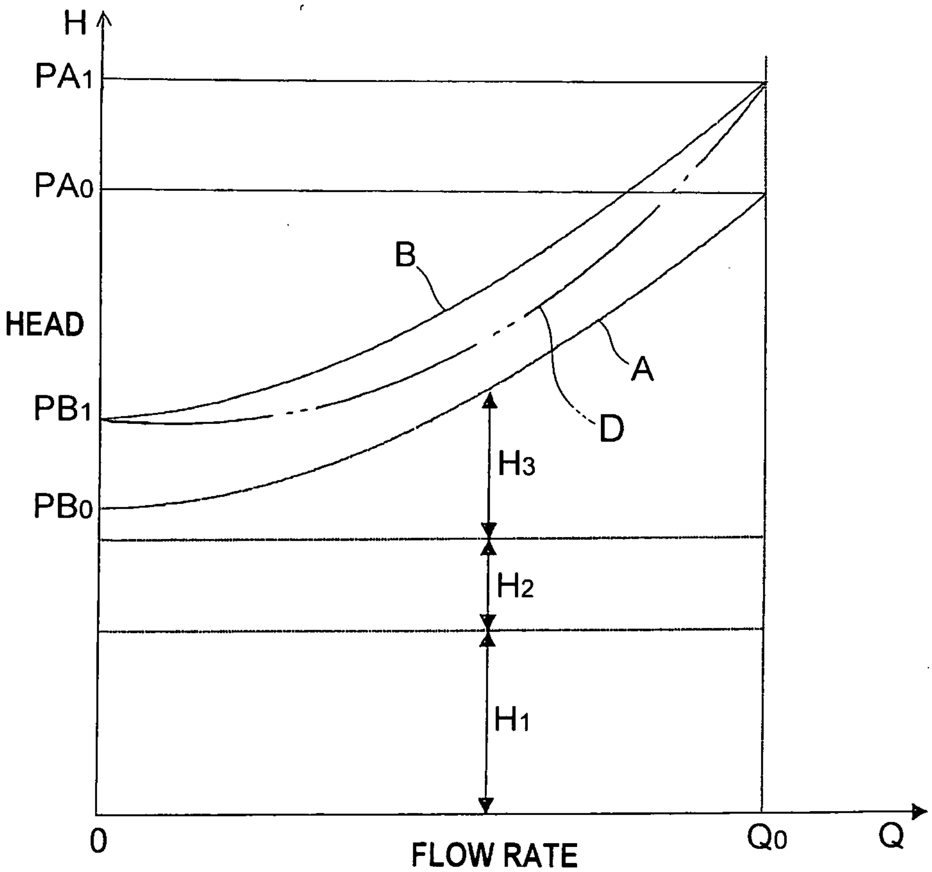


FIG. 8

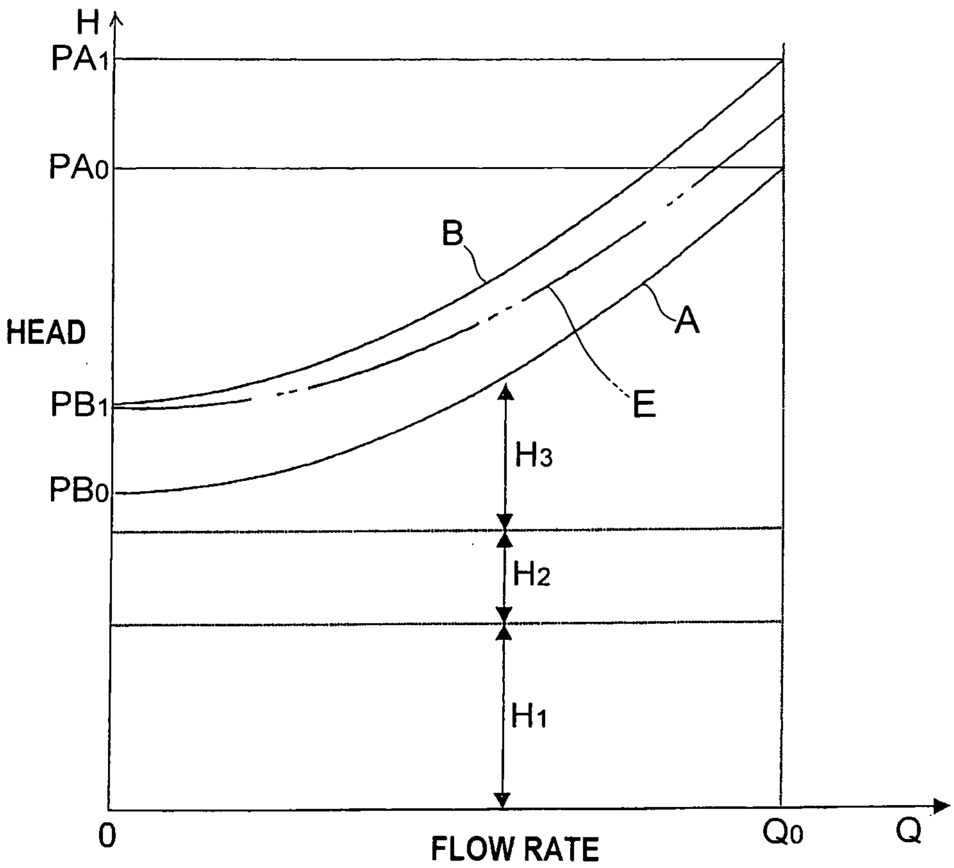


FIG. 9

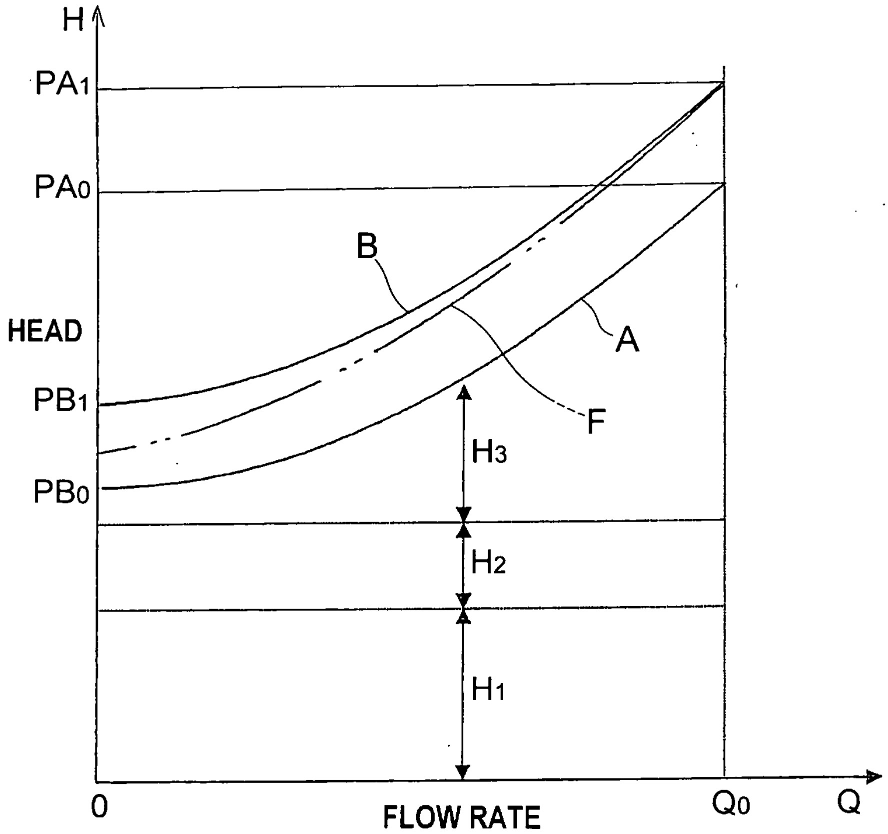
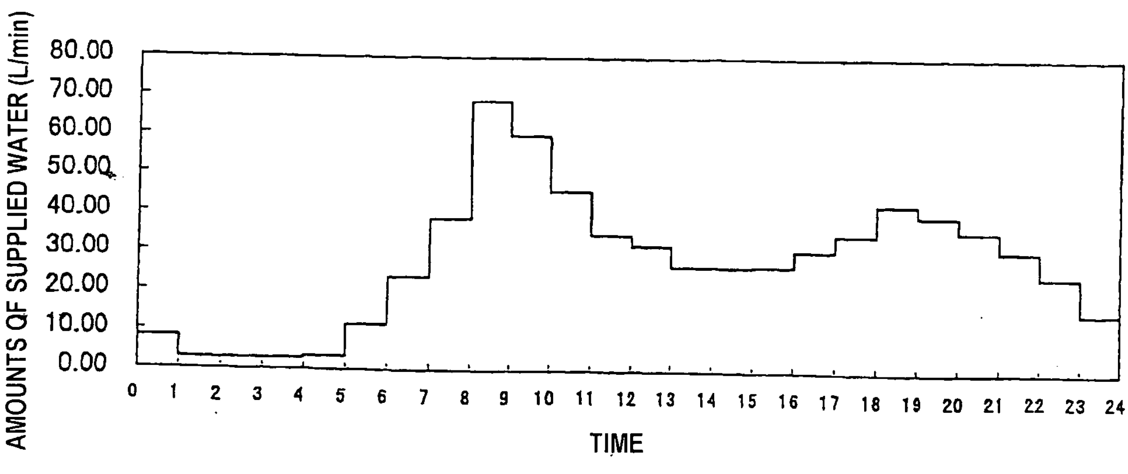

H
PA1
PA0
B
HEAD
A
PB1
F
H3
PB0
H2
H1
0
FLOW RATE
Q0
Q

FIG. 10


AMOUNTS OF SUPPLIED WATER (L/min)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
TIME

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/051196

A. CLASSIFICATION OF SUBJECT MATTER
F04D15/00(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)
F04D15/00

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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.
X A	JP 2005-351252 A (Nikkiso Co., Ltd.), 22 December 2005 (22.12.2005), paragraphs [0018] to [0021]; fig. 4 to 6 (Family: none)	1 2-6
A	JP 2000-110769 A (Toshiba Corp.), 18 April 2000 (18.04.2000), entire text; all drawings (Family: none)	1-6

☐ Further documents are listed in the continuation of Box C.
☐ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 April, 2012 (09.04.12)	17 April, 2012 (17.04.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

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Patent documents cited in the description

- JP 59051193 A **[0010]**